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Volume 1 of 4

SPACE COMMUNICATIONS: THEORY AND APPLICATIONS

A BIBLIOGRAPHY

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Volume 1: Modulation and Channels

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-7022(01)
Volume 1 of 4

SPACE COMMUNICATIONS: THEORY AND APPLICATIONS

A BIBLIOGRAPHY

Volume 1: Modulation and Channels

An extensive collection of annotated references to reports, journal articles, and books published during the period 1958–1963.

Compiled by
Dr. Richard F. Filipowsky and
Louise C. Bickford

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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INTRODUCTION

Space Communications: Theory and Applications is a four-volume bibliography compiled by the Federal Systems Division, IBM under contract to the National Aeronautics and Space Administration. It contains an extensive listing of references to reports, articles, and books on several subjects directly pertinent to the field of space communications. The compilers have endeavored to provide maximum coverage of the literature for the period 1958 through 1963. However, references to publications of unusual significance that appeared before 1958, as well as a limited number of 1964 references, have also been included. The bibliography has been prepared primarily for use by communications specialists engaged in technical activities related to the aerospace program. Each of the four volumes is complete in its coverage of specific subjects and is being published separately.

Volumes 1, 2, and 3 are devoted primarily to a theoretical consideration of their subject matter but, when appropriate, references pertaining to applications are also included. Volume 4 contains references to four important and timely applications of space communications. The NASA Special Publication numbers and the particular subjects of each volume are as follows:

NASA SP-7022(01)	Volume 1	Modulation and Channels
NASA SP-7022(02)	Volume 2	Coding and Detection Theory
NASA SP-7022(03)	Volume 3A	Information Processing
	3B	Advanced Techniques
NASA SP-7022(04)	Volume 4A	Communications Satellites
	4B	Instrumented Satellites
	4C	Deep Space Applications
	4D	Manned Space Flight Applications

Each volume contains a Table of Contents for that particular volume and a separate Table of Contents for the complete set of four. For additional reference aid, a subject index is included in each volume. A listing of abbreviations (established by Science Abstracts, Section B, Electrical Engineering Abstracts, London) of widely used journals and periodicals is included in each volume, for the purpose of identifying source documents.

Arrangement of references in the bibliographic listing is based on subjects in accordance with the Table of Contents. Under each specific topic, references are divided into "Principal Publications" and "Related Publications." Within each of these categories, references are listed in chronological order and, when further separation is necessary, by individual author. Each citation to a reference is accompanied by an annotation if the title of the reference is not sufficiently informative. Whenever possible, annotations included in this bibliography have been extracted from the original reference or from its abstract.

For additional information concerning the structure and function of the Table of Contents, and for a detailed description of the arrangement of references, the user is referred to the "User's Guide" which follows this Introduction.

AVAILABILITY OF DOCUMENTS

References cited in this bibliography are available for examination in the designated issues of the original journals. Copies of particular issues may be borrowed from libraries maintaining sets of these journals. In some instances, reprints may be obtained by writing to the editorial office of the journal.

Copies of NASA SP-7022(01), the first volume of Space Communications: Theory and Applications, can be obtained from NASA (Code ATSS-A), without charge, by NASA offices and contractors, U. S. Government agencies and their contractors, and organizations that are working in direct support of NASA programs.

Other organizations and individuals can purchase copies of NASA SP-7022(01) from the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402.

USERS GUIDE

The Table of Contents for each volume best illustrates the general structure of the volume and the arrangement of its contents. The main subject is synonymous with the subtitle of the volume and is designated by the number 1, 2, 3 or 4. Each volume or subject (1) is divided into divisions (1.0, 1.1, 1.2, etc.), sections (1.10, 1.11, 1.12, etc.) and finally, into subdivisions (1.110, 1.111, 1.112, etc.).

Arrangement of references and other text under the four categories is as follows:

Subject 1: A general description of the contents of the entire volume which briefly identifies all important subtopics.

Division 1.1: A more detailed statement of content is usually presented with emphasis on the fundamental aspects of the topics to be considered. Specific references to related sections and subdivisions are included.

Section 1.10: An explanatory note is provided, when appropriate, to describe a single topic covered in detail in the following subdivisions.

Subdivision 1.100: This is the most limiting level of categorization and will normally contain a complete compilation of information on a specific topic. It opens with a statement that identifies the types of references Included and the types that are Not Included. Cross-reference instructions follow and refer only to those related sections or subdivisions that appear in the same volume. Finally, all citations and annotations appear in this category, divided into two groups: Principal Publication and Related Publications. The last digit of the subdivision number has special significance in the listing of pertinent references. For example, if the complete category number is 1.111, the final "1" signifies that references pertaining to the fundamental and theoretical aspects of the subject appear under it. If the last digit is "7" or "8", the references which appear under it will pertain to specific applications related to the topic under discussion. Similarly, testing and simulation references are denoted when the last digit is "9". The user may note that all of the final digits in a category are not used in the bibliography. This apparent omission does not mean that divisions, sections, or subdivisions are missing but that pertinent references have not been identified at this time. However, the unused numbers have been assigned and if relevant references appear in the future, they can be incorporated in a supplementary or revised issue of the bibliography.

The index for each volume is constructed on a two-tier basis, i.e., a major subject or technical expression and those supporting expressions that are directly associated with the major subject. A special effort has been made to retain the original terminology of authors in the index. New terms and translations of foreign terms, as used by individual authors, have been mixed with older and more familiar expressions and are included in the index in proper alphabetical order.

Duplicate entries to the same reference will be found occasionally within a subdivision. The user will note that both entries are included because different sources are identified and the repetition may provide more convenient access to the document. Defense Documentation Center (DDC, formerly ASTIA) documents are designated AD, followed by six digits. NASA documents are designated N62 (or N63, N64) followed by five digits. AIAA documents are designated A62 (or A63, A64) followed by five digits.

Titles of foreign language citations have been translated into English.

ABBREVIATIONS OF PRIMARY SOURCE DOCUMENTS

AIEE - American Institute of Electrical Engineers
Conf. - Conference
Conv. - Convention
Engng. - Engineering
IEE - Institution of Electrical Engineers
IEEE - Institute of Electrical and Electronic Engineers
Inst. - Institute
Instn. - Institution
Internat. - International
IRE - Institute of Radio Engineers
J. - Journal
Nat. - National
Proc. - Proceedings
Rec. - Record
Symp. - Symposium
Trans. - Transactions

Ann. Radioelect. - Annales de Radioelectricite
Arch. Elekt. Ubertragung - Archiv der Elektrischen Ubertragung
Avtomat. i Telemekh. - Avtomatika i Telemekhanika
Bell Syst. Tech. J. - Bell Systems Technical Journal
Elektron. Rundschau - Elektronische Rundschau
IRE Trans. Comp. Parts - IRE Transactions Component Parts
IRE Trans. Commun. Syst. - IRE Transactions Communications Systems
IRE Trans. Electronic Comp. - IRE Transactions Electronic Components
IRE Trans. Inform. Th. - IRE Transactions Information Theory
IRE Trans. Microwave Th. Tech. - IRE Transactions Microwave Theory and Techniques
IBM J. Res. Developm. - IBM Journal of Research and Development
J. Appl. Phys. - Journal of Applied Physics
JPL Res. Summ. - JPL Research Summary
JPL Space Progr. Summ. - JPL Space Program Summary
Nachrichtentech. Z. - Nachrichtentechnische Zeitschrift
Proc. Electronic Comp. Conf. - Proceedings Electronic Computer Conference
Radio Engng. - Radio Engineering
RCA Rev. - RCA Review
Rec. Nat. Commun. Symp. - Record National Communications Symposium
Rev. Sci. Instrum. - Review of Scientific Instruments
Telecomm. Radio Engng. - Telecommunications and Radio Engineering

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SUBJECT 1

MODULATION AND CHANNELS

Subject 1 deals with the theoretical and practical aspects of signal formation methods for transmitting information over communications channels. It also contains references to the characteristics of practical communications channels. Coding, i.e., information processing for communications purposes, and multiplexing and detection methods are combined as subject 2 in the next volume of this series. The actual modulation and demodulation circuits and references to equipment are not included in this series of volumes.

The emphasis in selecting references is on their importance for space communications. However, it is well known that all frequency ranges from VLF to microwaves and optical frequencies have applications in space missions. This also applies to practically every known modulation method. This volume will therefore be representative of documentation, from 1958 to 1963, in modulation and channels for communications with actual or potential applications in space missions.

DIVISION 1.1
FUNDAMENTALS AND COMMUNICATIONS THEORY

Division 1.1 is the general theoretical division of the subject. Any references to fundamental problems which concern several of the following divisions are included here. References to more specialized analytical publications are assigned to special sections or subdivisions within the respective divisions. For example, the general theory of signal space is here in 1.140, while the special theory of elementary signals for digital waveforms is in 1.3.

Statistical mathematics and the theory of random variables is of principal importance in many phases of space communications. Selected references in this area have been included in the subdivisions of section 1.11 below, but the reader is advised to consult the references in subdivision 1.110 for further guidance.

Section 1.10
General Problems in Modulation and Channels

1.100: References to Modulation in General

Included: Books on modulation; Surveys on transmission techniques.

Not Included: Publications on electronics in general; Radio techniques in general.

Cross References: Books and surveys on communication and information theory (1.120); Books and surveys on noise and disturbances (1.701); Comparisons on modulation methods (1.800); General references on multiple modulation methods (1.902).

Principal Publications:

MODULATION THEORY
H. S. Black, Princeton, N. J., D. Van Nostrand, 1953, 538 p.

TRANSMISSION AND INFORMATION THEORY
S. Weber, Electronics, vol. 32, no. 43, May 1959, p. 106/108.
Transmission Rate - Reception Theory - Pulse Code Modulation - Battle for Bandwidth - Speech Compression.

INFORMATION TRANSMISSION, MODULATION, AND NOISE: A UNIFIED APPROACH TO COMMUNICATION SYSTEMS
M. Schwartz, McGraw-Hill Book Co., Inc., 1959, 461 p.
Information Transmission, modulation, and noise; a unified approach to communication systems.

RESEARCH ON THE THEORY AND UTILIZATION OF VARIOUS PHENOMENA IN THE PERFORMANCE OF CIRCUIT FUNCTIONS.

C. Volz et al., Solid Circuits Res. Lab., Penn. State U., Col. of Engrg., University Park, Penn., Scientific rept 7, 1 Feb.-1 May 1960, 36 p., AD 243 596

. . . classifying circuit operations: (1) physical considerations and common engineering concepts (2) mathematical properties . . . The conveyance of information from input to to output is deemed the common purpose of all physical systems. The concepts of subject and transport were originated in recognition of the purpose and are intended to express precisely how the information is conveyed.

INFORMATION HANDLING AND PROCESSING IN LARGE COMMUNICATIONS SYSTEMS
W. F. Leubbert, Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 099-1, 11 July 1960, AD 243 676.

. . . demonstrated that communications systems can be viewed as information processing systems with rather different characteristics from conventional one-location data processors, and that both communications and conventional systems can be viewed as special cases of a more general type of system. Von Neumann's concept of interchangeability of program and data in computers can be extended to interchangeability of system and user information in communications systems. The result would be entirely new dimensions for planning and techniques for overcoming some of the most severe limitations of current communications systems.

ELECTRONIC CIRCUITS, SIGNALS AND SYSTEMS
S. J. Mason & H. J. Zimmerman, New York, J. Wiley & Sons, Inc., 1960, 611 p.

PROCEEDINGS SYMPOSIUM ON THE APPLICATION OF LOW NOISE RECEIVERS TO RADAR AND ALLIED EQUIPMENT VOLUME II. JOINTLY SPONSORED BY CANADA, THE UNITED KINGDON AND THE UNITED STATES.
Lincoln Lab., MIT, Lexington, 22 Nov. 1960, AD 248 691.

CRITERION PROBLEM IN DATA TRANSMISSION
M. A. Rappeport, IEEE Paper No. 63-534, Feb. 1963, 35 p.

STANDARDIZED METHOD FOR DETERMINATION AND PRESENTATION OF QUANTIZED COMMUNICATION REQUIREMENTS
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. ICS-62-MGT-36, June 1962, 57 p., AD 295 574.

. . . Ray communication data must be quantized in order to take advantage of EDP applications to design problems (file maintenance and information retrieval). . . . program of developing and analyzing Air Force Communications requirements.

MODULATION METHODS
R. A. Heising, Proc. IRE, vol. 50, May 1962, p. 896/901.

AN INTRODUCTION TO MODULATION, CODING, INFORMATION THEORY, AND DETECTION
G. Raisbeck, Arthur D. Little, Inc., Cambridge, Mass., Dec. 1962, 80 p., AD 415 178.

. . . expository essary on information theory for engineers interested in communications, sonar, and radar who have no specialized knowledge of statistical communication theory. . . . quantity of information and channel capacity are defined and explained in simple terms. . . .

DISCUSSION: MODULATION OR CODING
G. P. Divnogortsev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 71/72.

It is known . . . that "modulation is a process having as its purpose the translation of the spectrum of a low-frequency signal into the high-frequency range so that the signal can be transmitted by radio facilities," . . . a number of papers have recently appeared . . . which, with very little foundation and quite unnecessarily, attribute the concept of modulation to processes having nothing in common with translation of a signal spectrum. . . . such terms as phase-difference modulation (PDM), relative phase modulation (RPM), relative frequency modulation (RFM) and relative amplitude modulation (RAM).

. . . are but addition of signal coding equipment at the input and output of the old systems. . . .

PROBLEMS OF CYBERNETICS (Translation)
A. A. Lyapunov, Joint Publications Research Service, Washington, D. C., JPRS-20780, Aug. 23, 1963, 297 p., 148 refs., N63-20662.

. . . Information and coding theory . . . Programming the process of musical composition, transformation of program schemes and their use in programming . . .

COMMUNICATION SYSTEMS TECHNIQUE BASED ON FUNDAMENTAL CONCEPTS OF JACQUES HADAMARD
R. G. Segers, Vitro Labs., West Orange, N. J., Final rept., 10 June 1963, 70 p., AD 406 902.

A variety of fundamental investigations, with common analytical foundation in the work of Jacques Hadamard, was conducted for the purpose of development of advanced communications systems. . . . demodulation problem as formulated in a system of integral equations by D. C. Youla. . . . communication techniques derivable from incidence matrices of balanced incomplete block design configurations.

IDENTIFICATION PROBLEMS IN COMMUNICATION AND CONTROL SYSTEMS
L. A. Zadeh, et al., Princeton U., N.J., March 1963, 231 p., AD 416 359.

. . . conference was to consider problems underlying the areas of communication and control theory . . . connected with the identification of signals and systems . . . mathematical aspects

. . . difficulties involved in relating the purely mathematical forms of such representation to the models of physical systems.

Section 1.11
Fundamentals of Statistical Mathematics

This section contains, in eight subdivisions, a number of selected references relating to the mathematical fundamentals of many important communications problems. Statistical mathematics has increasing applications in practical space communications problems and special subdivisions (1.117 and 1.119) have been established to present references to tables and graphical and experimental procedures.

It is unavoidable that the field of the following subdivisions overlap; the reader is advised to check them all. He is also reminded that many more references will be quoted in the books, surveys and principal articles mentioned below.

1.110: General References to Statistical Mathematics as Applicable to Modulation and Channels

Included: Algebra of stochastic quantities; Time statistics of random processes; Statistical computations in general; Probability theory in general; Mathematical statistics; Time series analysis, statistical problems; Statistical analysis in general.

Not Included: Statistical detection theory (2); Statistical description of information sources (2); Data processing devises for statistical computations (3A); Simulation of statistical processes (3A); Statistical characteristics of control systems; Statistical circuit theory.

Cross References: Time series analysis for sampled data transmission systems (1.411); Statistical description of communication channels (1.611); Statistical description of noise and disturbances (Sect. 1.71); Statistical description of modulated signals (1.210); Statistical information theory (Sect. 1.12).

Principal Publications:

METHODS OF SOLVING NOISE PROBLEMS
W. R. Bennett, Proc. IRE, vol. 44, May 1956, p. 609/638.

THEORY OF RANDOM FUNCTIONS AND ITS APPLICATION TO PROBLEMS OF AUTOMATIC CONTROL
V. S. Pugachev, Moscow, Fizmatgiz, 1957, 730 p.

. . . English translation of the first edition of this Russian test, published in Moscow in 1957. A second Russian edition (1960) has been issued and Pergamon Press plans to publish a translation. . . . The first eight chapters present . . . fairly standard material on probability and random processes . . . The next three chapters (9-11) provide additional material on random processes, particularly stressing Pugachev's work on what he calls canonical expansions of random processes. . . . The mathematical development in these chapters is not as careful as in the earlier sections of the book. . . . In the next four chapters (12-15) the problem of noise through linear and nonlinear systems is treated. . . . The next chapter, Ch. 16, is the longest in the book, and treats in great generality the problem of minimum mean-square filtering and prediction. A generalized formulation is given covering the work of Zadeh and Ragazzini, Davis, Booton, and others. . . . The final chapter discusses some methods of calculating statistical parameters from experimental data. . . . The English-language texts closest to Pugachev's in spirit and content are those of Laning and Battin, and of Y. W. Lee. . . .

TIME STATISTICS OF NOISE
W. M. Brown, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 137/144.

. . . measurements on a noise are usually time averages of the signals . . . called time statistics.

PROBABILITY & INFORMATION (Monographies Dunod, No. 20) (In French)
A. M. Yaglom & I. M. Yaglom, Paris 6, France, Dunod, 1959, 175 p.

INFORMATION THEORY AND STATISTICS
S. Kullback, New York, John Wiley & Sons, Inc., 1959, 395 p.

PROBABILITY THEORY IN TELEPHONE TRANSMISSION
B. B. Jacobsen, Elect. Commun., vol. 35, no. 4, 1959, p. 266/268.

Telephone switching problems . . . long-distance telephone transmission . . .

TIME SERIES ANALYSIS
E. J. Hannan, New York, John Wiley & Sons, Inc., 1960, 152 p.

. . . an introduction to the statistical analysis of stationary second-order time series in discrete time. . . .

MODERN PROBABILITY THEORY AND ITS APPLICATIONS
E. Parzen, New York, John Wiley & Sons, Inc., 1960, 464 p.

ON COMMUNICATION PROCESSES INVOLVING LEARNING AND RANDOM DURATION
R. Bellman, et al., Rand Corp., Santa Monica, Calif., rept. P-1194, 23 Jan. 1958, AD 244 750.

. . . problems within the framework of multistage processes of stochastic type, and as such may be treated by the theory of dynamic programming. . . . how to treat communication problems involving the use of a channel whose statistical properties are not completely known

. . . to show how quite general processes can be treated in unitary fashion by the functional equation technique of dynamic programming.

THEORY OF RANDOM PROCESSES AND ITS APPLICATION IN RADIO ENGINEERING (In Russian) (Second Edition)
B. R. Levin, Moscow, Izd. Sovestskoye Radio, 1960, 664 p.

. . . minimum required information from probability theory . . . examples from radio engineering which illustrates the application of methods of probability theory in solving a number specific radio engineering problems. . . .

PROCEEDINGS OF THE FOURTH BERKELEY SYMPOSIUM ON MATHEMATICAL STATISTICS AND PROBABILITY, VOLUME I: THEORY OF STATISTICS
J. Neyman (editor), Univ. of California Press, 1961, 767 p.

AUTOCORRELATION AND SPECTRAL ANALYSIS (IN: Mathematical Methods for Digital Computers, A. Ralston and H. Wils, editors)
R. W. Southworth, New York, John Wiley & Sons, Inc., Sept. 1959, p. 213/221.

SELECTED TOPICS IN THE THEORY OF FLUCTUATIONS IN RADIO ENGINEERING (In Russian.)
R. L. Stratonovich, Moscow, Sovetskoye Radio Press, 1961, 560 p.

Explained . . . is the mathematical apparatus used to investigate fluctuations in different types of equipment. . . . there are analyzed typical cases of the effect of a signal and fluctuation on linear and nonlinear systems. There is considered the effect of a signal and noise on a radio receiver. . . . analysis of the operation of an oscillator in the presence of fluctuations. Results . . . of an investigation of the noise spikes and their influence on the operation of electronic relays is analyzed. . . . intended for scientific workers, engineers and students . . .

STATISTICAL ANALYSIS AND OPTIMIZATION OF SYSTEMS
E. L. Peterson, New York, John Wiley & Sons, Inc., 1961, 190 p.

. . . theory and methods underlying the analysis, synthesis, and optimization of systems in which statistical uncertainty is involved in the process dynamics. . . . recent work in control systems is reflected throughout this book. . . .

NONLINEAR TRANSFORMATIONS OF RANDOM PROCESSES
R. Deutsch, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1962, 138 p.

. . . few selected topics . . . are as follows: "Envelopes and Pre-Envelopes": Hilbert transforms and application. "Characteristic Function Method": "Correlation Function Method" : "Multiplication and Power Law Devices": "Modulation and Detection": "Sampling Theorem" . . .

ZEITSCHRIFT FUR WAHRSCHEINLICHKEITS-THEORIE UND VERWANDTE GEBIETE (Journal of Probability Theory and Related Arts) (In German.)
L. Schmetterer (editor), Berlin, Springer-Verlag, 1962.

SOME STATISTICAL THEORY FOR THE ANALYSIS OF RADIO PROPAGATION DATA
M. M. Siddiqui, J. Res. Nat. Bur. Stand., vol. 66D, no. 5, Sept.-Oct. 1962, p. 571/580.

The statistical theory of stationary processes has wide applications in the analysis of radio-wave propagation data. Assuming knowledge of the basic concepts of probability theory, characteristics of stationary processes such as covariance and spectral density functions were developed, problems of estimating these characteristics were tackled, and numerous examples were worked out to illustrate the theory.

NOISE AND RANDOM PROCESSES
J. R. Ragazzini, et al., Proc. IRE, vol. 50, May 1962, p. 1146/1151.

THE THEORY OF PROBABILITY (Second Edition)
B. V. Gnedenko, New York, Chelsea, 1962, 459 p.

Gnedenko's book . . . translated into English.

. . . the variety of topics treated is quite different from that of any competitor, and it should prove very useful.

AN INTRODUCTION TO THE THEORY OF STATIONARY RANDOM FUNCTIONS
A. M. Yaglom, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1962, 235 p.

. . . translation is remarkably lucid and readable, and the original work has been further enhanced by an expanded bibliography, numerous explanatory footnotes, and special Appendices written for the English edition. The original version of this book was published a decade ago as a long review article in the Russian journal Uspekhi Mathematicheskikh Nauk (vol. 7, no. 5; 1952). . . . Revised English edition translated and edited by R. A. Silverman.

OPTIMIZING STATISTICAL ANALYSIS: DATA SCREENING AND PRECONDITIONING
A. J. Scott, Northwestern Univ., Evanston, Ill., Feb. 1964, 47 p., AD 433 551.

LECTURES ON ELEMENTARY STATISTICS AND PROBABILITY
D. J. Hudson, European Organization for Nuclear Research, Geneva, Switzerland, Aug. 15, 1963, 107 p., N64-10153.

. . . Presented in the classical way . . . Some statistical concepts are introduced which form the basis of the more advanced science of statistical inference.

RANDOM PROCESSES IN COMMUNICATION ENGINEERING (IN: Symposium on Engineering Applications of Random Function Theory and Probability, First, Proceedings.)
D. Slepian, New York, John Wiley & Sons, Inc., 1963, p. 389/421, 14 refs., A63-14772.

Survey history of the art of designing and constructing electrical communication systems, showing the mutual relationship between probability theory and communication engineering and their concurrent development. This interrelationship is illustrated in the fields of traffic problems, the interaction of signals and noise, signal statistics, and noise theory.

OUTLINE OF AN ALGEBRA OF STOCHASTIC QUALITIES
W. Weibull, Sweden, (ASD TDR 63-63), Jan. 1963, 57 p., AD 298 991.

THEORY OF RANDOM FUNCTIONS WITH APPLICATION TO NOISE IN RADIO RECEIVERS. (IN: Symposium on Engineering Applications of Random Function Theory and Probability, First, Proceedings.)
A. J. F. Siegert, New York, John Wiley & Sons, Inc., 1963, p. 68/87, 14 refs., A63-14766.

Introduction to some of the concepts and methods of random function theory. The mathematical treatment is heuristic using probability densities rather than distribution functions. Application to a class of problems arising in the theory of noise is used to introduce a mathematical description of random functions, and to show the motivation for the definition of special types, such as Gaussian and Markovian random functions.

STATISTICAL COMPUTATION AND STATISTICAL AUTOMATA
G. Pask, Systems Research Ltd., London, 1963, 18 p., AD 408 196.

RANDOM PROCESSES IN CONTROL AND COMMUNICATIONS
R. F. Drenick, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 4, Oct. 1963, p 275/280.

. . . surveys the main results of information theory, and of related theories. . . . written originally for the audience of Science. . . . reprinted here at the suggestion of the Editor of these Transactions, in the hope that it will be diverting, and perhaps also instructive, to an audience of engineers. . . .

A NOTE ON POWER-LAW DEVICES AND THEIR EFFECT ON SIGNAL-TO-NOISE RATIO
C. N. Berglund, Queen's U., Belfast, Gt. Brit., Research rept. no. 62-3, Aug. 1962, 21 p., 5 refs., AD 291 427.

. . . results are general, applying to Gaussian and non-Gaussian noises and modulated and unmodulated signals, and allow important conclusions to be reached concerning the value of power-law devices in communication systems in various signal and noise environments. . . .

WAHRSCHEINLICHKEITSTHEORIE (Probability Theory) (In German.)
K. Krickeberg, Stuttgart, B.G. Teubner Verlag., 1963, 200 p.

PROBABILITY ANALYSIS OF AUTOMATIC CONTROL SYSTEMS, (Probability and Statistical Characteristics of Actuations and Processes. Linear Stationary and Nonstationary Systems.) (In Russian.)
N. A. Livshits and V. N. Pugachev, Moscow, Sovetskoye Radio, vol. 1, 1963, 896 p.

Related Publications:

RECOGNITION OF MEMBERSHIP IN CLASSES
G.S. Sebestyen, IRE Trans. Inform. Th., vol. IT7, no. 1, Jan. 1961, p. 44/50.

. . . A geometrical approach is taken where membership in classes is regarded measurable by metrics with which a set of points, representing different members of the same class, may be brought "close" to one another. For the case where classes are Gaussian processes, the method described herein and that of decision theory are found to agree. A practical application of the method to the automatically "learned" recognition of spoken numerals is described.

ARITHMETIC SIMULATION OF RANDOM PROCESSES
A. G. Postnikov, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, FTD TT 62 1367, 4 June 1963, 98 p., AD 414 717.

THE FUNCTION SPACE POINT OF VIEW IN TIME SERIES ANALYSIS
E. Parzen, Applied Mathematics and Statistics Labs., Stanford U., Calif., 29 March 1963, 37 p., AD 404 896.

THE HEURISTICS OF DATA TRANSFORMATION
H. E. Reinhardt, Mathematics Research Center, U. of Wisconsin, Madison, MRC tech. summary rept. no. 355, Feb. 1963, 15 p., 9 refs., AD 401 543.

1.111: Fundamentals of Random Processes

Included: Zero-crossing problem in general; Minimal variance estimates; Matrix pseudo inverse; Theory of inverse moments; Inverse characteristic function; Constrained randomization; Axis crossing intervals; Nonlinear transformations of random processes; Band-limited processes in general; Price's theorem; Stationary random processes; Fundamentals of correlation processes.

Not Included: Random parameters in control processes.

Cross References: Zero-crossing problems of Gaussian processes (1.112); Cross-correlation and auto-correlation of random signal functions (1.210); Band-limited Gaussian noise (1.714); Non-stationary random processes (1.114); Stochastic processes in general (1.114); Experimental evaluation of correlation characteristics (1.119).

Principal Publications:

THE AXIS-CROSSING INTERVALS OF RANDOM FUNCTIONS—II
J. A. McFadden, IRE Transactions Inform. Th., vol. IT-4, no. 1, March 1958, p. 14/24.

TRANSFORM-ENSEMBLE METHOD FOR ANALYSIS OF LINEAR AND NONLINEAR SYSTEMS WITH RANDOM INPUTS
Y. H. Ku, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 441/455.

. . . presents a general transform-ensemble method for a systematic analysis of physical systems with random inputs. The concept of the transform of an ensemble average is introduced. It is shown that for a certain class of linear and nonlinear systems with continuous random response there exists a corresponding class of linear and nonlinear random-walk problems.

It is shown that it is possible with the proper transform to map a random process in one domain into a simpler random process in another domain to permit an easier solution of the problem. It is now possible to obtain solutions of stationary random processes and corresponding solutions of non-stationary random processes. The philosophy and proof of the transform of statistical quantities is given as a theorem and illustrated with a number of examples.

MINIMUM COEFFICIENT RATE FOR STATIONARY RANDOM PROCESSES
L. L. Campbell, Inform. Control, vol. 3, no. 4, December 1960, p. 260/371.

ZERO-CROSSING DISTRIBUTION OF STATIONARY RANDOM SIGNALS
H. Debart, Cables & Transmission, vol. 14, no. 3, July 1960, p. 190/199.

OPTIMUM INTERVAL APPROXIMATION IN TIME DOMAIN (CORRESPONDENCE)
S. K. Mullick, IRE Trans. Circuit Theory, vol. CT-9, no. 3, Sept. 1961, p. 369/371.

A METRIC SPACE OF DISCRETE PROBABILITY DISTRIBUTIONS
C. Rajski, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 371/377.

A functional defined by means of entropy is considered. It is shown that it is a distance in the set of discrete probability distributions. . . .

ON THE DETERMINATION OF THE NUMBER OF SAMPLINGS AND THE APPROXIMATE FUNCTION FOR STATIONARY RANDOM PROCESSES
N. L. Sosenskiy, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 4/12.

By using the linear interpolation theory of stationary random processes, we will solve the problem of determination of the number of samplings that are necessary to approximate a stationary random process to a given degree of accuracy. . . .

ASYMPTOTIC EIGENFUNCTIONS AND EIGENVALUES OF A HOMOGENEOUS INTEGRAL EQUATION
J. Capon, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 2/4.

. . . of importance in the Karhunen-Loeve expansion of second-order stationary random functions. . . . for the case where the kernel is the Fourier transform of a rational function of ω^2. . . .

THE REPRESENTATION OF NARROW-BAND PROCESSES (CORRESPONDENCE)
M. Zakai, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 323/325.

The definition and properties of this representation are usually derived by the method originally used by Rice, namely through the Fourier series representation of noise currents. The purpose of this note is to derive representation (1) directly from the notion of analytic signals and to derive some properties of this representation. . . .

THE MATRIX PSEUDOINVERSE AND MINIMAL VARIANCE ESTIMATES
C. M. Price, Aerospace Corp., Los Angeles, Calif., TDR169 3550 01TN2, SSD TDR 63 92, 25 March 1963, 14 p., AD 405 938.

. . . The first section reviews and extends certain known results concerning the matrix pseudoinverse . . . The second section uses . . . a generalized version of the Gauss-Markoff Theorem concerning unbiased linear estimates having minimal variance. In the third section . . . theoretical foundation for parameter estimation in orbit determination work . . .

BOUNDS FOR DISTRIBUTIONS WITH MONOTONE HAZARD RATE
R. E. Barlow, et al., Boeing Scientific Research Labs., Seattle, Wash., D1 82 0247; MN 292, May 1963, 77 p., AD 406 763.

POWER SPECTRA AND THEIR ESTIMATION, WITH PARTICULAR REFERENCE TO DISCRETE TIME SERIES HAVING AN UNKNOWN TREND
H. H. Evans, Weapons Research Establishment, Australia, Tech. note SAD-110, Feb. 1963, 35 p., 15 refs., N63-17449.
. . . a technique is evolved for estimating the spectrum of noise superimposed on an imperfectly known trend. . . .

SOME ASPECTS OF CONSTRAINED RANDOMIZATION
G. J. Sutter, et al., Iowa State U., Iowa City, Interim technical rept., Jan. 1963, 30 p., AD 402 644.

ZERO-CROSSING INTERVALS OF RANDOM PROCESSES
A. J. Rainal, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., Technical rept. no. AF-102, April 1963, 41 refs., AD 401 148.
. . . Probabilities and probability densities defined by the zero-crossing points of various Gaussian processes are presented. . . . sine wave plus a Gaussian process . . . correlation coefficients for two successive intervals are presented. The first moments associated with the probability densities are compared with the exact theoretical values.

ON THE LENGTHS OF INTERVALS IN A STATIONARY POINT PROCESS
J. A. McFadden, Journal of the Royal Statistical Society, Series B (Methodological), 24:2, 1962, p. 364/382.
. . . Two different random variables are introduced for the lengths of intervals, according to whether the measurement is made from an arbitrary event or beginning at an arbitrary time, and their properties are compared. . . .

THEORY OF INVERSE MOMENTS
Z. Govindarajulu, Case Inst. of Tech., Cleveland, Ohio, Publication no. 1066, Sept. 1962, 24 p., AD 410 087.
The characteristic function for inverse moments called the inverse characteristic function (inverse c.f.) is defined. Liafounov's inequality for inverse moments is obtained . . .

STATISTICAL DERIVATIONS OF COMPARISON CORRELATION FUNCTION (Correspondence)
R.I. Levine, et al., Proc. IEEE, vol. 51, no. 4, April 1963, p. 624/625.

INDUCTIVE PROBABILITY FROM A CLASSICAL POINT OF VIEW (Correspondence)
B. Harris, Proc. IEEE, vol. 51, no. 3, March 1963, p. 476/477.
. . . Carnap's extension of Laplace's law of succession. . . . there are no strong theorems which indicate that this measure is basic. Instead there are peripheral results which show that this measure in intuitively satisfying. . . .

MEAN NUMBER OF CROSSINGS IN AN N-THRESHOLD CIRCUIT
Y. A. Kashin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 10, Oct. 1963, p. 8/13.

The problem of determining the probability density of the simultaneous crossings of a set of n-fluctuating processes with respect to n-thresholds is formulated and solved. . . . Examples of the mean number of crossings in single-threshold and two-threshold systems for correlated and noncorrelated noise are given.

APPROXIMATE DETERMINATION OF THE DISTRIBUTION FUNCTION OF FADE LENGTHS BELOW THRESHOLD LEVEL FOR THE ENVELOPE OF THE SUM OF A DETERMINISTIC SIGNAL AND GAUSSIAN STATIONARY NOISE.
B. R. Levin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 20/26.

The distribution function of the axis-crossing intervals for the envelope of the sum of a sinusoidal signal and Gaussian noise by the first-approximation curve for noise alone when the intervals are small and by an exponential curve when the intervals are too large is approximated. . . . compared with known experimental data as well as with Rice's approximation method. . . .

THE ZERO-CROSSING PROBLEM
H. Levenbach, Queensland U., Australia, Sept. 1963, 103 p., AD 431 144.

An expository survey of the zero-crossing problem is presented. . . . At present none of the probabilities or probability densities can be derived explicitly by analytical means. . . . to demonstrate the complexity of the problem . . . applied to the case of the Gaussian processes.

. . . Finally, a complete list of the mathematical, physical, and engineering references is compiled, including those of closely related topics.

THE REPRESENTATION OF A CLASS OF TWO STATE STATIONARY PROCESSES IN TERMS OF INDEPENDENT RANDOM VARIABLES
M. Rosenblatt, Brown U., Div. of Applied Mathematics, Providence, R.I., Technical rept. no. 9, March 1963, 17 p., AD 400 729.

ANALYSIS OF A STRUCTURE WITH A RANDOM GEOMETRY
J. L. Sanders, Jr., Harvard U., Div. of Engineering and Applied Physics, Cambridge, Mass., Tech. rept. 16, April 1963, 11 p., N63-17763.

A theoretical one-dimensional structure with a random geometry is analyzed to outline the problem of determining properties of physical random structures . . .

ON STATIONARITY CONDITIONS FOR A CERTAIN PERIODIC RANDOM PROCESS

F. J. Beutler, J. Math. Anal. Appl., vol. 3, no. 1, Aug. 1961, p. 25, 36 refs., N64-15840.

A study was made of the statistical analysis of a periodic signal x(t) accompanied by additive noise (t) (assumed stationary and independent of x(t)).

A NEW METHOD IN THE PROBABILITY THEORY OF NUMBERS (In Russian.)

E. V. Novoselov, Akademiia Nauk SSSR, Izvestiia, Seriia Matematicheskaia, vol. 28, March-April 1964, p. 307/364, 40 refs., A64-17122.

. . . theory of approximating the arithmetic functions by the periodic ones. It is stated that this theory not only belongs organically to the polyadic analysis, developed earlier by the author, but it can also be formulated both in theoretical-numerical and probability terms. The theory makes it possible to obtain in a new way a great number of the known results from the theory of numbers, together with the new ones.

ESTIMATES OF THE BISPECTRUM OF STATIONARY RANDOM PROCESSES

M. Rosenblatt, et al., Brown Univ., Providence, R.I., Div. of Applied Mathematics, Rept. no. TR11, March 1964, 83 p., AD 436 818.

Recently interest has arisen in applications of higher order spectra and in particular in the bispectrum. Various nonlinear effects in random phenomena are studied. . . .

A METHOD FOR THE IDENTIFICATION OF STATIONARY LINEAR SYSTEMS AND RANDOM SEQUENCES.

Y. Ho, Cruft Lab., Harvard Univ., Cambridge, Mass., Rept. no. TR411, 30 April 1963, 14 p., AD 423 280.

A class of recursive schemes was proposed previously for the identification of general linear stationary system. The purpose is to explore, in greater detail, the properties of this class of identification methods and to fill in some of the omitted proofs in the earlier note.

CERTAIN PROPERTIES OF RANDOM PULSE PROCESSES (Translation.)

Y. I. Khurgin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, FTD TT62 1147, 8 Oct. 1963, 9 p., AD 423 603.

Descriptors: (*Noise (Radio), Statistical distributions), (*Probability, . . . Analysis of variance).

CUMULANT TRANSFORMATION AND ITS POSSIBLE APPLICATIONS IN THE INVESTIGATION OF DYNAMIC SYSTEMS (In Russian.)

A. M. Tsirlin, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Nov.-Dec. 1963, p. 93/100, A64-14242.

Discussion of an integral transform whereby a convolution of initial functions appears as a sum of the transformed functions. This type of transform is termed cumulant due to its analogy with the relations between moments and cumulants in the distribution law of a random quantity. An analysis of the properties of the cumulant transform shows that it is best suited for the solution of problems usually solved by means of logarithmic frequency characteristics, and yields substantial advantages over the latter technique.

STATISTICAL CHARACTERISTICS OF THE LOGARITHM OF THE ENVELOPE OF A RANDOM PROCESS

L. E. Kopilovich, Radio Engineering and Electronic Physics, March 1963, p. 436/439. A64-10444.

. . . dependence between the statistical characteristics of the logarithm of the envelope of a random process and the envelope itself, or its square, the power.

INFORMATION AND INFORMATION STABILITY OF RANDOM QUANTITIES AND PROCESSES

M. S. Pinsker, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, FTD TT62 956, Aug. 1963, 248 p., AD 420 585.

Contents: . . . Probability Spaces . . . Stationary Random Processes in a Discrete Argument with a Finite Number of States . . . Normally distributed Random Variables and Processes— . . . Gaussian Random Processes . . .

THE STUDY OF CORRELATED RANDOM VALUES

G. A. Stepan'yants, Air Force Systems Command, Wright-Patterson AFB, Ohio

Foreign Technology Div., 13 Nov. 1962, 8 p., Transl. into English from Vopr. Avtomat. Regulir., Dvizhushchikhsya Ob'yektov (Moscow), Issue 139, 1961, p. 129/133, AD 292 609, N64-16056.

. . . characteristics, other than the coefficient of correlation, that can determine the relationship between random values. It was concluded that the parity coefficient and the parity function can be used to describe the relationship between two random values, and also to study the nature of a random process.

AN EXTENSION OF PRICE'S THEOREM (Correspondence)

E. L. McMahon, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, 168 p.

AN ESTIMATE OF THE VARIATION OF A BAND-LIMITED PROCESS

A. Papoulis, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 72/74.

Upper and lower bounds are established for the mean-square variation of a stationary process X(t) whose power spectrum is bounded by w_c, in terms of its average power P_0 and the average power P_1 of its derivative. . . .

ZERO CROSSINGS, PEAKS AND OTHER STATISTICAL MEASURES OF RANDOM RESPONSES
S. H. Crandall, Massachusetts Inst. of Tech., Cambridge, 1963, 7 p., AD 432 558, N63-20104.

Several statistical properties of a stationary random process that are of interest in random vibration applications are reviewed. In the first three sections, the zero crossings, threshold crossings, distribution of peaks, and a simple model of fatigue damage are obtained directly from calculations. . . .

Related Publications:

FLUCTUATIONS OF RANDOM NOISE POWER
D. Slepian, Bell Syst. Tech. J., vol. 37, no. 1, Jan. 1958, p. 163.

The probability distribution of the power, y, of a sample of Gaussian noise of time duration T is considered. Some general theory is presented along with curves for the cumulative distribution and probability density of y for several different power spectra and values of T.

LOSS AND RECOVERY OF INFORMATION BY COARSE OBSERVATION OF STOCHASTIC CHAIN
S. Watanabe, et al., Inform. Control, vol. 3, no. 3, Sept. 1960, p. 248/278.

. . . Loss of information caused by the coarseness of the definition of microstates can be recovered, partially or totally depending on the case, when there is correlation in the chain. The range of correlation in some cases is increased by the coarse definition of states, thus creating a longer "after effect." If the correlation is weak, this after effect tapers off exponentially with time. . . .

A NOTE ON THE CHARACTERIZATION OF OPTIMAL PROCESSES (Correspondence)
F. Tung, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 56/57.

In a recent paper, Balakrishnan presented the first results to the problem of optimum filtering in which he seeks to characterize the class of processes for which the optimal mean square operator is of specified form. . . . It is interesting to note that . . . the following theorem can be derived. . . .

SIGNALS, SCATTERERS, AND STATISTICS
V. Twersky, IEEE Trans. Antennas and Propagation, vol. AP-11, Nov. 1963, p. 668/680, 22 refs.

Study of an ensemble of complex numbers, such as a set of signals in time and the field scattered by different configurations of scatterers . . . considered are: (1) the average total intensity, the coherent intensity, and the incoherent intensity; (2) the coherent phase, average phase, and average-square phase; and (3) the variance of the real and imaginary components of the ensemble and their covariance, as well as the higher moments. . . .

DISTRIBUTION LAWS OF THE ENVELOPE OF RANDOM PROCESSES WITH A MAXIMUM ENTROPY (In Russian)
L. E. Kopilovich, Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 339/346.

Study of the distribution laws of the envelope of radio signals with a maximum entropy, using the method proposed by Shannon. It is shown that certain known distribution laws of the envelope can be obtained as solutions of the special isoperimetric problem—i.e., as distributions with a maximum entropy in the presence of definite limitations on the random processes.

1.112: Gaussian Random Processes

Included: Multivariate normal distribution; Normal stationary processes; Zero-crossing problems of Gaussian processes; Complex Gaussian random processes; Normal distributions; One-sided barrier problem; Bivariate normal distribution.

Not Included: Detection problems in Gaussian noise (2); Decision theory for signals in Gaussian noise (2); Physical fundamentals of Gaussian noise; Generators for Gaussian noise, Gaussian processes in control systems.

Cross References: Gaussian noise and its characteristics (Sect. 1.71); Zero-crossing problems in general (1.111); Statistics of signal plus Gaussian noise (1.716).

Principal Publications:

MATHEMATICAL ANALYSIS OF RANDOM NOISE
S. O. Rice, Bell Syst. Techn. J., vol. 23, July 1944, p. 282/332 and vol. 24, Jan. 1945, p. 46/158.

A METHOD OF COMPUTING BIVARIATE NORMAL PROBABILITIES (With an Application to Handling Errors in Testing and Measuring)
D. B. Owen, et. al., Bell Syst. Techn. J., vol. 38, no. 2, March 1959, p. 553/572.

Charts and formulas are presented from which bivariate normal probabilities may be computed.

ON THE CHARACTERISTIC FUNCTION OF A STATIONARY RANDOM PROCESS WITH GAUSSIAN ENVELOPE (Correspondence)
R. Esposito, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1997.

. . . two recent letters to the editor by Bunkin and Gudzenko . . .

ZERO-CROSSING INTERVALS OF GAUSSIAN PROCESSES
A. J. Rainal, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 372/378.

THE ONE-SIDED BARRIER PROBLEM FOR GAUSSIAN NOISE
D. Slepian, Bell Syst. Techn. J., vol. 41, no. 2, March 1962, p. 463/501.

This paper is concerned with the probability, P [T, r( )], that a stationary Gaussian process with mean zero and covariance function r ( ) be nonnegative throughout a given interval . . . upper and lower bounds . . . comparison theorems . . . probability distribution for the interval between two successive zeros of the process. (Very good bibliography.)

NORMAL DISTRIBUTIONS (Correspondence)
A. Papoulis, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1049.

. . . There exist uncorrelated rv X and Y with non-normal marginal and joint distributions but such that their sum X + Y is normal . . .

ASYMPTOTIC THEORY FOR PRINCIPAL COMPONENT ANALYSIS
T. W. Anderson, Columbia U., New York, 19 July 1962, 27 p., AD 404 962.

The asymptotic distribution of the characteristic roots and (normalized) vectors of a sample covariance matrix is given when the observations are from a multivariate normal distribution whose covariance matrix has characteristic roots of arbitrary multiplicity. Tests of hypotheses of equality of population roots . . . confidence intervals for assumed equal roots.

A CENTRAL LIMIT THEORY FOR NON-LINEAR FUNCTIONS OF A NORMAL STATIONARY PROCESS
T. Sun, Brown U., Div. of Applied Mathematics, Providence, R.I., Technical rept. no. 8, Jan. 1963, 62 p., 7 refs., AD 297 217.

FACTORS FOR ONE-SIDED TOLERANCE LIMITS AND FOR VARIABLES SAMPLING PLANS
D. B. Owen, Sandia Corp., Albuquerque, N. Mex., SCR-607; supersedes SCR-13, March 1963, 406 p., 82 refs., N63-16782.

Tables are given of a quantity k which is used to define single-sample variables sampling plans and one-sided tolerance limits for a normal distribution. . . .

CONDITIONAL MEANS AND COVARIANCES OF NORMAL VARIABLES WITH SINGULAR COVARIANCE MATRIX
G. Marsaglia, Boeing Scientific Research Labs., Seattle, Wash., Rept. no. D1-82-0235, Feb. 1963, 3 p., AD 299 080.

EXPRESSING THE NORMAL DISTRIBUTION WITH COVARIANCE MATRIX A+B IN TERMS OF ONE WITH COVARIANCE MATRIX A.
G. Marsaglia, Boeing Scientific Research Labs., Seattle, Wash., Rept. no. D1-82-0234; Mathematical note no. 287, Feb. 1963, 6 p., AD 299 120.

ASYMPTOTIC DISTRIBUTION OF FUNCTIONS OF A NORMAL RANDOM VARIABLE
N. C. Severo, et al., Buffalo U., New York, ARL 62-468, Dec. 1963, 29 p., AD 299 064.

THE NORMAL BIVARIATE DENSITY FUNCTION AND ITS APPLICATIONS TO WEAPON SYSTEMS ANALYSIS, A REVIEW
H. C. Sebring, General Electric Co., Philadelphia, Pa., 10 April 1962, 27 p., AD 412 332.

. . . It is discussed in terms of probability area in a plane, and as a correlation surface. Several numerical methods of solving the normal bivariate distribution double integral are presented, and a curve is included for converting elliptical error distributions to circular probable errors. Regression and correlation coefficients are discussed. . . .

TABLES FOR THE INTEGRAL OF THE CIRCULAR BIVARIATE NORMAL FREQUENCY FUNCTION
W. L. Weaver, et al., NASA, Langley Research Center, Langley Station, Va., NASA TN D-1819, July 1963, 38 p., 7 refs., N63-18160.

The evaluation of the integral was performed numerically by using the quadrature formulas of Gauss.

COVARIANCE MATRIX APPROXIMATION
L. B. Schlegel, AIAA Journal, vol. 1, Nov. 1963, p. 2672, 2673, A63-25735.

. . . The determinant of the covariance matrix of a trivariate normal distribution is a figure of merit which relates to error volumes in tracking and prediction problems. In computing this determinant, neglect of the covariance elements leads to pessimistic estimates of system accuracy, hence is a safe approximation for preliminary analysis. . . .

PERIODOGRAM FOR COMPLEX GAUSSIAN RANDOM PROCESSES (Correspondence)
C. L. Mehta, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 165.

COMPARISON OF A FIXED SAMPLE SIZE AND A SEQUENTIAL TEST FOR THE MEAN OF A NORMAL DISTRIBUTION WITH KNOWN VARIANCE
E. H. Baur, Aerojet-General Corp., Sacramento, Calif., Rept. no. 9200 5 64, 5 Feb. 1964, 11 p., AD 434 415.

THE ZERO-CROSSING PROBLEM
H. Levenbach, Queen's U., Kingston, Canada, Res. rept. 63-4, Sept. 1963, 116 p., N64-16943.

. . . expository survey of the zero-crossing problem is presented . . . concerned with the probabilities and probability densities defined by the zero-crossing points of a stationary random process. At present none of the probabilities or probability densities can be derived explicitly by analytical means . . . applied to the case of the gaussian processes . . . comparing the empirical and theoretical results. Finally, a complete list of the mathematical, physical, and engineering references is compiled, including those of closely related topics.

Related Publications:

HORNS ON A SIGNAL-NOISE WAVE (in Russian.)
V. I. Tikhonov, Radiotekhnika i Elektronika, vol. 8, Nov. 1963, p. 1803/1811, 10 refs., A64-12028.

. . . formulas for the mean number of "horns" per unit time of a wave composed of normal steady noise and a signal. . . . considers two types of signals: a signal in the form of normal quasi-harmonic (narrow-band) noise, and a harmonic signal. . . . several numerical examples. . . .

ERROR OF THE GAUSSIAN APPROXIMATION (Correspondence)
D. Silber, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1259.

By the Central Limit Theorem, the probability density function of the sum of a number of independent random variables having arbitrary (within the validity of the Central Limit Theorem) probability densities approaches a Gaussian density as the number of added random variables becomes large. An assumed Gaussian density for the sum of a finite number of random variables will have an error that decreases (assuming the same probability density for each added random variable) as the number of added variables increases . . . there is little information in the literature on evaluation of the error. In particular, information concerning the error of the "tails" (of interest in finding the probability of false alarm) is lacking. Following is an evaluation of this error for rectangular individual densities, carried out with the aid of a digital computer. . . .

APPROXIMATE CALCULATION OF THE DISTRIBUTION FUNCTION OF A NORMAL PROCESS AT THE OUTPUT OF A TYPICAL RADIO SECTION
V. S. Borodin, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 1/6.

. . . A typical section consists of the first RC filter, the square-law detector and the second RC filter. A comparison of two methods of calculating the cumulants of distribution is given. . . .

1.113: Markov Processes

Included: Discrete time Markov processes in general; Markov chains; Markov envelope processes; Semi-Markov processes; Wide sense Markov processes.

Not Included: Automata and switching processes; Coding theory (2).

Principal Publications:

FURTHER COMMENTS ON "A MARKOFF ENVELOPE PROCESS" (Correspondence)
C. T. Isley, et al., IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 186/188.

ELEMENTS OF THE THEORY OF MARKOV PROCESSES AND THEIR APPLICATIONS
A. T. Bharucha-Reid, New York, McGraw-Hill Book Co., Inc., 1960, 468 p.

PREDICTION FOR WIDE-SENSE MARKOV PROCESSES (Correspondence)
F. J. Beutler, IRE Trans. on Inf. Theory, vol. IT-7, no. 4, Oct. 1961, p. 267/269.

. . . minimum-mean-square linear estimator . . . solution of a generalized Wiener-Hopf equation. . . . nonrealizable time-varying weighting function . . .

THE PASSAGE PROBLEM FOR A STATIONARY MARKOV CHAIN
J. H. Kemperman, Statistical Research Monographs, Univ. of Chicago Press, vol. 1, 1961, 127 p.

ON THE GENERATION OF MARKOV CHAINS
J. F. Ormsby, Electronics Research Lab., U. of Calif., Berkeley, 29 Aug. 1962, 34 p., S60 I480, AD 408 452.

MULTIVARIATE WIDE-SENSE MARKOV PROCESSES AND PREDICTION THEORY
F. J. Beutler, Repr. from Ann. Math. Statistics, vol. 34, no. 2, June 1963, p. 424/438, 7 refs., N63-19978.

. . . (MWM processes) . . . only the stationary multivariate gaussian Markov process appears to have been studied. Analysis of this process has centered on its second-order properties, the gaussian density function serving as a principal tool. The same second-order properties hold for any MWM, and these depend on the covariance matrix. . . . The most significant application of MWM processes is to the theory of linear minimum mean square error prediction of multivariate stochastic processes. . . .

A GENERALIZATION OF A MARKOFF ENVELOPE PROCESS (Correspondence)
R. Esposito, Proc. IEEE, vol. 51, no. 12, Dec. 1963, p. 1792.

. . . known that the envelope of the output of a high-Q single tuned RLC filter is a first-order Markoff process when the filter input is white Gaussian noise. The purpose of this communication is to show that the same result holds true for the perturbation of the envelope of a steady oscillation supported by a nonlinear element in parallel with the single tuned circuit driven by a white noise current . . .

SYSTEM ANALYSIS OF SEMI-MARKOV PROCESSES
R. A. Howard, IEEE Trans. Mil. Electronics, vol. MIL-8, no. 2, April 1964, p. 114/124.

Flow graph analysis has proved a valuable approach to the study of probabilistic systems. This paper extends the analytic procedures to semi-Markov processes, Markov processes whose transition times can also be arbitrary random variables. . . .

MARKOV PROCESSES IN COMMUNICATION NETWORKS
W. S. Litchman, et al., IEEE Trans. Commun. Electronics, vol. CE, no. 67, July 1963, p. 404/408.

. . . designing a system of nodes interconnected in a pattern by transmission links and then of designing means for controlling movement of messages through the system. Optimum or quasi-optimum methods of message routine.

. . . A useful tool . . . is the theory of Markov processes. This paper illustrates several possible applications of the Markov theory to communication system design.

TRANSIENT SOLUTIONS FOR 3-STATE DISCRETE TIME MARKOV PROCESSES
E. A. Silver, Mass. Inst. of Tech., Cambridge, July 1963, 55 p., AD 417 221, AD 417 151.

Through the combined use of flow graph analysis, geometric transform techniques and the properties of quadratic functions, there are obtained closed form expressions for the transient solution of any time-discrete 3-state Markov process. The results are significantly more complex than in the 2-state case.

1.114: Other Special Random Processes

Included: General stochastic processes; Non-stationary processes; Non-Gaussian processes; Ergodic processes in general.

Cross References: Gaussian processes (1.112); Markov processes (1.113); Fundamentals of random processes (1.111); Special distributions of random processes (1.117).

Principal Publications:

STATISTICS OF REGENERATIVE DIGITAL TRANSMISSION
W. R. Bennett, Bell Syst. Techn. J., vol. 37, no. 6, Nov. 1958, p. 1501/1542.

Statistics of a synchronous binary message pulse train applied to a regenerative repeater are related to those of the original binary message, which is assumed ergodic. It is shown that the ensemble of possible message pulse trains is a nonstationary random process having a periodically varying mean and autocovariance.

NONSTATIONARY VELOCITY ESTIMATION
T. M. Burford, Bell Syst. Techn. J., vol. 37, no. 4, July 1958, p. 1009/1021.

A nonstationary noise may frequently be approximated by the product of a stationary noise and a deterministic function of time.

STOCHASTIC PROCESSES: PROBLEMS AND SOLUTIONS
L. Takacs, New York, John Wiley & Sons, Inc., 1960, 135 p.

. . . one of an excellent series of new monographs on applied probability and statistics. . . . the book is primarily a collection of problems and their solutions and is intended for readers who are already familiar with probability theory. . . .

LINEAR STOCHASTIC OPERATORS
G. Adomian, Hughes Aircraft Co., Culver City, Calif., Aug. 1961, 162 p., Rept. no. RS 278, AD 413 827.

. . . allows the operators as well as the operand to be stochastic. Statistical measures and distributions can be found for the transformed quantity under very general conditions. The effects of a propagation medium or of a physical observation or measurement process can be represented in terms of such stochastic operations allowing a treatment of random inhomogeneous media or of measurement or control processes involving statistically varying parameters. . . . Further, the inverse problem of a stochastic differential equation is studied relating it to the operator formulation to give statistical measures for the dependent variable.

ON ANALYTIC METHODS IN THE THEORY OF PROBABILITY
A. Kolmogoroff, Minneapolis-Honeywell Regulator Co., Minn. Military Products Group, 1960, 50 p., Transl. into English from Math. Ann. (Leipzig), no. 104, 1961, p. 415/458, (MH-Transl. 197), N64-11625.

. . . stochastic process . . . called stochastically-defined, if a deterministic description of the state, X_0, of the physical system at an instant, $t>t_0$, also implies that the distribution function of the probabilities of the possible state, X, of the associated stochastic process is also known at the instant,

t . . . If the set of possible states of the system is finite, the stochastically-defined process can be characterized by a set of linear, ordinary, differential equations. If the possible states of the system are described in terms of one or more continuous parameters, then the analytic description of samples is in terms of solutions of linear, parabolic, differential equations. The solutions of the associated differential equations yield various probability distribution functions, among which Laplace's normal distribution function has the simplest analytic description.

STOCHASTIC SERVICE SYSTEMS
J. Riordan, New York, John Wiley & Sons, Inc., 1962, 139 p.

The term "queueing theory" has been loosely extended in current usage to cover studies of any service facility which has randomness somewhere in its input or service characteristics.

. . . The book roughtly divides its attention between systems with loss and systems with delay.

. . . written for the applied mathematician. . . . It is not an introduction. For reasons of both style and content, it could not be recommended as a good place to begin the study of queueing theory. It contains little descriptive detail, no worked-out guides for application, and no concrete illustrative practical examples. . . .

H. Bunke, Berlin Zeitschrift fur angewandte Mathematik und Mechanik, Jan.-Feb. 1963, p. 63/70, A63-17117.

ON THE SIGNIFICANCE OF INSTANTANEOUS AND SHORT-TERM CORRELATION FUNCTIONS FOR A CLASS OF STOCHASTIC PROCESSES (Correspondence)

A. A. Wolf, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1983.

STOCHASTIC GREEN'S FUNCTIONS

G. Adomian, Hughes Aircraft Co., Culver City, Calif., April 1963, 62 p., Rept. no. TM758, AD 415 761.

With attempts to develop instantaneous adaptive-learning systems a real need has arisen to define clearly the concept of instantaneous correlation functions and their physical realization. Several authors have considered this problem partially. The purpose of this note is to define the notion of instantaneous correlation as a limiting value of short-term correlation and to develop appropriate expressions for such correlation functions in terms of an orthogonal series.

. . . approach to the theory of random equations . . . operator theory is developed which allows the operators as well as the operand to be stochastic. Statistical measures and distributions are found for the transformed function under general conditions . . .

ON THE ASYMPTOTIC DISTRIBUTION OF THE AUTOCORRELATIONS OF A SAMPLE FROM A LINEAR STOCHASTIC PROCESS

T. W. Anderson, et al., Columbia U., New York, N. Y., 1961, 16 p., 9 refs., N64-11940, AD 424 463.

. . . A proof is given of the asymptotic normal distribution of the autocorrelations of a linear process under the assumption of finite second-order moments . . .

SOME ANALYTICAL TECHNIQUES FOR A CLASS OF NON-GAUSSIAN PROCESSES

B. A. Bowen, Queen's U., Kingston, Canada, June 1963, 61 p., Rept. no. RR63 3, AD 428 431.

. . . a study of impulse noise interference in a simple communications receiver model. A review of the cumulant concept is presented, then an impulse model postulated. . . . the cumulants are defined in terms of integrals of functions of the wave shape of the impulse events. . . . A unique presentation is derived to compare the moments of a guassian process to a nongaussian one. It is shown that as the ratio of the equivalent order moments is different from unity, correction terms are generated which change the probability distribution to a nongaussian form. The cumulants are used in conjunction with a transform technique to derive the correlation function of impulse noise or of signal plus noise when a linear filter is followed by a nonlinear device. The results reduce to the known gaussian results as the impulse rate is increased.

STABILITÄT BEI STOCHASTISCHEN SIFFERENTIALGLEICHUNGSSYSTEMEN (The Stability of Stochastic Systems of Differential Equations) (In German)

. . . concepts of (1) mean stability and (2) stability of probability for the equilibrium state of a system of differential equations which depends upon stochastic processes.

ON THE EXPANSION OF ARBITRARY ERGODIC PROCESSES INTO INFINITE SERIES OF ORTHOGONAL COMPONENTS (Correspondence)

T. Fine, Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1673/1675.

DIAGRAMMA DLIA OPREDELENIIA OSHIBKI SREDNEGO ZNACHENIIA I VYBORA VREMENI OSREDNENIIA STATSIONARNOGO SLUCHAINOGO PROTESSA (Diagram for the Determination of the Mean-Square Error and the Selection of the Averaging Time of a Steady Random Process) (In Russian)

V. T. Kondarshikhin, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1414/1415, A64-13225.

Presentation of a diagram for assessing the mean-square error resulting from limitations imposed on the averaging time. The diagram is also suitable for the selection of the averaging time for an ergodic steady random process having a correlation function of typical form.

STOCHASTIC PROGRAMMING

S. M. Sinha, Operations Research Center, Univ. of Calif., Berkeley, Aug. 1963, 63 p., Rept. no. 63 22RR, AD-424 202.

Descriptors: Linear programming, Stochastic processes, Mathematical analysis. . . .

THE REPRESENTATION OF STOCHASTIC PROCESSES BY ORTHOGONAL EXPANSIONS (IN: Joint Automatic Control Conference, 4th, Univ. of Minnesota, Minneapolis, Minn., June 19-21, 1963, Preprints of Technical Papers)

J. B. Thomas, p. 287/291, 37 refs., A64-11196.

Review of types of series used to represent noises or random signals in problems of communications and control theory . . . considered are the Fourier series, the sampling theorem expansion, and the Karhunen-Loeve expansion.

A NEW APPROACH TO THE SPECTRUM ANALYSIS OF NON-STATIONARY SIGNALS (IEEE Winter General Meeting, New York, N. Y., Jan. 27-Feb. 1, 1963, Paper 63-63)

W. W. Wierwille, IEEE Trans. Applications and Industry, Nov. 1963, p. 322-327, 26 refs., A64-12332.

. . . allows proper spectral measurements of time-nonstationary signals. The power spectrum is defined on the basis of ensemble averages and therefore contains a time variation when the signals are nonstationary. It is shown that a spectrum analyzer can be designed which measures these time-varying spectra in a nearly optimum manner. . . .

MEAN ERGODIC THEOREMS AND TESTS FOR A CERTAIN CLASS OF RANDOM PROCESSES (Correspondence)
A. A. Wolf, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 403/404.

With recent advances in the use of stochastic processes as probes in parameter identification (1), (2), fault detection and media characterization (3), a great deal of interest has developed concerning the nature of ergodic processes and simple a priori tests for determining its presence in a stationary random process (4), (5). . . .

ON THE EXPANSION OF ARBITRARY ERGODIC PROCESSES INTO INFINITE SERIES OF ORTHOGONAL COMPONENTS (Correspondence)
A. Wolf, Proc. IEEE, vol. 51, no. 3, March 1963, p. 487/488.

. . . The expansion of deterministic functions into series of terms is conceptually quite important. It would appear that the expansion of random variables into infinite series would be of value physically as well as important mathematically. The purpose of this note is to outline a theory for accomplishing this sort of expansion and to give a physically realizable method for implementing it. . . .

RELATIONS BETWEEN TIME AND ENSEMBLE AVERAGES FOR WEAKLY NONERGODIC RANDOM PROCESSES (Correspondence)
A. A. Wolf, Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1672/1673.

. . . a consequence of ergodicity is that the time and ensemble averages of a stationary random process are equal in some probabilistic sense. Conditions that a certain class of stationary processes be weakly ergodic have been given by Wolf based on the correlation function of the process and by Parzen based on the characteristic function of the process. Others have solved special cases of this particular problem in the weak sense and measure-theoretic ergodicity has been the subject of many investigators . . . For nonergodic processes, however, little has been done either in the measure-theoretic sense or in the probabilistic sense. The purpose of this communication is to present some preliminary results for the relations between time and ensemble averages of weakly nonergodic random processes. . . .

ON CONDITIONS FOR DETERMINING ERGODICITY IN A CLASS OF STATIONARY RANDOM PROCESSES
A. A. Wolf, IEEE Trans. Commun. Electronics, vol. CE, no. 68, Sept. 1963, p. 546/553.

. . . Necessary and sufficient conditions are given for determining that a class of stationary random processes are ergodic in the quadratic mean. The theorems given are wide-sense theorems and refer to relations between temporal averages and probability averages for first-order statistics. This, however, is generally required in engineering applications.

A STUDY OF CORRELATOR BEHAVIOR USING "NON-STATIONARY" SIGNALS. PART II.
Dewey, G. C. & Co., Inc., New York, June 1963, 38 p., R127 1, AD 412 534.

. . . cross-correlation gains of an analog and clipper correlator . . . The signals and noise used in this study we have characterized as being non-stationary. An attempt has been made to compare experimentally determined gains for the case of small signals buried in noise with those predicted theoretically.

1.117: Special Distributions of Random Processes (Tables and Graphs)

Included: Skew distribution functions; Chi-square distributions; Pearson distributions; Exponential distribution; T-distribution; Behrens-Fisher distribution; Practical signal and noise distributions; Second order statistics of special processes; Chi-distribution; Log-normal distributions; Characteristic functions of special processes; Moment descriptions; Multivariate distributions; Rectangular distribution; Nakagamirice distribution; Factorial distributions; Compound and generalized distributions; Contagious distributions; Binomial distribution.

Not Included: Distributions of information sources (2).

Cross References: Normal distributions (1.112); Distributions of pulsive noise (1.717); Distributions of signals plus Gaussian noise (1.716); Distributions of correlated noise (intermodulation) (1.742).

Principal Publications:

THE FLUCTUATION RATE OF THE CHI PROCESS
R. A. Silverman, IRE Trans. Inform. Th. vol. IT-4, March 1958, p. 30/34.

. . . defined as a natural generalization of the chi distribution of statistical theory. A formula is derived, contains as a special case the familiar expression for the fluctuation rate of the envelope of Gaussian noise.

THE SUM OF LOG-NORMAL PROBABILITY DISTRIBUTIONS IN SCATTER TRANSMISSION SYSTEMS
L. F. Fenton, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 57/67.

THE EFFECT OF MIXING TWO NOISY SIGNALS

N. A. Huttly, Marconi Rev., 4th Qtr. 1960, vol. 23, 1960, p. 153/169.

Each signal is taken to be a sine wave with random noise. The signals are multiplied together and the product passed through a bandpass filter with a given impulse response. Integrals are given for the output signal amplitude and for the variance of the noise output. These are evaluated for the particular case where the bandpass filter is a single tuned circuit. Approximate solutions are given for the output signal-to-noise ratio when certain assumptions can be made about the bandwidths and the beat note frequency. . . .

USE OF STATISTICAL MOMENTS FOR SPECIFYING NOISE IN LONG-DISTANCE TELEPHONE CIRCUITS

B. B. Jacobsen, Elect. Commun., vol. 36, no. 3, 1960, p. 197/201.

. . . treats the problem: How should the tolerable noise power on a telephone circuit be expressed? The object is . . . to formulate it in a way that does not place any unnecessary restrictions on noise of any particular time distribution. An important requirement is that it should be realistic and in practice this means that very-intense noise must be accepted, but it must not occur too often or last too long. It has been proposed to specify the permissible amount of noise not by a distribution curve, but instead by its moments. . . . The purpose of the present paper is to consider the effect of specifying the permissible noise by its first three hourly moments. . . .

THE ENERGY SPECTRUM OF AN INDEFINITE INTEGRAL FROM A STATIONARY RANDOM PROCESS

B. R. Levin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 6, 1960, p. 27/30.

An expression is obtained for the instantaneous spectrum of an indefinite integral from a stationary random process. It is shown that the widely used formulas for the energy spectrum of the integral follows from this expression after averaging through time. . . .

CHARACTERISTIC FUNCTIONS

E. Lukacs, New York, Hafner, 1960, 216 p.

. . . a useful compendium of properties of characteristic functions, many of which were only available in French and Russian periodicals . . .

PROBABILITY DENSITY FOR THE DURATION OF FLUCTUATIONS

V. I. Tikhonov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 9, 1960, p. 10/24, 15 refs.

. . . study . . . of three approximate methods of calculating the probability density for the duration of the peaks of normal stationary fluctuations and certain experimental results are given. The field of application of the various methods is shown by comparing the theoretical probability densities with the experimental results.

THE PROBABILITY DISTRIBUTIONS OF THE OUTPUTS OF FIRST ORDER AND TUNED SECOND ORDER FILTERS WITH COIN-TOSS SQUARE WAVE INPUTS

A. R. Cohen, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 371/377.

. . . A method is presented for constructing the probability distribution functions of the outputs of an RC low-pass filter and a tuned second-order filter for coin-toss square wave inputs. The input is a binary process in which axis crossings can occur only on a set of equally spaced sample points . . .

APPROXIMATE BAND-PASS LIMITER ENVELOPE DISTRIBUTIONS

W. Doyle, et al., Rand Corp., Santa Monica, Calif., Feb. 1962, 21 p. incl. illus., 20 refs., Memo. no. RM-2987-PR, AD 274 684.

. . . An approximate distribution is computed for the envelope of sine wave plus noise after passage through a wide-band filter, limiter and narrow-band filter. . . .

TABLES OF THE CUMULATIVE NON-CENTRAL CHI-SQUARE DISTRIBUTION

G. E. Haynam, et al., Case Inst. of Tech., Cleveland, Ohio, Nov. 1962, 89 p., Pub. no. 104, AD 426 500.

ESTIMATION OF THE SECOND-ORDER STATISTICS OF RANDOMLY TIME-VARYING LINEAR SYSTEMS

M. J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 2 Nov. 1962, 42 p. incl. illus., 13 refs., Rept. no. 34G-7, AD 289 607.

. . . by application of a known input signal and observation of the resulting output which may be obscured by additive white noise. The system is characterized by its impulse response correlation function f(tau lambda) and is approximated by a sampled-data model.

TABLES OF BOUNDS FOR DISTRIBUTIONS WITH MONOTONE HAZARD RATE

R. E. Barlow, et al., Boeing Scientific Research Labs., Seattle, Wash., Dec. 1963, 54 p., Document no. D1 82 0249; Mathematical note no. 294, AD 426 831.

. . . presented in a form convenient for applications . . . machine calculation has been necessary . . . Applications of the bounds are discussed together with some numerical examples . . .

SPECTRAL DENSITY AND AUTOCORRELATION FUNCTIONS ASSOCIATED WITH BINARY FREQUENCY-SHIFT KEYING

W. R. Bennett, et al., Bell Syst. Tech. Journal, vol. 42, no. 5, Sept. 1963, p. 2355/2385.

General equations are derived for the spectral density and autocorrelation functions of a wave

train consisting of sine-wave segments with constant amplitude. The frequency of a segment may be either f_1 or f_2 . . . The results fall into two main classes—namely, that of discontinuous phase at the transitions . . . and that of continuous phase at the transitions . . . No restriction is made on the relative magnitudes of the different frequencies involved.

SOME STATISTICAL PARAMETERS RELATED TO THE NAKAGAMI-RICE PROBABILITY DISTRIBUTION.

W. R. Burns, Journal of Research, Section D-Radio Science, vol. 68D, April 1964, p. 429/434, 9 refs., A64-17497.

Presentation of formulas and tables for the mean and standard deviation of $R=20 \log_{10} r$ where the random variable r has the Nakagami-Rice distribution. A simple formula for the mean value of R is obtained in terms of a well-known exponential integral function. Information obtained by Norto concerning the median and interdecile range of R is also presented. This distribution is useful in the investigation of the short-term fading characteristics of certain radio fields.

ON A PROBLEM IN SINGLE-SIDEBAND COMMUNICATIONS

J. Dutka, R.C.A. Rev., vol. 24, no. 3, Sept. 1963, p. 391/405.

. . . A problem in the design of a single-sideband modulation system is considered which reduces to the determination of the distribution function of the sum ot an infinite series of independent random variables. An approximation is obtained in the form of a distribution of a finite sum of independent uniform (but not necessarily equidistributed) random variables which is useful here and for broader classes of problems. Five-decimal-place tables of the original distribution function are computed, and some analytic properties of the distribution function are obtained.

A CHARACTERIZATION OF THE EXPONENTIAL DISTRIBUTION

T. S. Ferguson, California U., Los Angeles, Working paper no. 31, March 1963, 17 p., 6 refs., AD 401 459.

DISTRIBUTION OF OVERSHOOT PERIODS FOR THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE

V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 1/7.

Experimental results are presented showing the average number of overshoots and the distribution of positive or negative overshoot periods in a smoothed envelope comprising the sum of a sinusoidal signal and quasi-sinusoidal noise. The experimental data obtained are compared with results of analytical investigations.

SELECTION AND RANKING PROCEDURES AND ORDER STATISTICS FOR THE BINOMIAL DISTRIBUTION

S. S. Gupta, Applied Mathematics & Statistics Labs., Stanford Univ., Calif., 24 Sept. 1963, 115 p., Technical rept. no. 68, AD 421 011.

Some work on selection and ranking procedures for binomial populations are described. . . . Order statistics from the binomial distribution are discussed and some new tables of moments and cumulative distribution function of these order statistics are described.

SOME FAMILIES OF COMPOUND AND GENERALIZED DISTRIBUTIONS

J. Gurland, Mathematics Research Center, U. of Wisconsin, Madison, Feb. 1963, 29 p., 28 refs., MRC Tech. Summ. rept. no. 380, AD 401 218.

Compound and generalized distributions have been discussed in the framework of contagious distributions. In particular, it is pointed out that the Negative Binomial may be regarded as a compound Poisson (using a Gamma variable as the compounder) or as a generalized Poisson (using a Logarithmic random variable as the generalizer.)

OUTPUT PROBABILITY DISTRIBUTION OF A MULTIPLIER AVERAGER WITH PARTIALLY CORRELATED INPUTS

M. J. Jacobson, Rensselaer Polytechnic Inst., Troy, N. Y., July 1963, 7 p., Rept. no. MATHREP 62, AD 432 656.

This paper studies the problem of determining the probability density function of the filtered output of a multiplier when the crosscorrelation function of the inputs is proportional to the autocorrelation function of the inputs. The two inputs are assumed to consist of identical signal plus uncorrelated noise. It is shown that the solution is known once the solution has been found for pure signal inputs. The general theory is applied to the problem where both inputs have the characteristics of RC-filtered white noise and where the postmultiplier filter is also an RC. . . .

TWO NOTES ON THE LOGNORMAL DISTRIBUTION

M. Kamins, Rand Corp., Santa Monica, Calif., RM-3781-PR, Aug. 1963, 30 p., 16 refs., N63-20750.

DIE STATISTISCHE VERTEILUNG VON AUGENBLICKSWERT UND AMPLITUDE EINER SUMME VON N GLEICH GROREN WECHSELSPANNUNGEN MIT INKOMMENSURABLEN FREQUENZEN (The Statistical Distribution of the Instantaneous Values and the Peak Values of a Sum of N Voltages of Equal Amplitude and Incommensurable Frequencies) (In German).

G. Kraus, et al., Arch. Elekt, Uebertragung, vol. 17, Jan. 1963, p. 6/12.

. . . In proportioning systems for the simultaneous transmission of n equal ac signals of different frequencies (e.g. for VF carrier-telegraphy) it is important to know the probability with which certain given instantaneous values or amplitudes are exceeded by the composite voltage. . . .

STATISTICAL PROPERTIES OF THE INTEGRAL OF A BINARY RANDOM PROCESS
D. G. Lampard, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 413/427, 26 refs.

. . . Statistical properties of the output z(t) of a finite time integrator are discussed. The input process considered is a binary random process y(t) having successive axis-crossing intervals which are statistically independent. Transform expressions are derived for the first- and second-order transition probability densities of the integrated process, and it is shown how these results may be extended to three or more dimensions. Four processes are considered as examples.

NOISE DISTRIBUTION AT THE OUTPUT OF A SYSTEM CONSISTING OF TWO RC-FILTERS AND A SQUARE-LAW STAGE BETWEEN THEM
Y. S. Lezin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 67/68.

NEW TABLES OF THE NONCENTRAL T DISTRIBUTION
M. O. Locks, et al., Rocketdyne, Canoga Park, Calif., Jan. 1963, 463 p., 10 refs., AD 402 373.

. . . probability densities and cumulative probabilities . . .

A FAST PROCEDURE FOR GENERATING EXPONENTIAL RANDOM VARIABLES
M. D. MacLaren, et al., Boeing Scientific Research Labs., Seattle, Wash., Jan. 1963, 9 p. incl. illus., tables, 3 refs. (Mathematical note no. 283; D1-82-0228, AD 297 091.

. . . in a digital computer . . . The method is exact, and in the sense that in theory it returns a random variable with exactly the exponential distribution. In practice the result is an approximation, but the accuracy of the approximation depends only upon the world length of the computer.

FACTORIAL DISTRIBUTIONS
W. H. Marlow, George Washington U., Washington, D. C., Jan. 1964, 13 p., Rept. no. T167, AD 427 802.

. . . A theorem shows that the distributions form a two parameter family. Several corrolaries show that the family is highly tractable, particularly in closed form expressions which exist not only for individual and cumulative probabilities but for various expectations as well . . .

TEST CRITERIA FOR PEARSON TYPE III DISTRIBUTIONS (Final rept.)
M. R. Mickey, et al., CEIR, Inc., Beverly Hills, Calif., June 1963, 108 p., AD 415 831.

RECEPTION OF A PULSE PACKET IN THE PRESENCE OF CORRELATED NOISE
V. F. Nesteruk, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 8/14.

A method of calculating the optimum configuration of a packet of coherent pulses received on a background of correlated noise is described. The optimum configuration of the packet is found for Markov noise.

A distinctive feature in the reception of a finite pulse packet is the fact that noise cannot be assumed to be uncorrelated. As a result, the probability of correct detection of a pulse packet will depend not only on the power level of the packet but also on the shape of the pulses of which the packet consists and on the power distribution over the packet . . .

THE BEHRENS-FISHER DISTRIBUTIONS
V. H. Patil, Michigan U., Coll. of Literature, Science, and The Arts, Ann Arbor, Feb. 1963, 135 p., Technical rept. no. 04597-3-T, AD 298 561.

DESCRIPTORS: Linear systems, Analysis of variance, Density, Distribution theory.

PERCENTAGE POINTS OF THE RATIO OF RANGES OF SAMPLES FROM A RECTANGULAR DISTRIBUTION
P. R. Rider, Aerospace Research Labs., Wright-Patterson AFB, Ohio, Nov. 1963, 17 p., refs., ARL 63-194; AD 426 107, N64-13655.

ON THE ASYMPTOTIC JOINT NORMALITY OF QUANTILES FROM A MULTIVARIATE DISTRIBUTION
L. Weiss, Mathematics Research Center, U. of Wisconsin, Madison, Dec. 1963, 7 p., Technical summary rept. 446, AD 433 877.

A simple proof is given of the asymptotic joint normality of sample quantiles from a multivariate population, under very mild conditions. The joint cumulative distribution function of the quantiles is studied, rather than the joint probability density function.

Related Publications:

THE PROBABILITY DENSITY OF THE OUTPUT OF AN RC FILTER WHEN THE INPUT IS A BINARY RANDOM PROCESS
J. A. McFadden, IRE Transactions Inform. Th., vol. IT-5

PROBLEMS OF INFORMATION TRANSMISSION NO. 5 STATISTICAL CODING
Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1961, 159 p., Trans. no. MCL-894/1 of Akademiya Nauk SSSR Laboratoriya Sistem Peredachi Informatsiy, Moskva, 125 p., 1960, AD 269 612.

. . . measuring the frequency distribution of message elements from various sources and adduces the results . . . in the case of certain sources, carried to the level of 4th-order distributions. In appendices to this collection of

articles there are provided tables of the functions necessary to compute the entropy of discrete distribution.

POWER SPECTRA OF SIGNALS MODULATED BY RANDOM AND PSEUDORANDOM SEQUENCES
R. C. Titsworth, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Oct. 1961, 45 p., Rept. 32-140, AD 268 119.

. . . concerned with the spectral distribution of signals coherently modulated by discrete random and randomlike sequences which change state only at integral multiples of some basic time division t sub 0. In general, a sequence may modulate signals randomly or in some fixed deterministic fashion. Furthermore, deterministic processes may be constructed to possess certain randomlike qualities. Special attention is directed to Markov chains and linear pseudorandom sequences; the signals selected by the modulation process are not restricted to any one class, and examples are given for sinusoids and square waves. Specifically, the effects of carrier-signal waveform and type of sequence upon the over-all power spectrum are considered. In the case of sinusoidal modulation, the effect of phase shift is investigated.

ESTIMATION IN MIXTURES OF DISCRETE DISTRIBUTIONS
A. C. Cohen, Jr., Georgia U., Athens Inst. of Statistics, Aug. 15, 1963, 11 p., refs. Tech. Rept. 12, N63-23426.

Parameters of mixed distributions are estimated using sample moments and sample zero frequencies. Mixtures consisting of two complete Poisson distributions, two truncated Poisson distributions, and a Poisson combined with a binomial distribution are considered.

SOME ELEMENTARY TESTS FOR MIXTURES OF DISCRETE DISTRIBUTION
T. de Oliveira, Columbia U., New York, June 1963, 15 p., AD 405 910.

INFORMATION FOR ESTIMATING THE PROPORTIONS IN MIXTURES OF EXPONENTIAL AND NORMAL DISTRIBUTIONS
B. M. Hill, Michigan Univ., Ann Arbor, Coll. of Literature, Science and the Arts, 1963, 15 p., AD 435 647.

The Fisher information for estimating the proportion in a mixture of two densities is investigated. A general power series expansion is obtained, which is then explored in detail for the case of two exponential densities, and for the case of two normal densities with equal scale. . . . The main qualitative conclusion is that extremely large, and often impractical, sample sizes are required to obtain even moderate precision in estimating the proportion unless the mixed distributions are very well separated.

THE EXTENSION TO PROBABILITY DISTRIBUTIONS FOR DETECTION SPATIAL FILTERS
W. D. Montgomery, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 2/5.

The idea of extending partial descriptions to a probability density function on a minimum information (maximum entropy) basis is applied in the context of detection spatial filters, . . . Several two-dimensional moment descriptions are thus extended and worked in detail. . . .

1.118: Various Other Problems of Statistical Mathematics Related to Space Communications

Included: Random surfaces.

Principal Publications:

A SYSTEMATIC APPROACH TO A CLASS OF PROBLEMS IN THE THEORY OF NOISE AND OTHER RANDOM PHENOMENA - PART III, EXAMPLES
A. J. F. Siegert, IRE Trans. Inform. Th., vol. IT-4, March 1958, p. 4/14.

STATISTICAL PROPERTIES OF THE CONTOURS OF RANDOM SURFACES
P. Swerling, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 315/321.

A random surface is a sample function of a random process (f (x,y)) depending on two real parameters. Examples of random surfaces would be: photographs or television pictures; topographic maps; atmospheric pressure charts; and the like.

A number of statistical properties of the contours of such surfaces are derived. An application of the results to the problem of obtaining bounds on the information content of quantized random surfaces is outlined.

ON A CLASS OF POLYNOMIALS USEFUL IN PROBABILITY CALCULATIONS (Correspondence)
L. L. Campbell, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 255/256.

RELATIONS AMONG MOMENTS OF ORDER STATISTICS IN SAMPLES FROM TWO RELATED POPULATIONS
Z. Govindarajulu, Case Inst. of Tech., Cleveland, Ohio, Nov. 1963, 5 p., AD 434 303.

It is shown that the moments of order statistics in samples drawn from a population symmetric about zero can be expressed in terms of the moments of order statistics in samples drawn from the population obtained by folding the symmetric population at zero. . . .

COMMENTS ON "STATISTICAL PROPERTIES OF THE CONTOURS OF RANDOM SURFACES" (Correspondence)
R. F. Pawula, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 208/209.

Swerling has recently considered the statistical properties of the contours of random surfaces. The methods used in the derivation of these properties were analogous to those used in a paper by Brown. In this communication some of these derivations shall be presented from a different approach using the Dirac δ function. . . .

1.119: Experimental Evaluation of Statistical Populations

Included: Confidence estimation; Studentization; Testing hypothesis, mathematical fundamentals; Statistical Instrumentation; Random noise generation, fundamentals; Evaluation of correlation characteristics; Computer processes for statistical investigation; stochastic distortions.

Not Included: Design of noise generators; Design of random number generators; Error evaluation in digital transmission systems; Experimental evaluation of error correcting codes (2); Simulation of statistical populations (3A); Noise measurements.

Cross References: Special statistical distributions (1.117); Assessment measures for noise and disturbances (1.711); Computer simulation of noise and disturbances (1.719).

Principal Publications:

ZUR MESSUNG DER WAHRSCHEINLICHKEITSDICHTE UND DES SPEKTRUMS VON STATIONÄREN ZEITROZESSEN (On the Measurement of the Probability Density and the Spectrum of Stationary Time Processes) (In German)
P. Fey, Hochfreq. & Elektroakustik, vol. 66, March 1958, p. 141/142.

APPROXIMATION OF AUTOCORRELATION FUNCTIONS BY A SERIES OF DAMPED COSINE FUNCTIONS
D. T. Friest, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 709/714.

A TRANSISTORIZED AMPLITUDE-DISTRIBUTION ANALYZER EMPLOYING DIGITAL TECHNIQUES
D. Hoffman, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 478/489.
A method for determining the first probability distribution and the first probability distribution density of the amplitude of a random or periodic signal is described. . . .

THE DESIGN AND CONSTRUCTION OF MEASURING DEVICES TO DETERMINE THE STATISTICAL PARAMETERS OF RANDOM SIGNALS
M. E. Neal, Oklahoma U., Norman, 1958, 58 p.

RUNS DETERMINED IN A SAMPLE BY AN ARBITRARY CUT
P. S. Olmstead, Bell Syst. Techn. J., vol. 37, no. 1, Jan. 1958, p. 55.

. . . certain nonparametric measures for use in detecting the presence of assignable causes in experimental data.

SPECIAL ELECTRONIC EQUIPMENT FOR THE ANALYSIS OF STATISTICAL DATA
E. R. Carlson, et al., Proc. IRE, vol. 47, May 1959, p. 956/962.

EMPIRICAL BASES FOR STATIONARY TIME SERIES
W. C. Kellogg, Cruft Lab., Harvard U., Cambridge, Mass., Oct. 1959, p. 1/16, Scientific rept. no. 2, AD 232 539.

A brief review is presented of some properties of orthogonal function expansions, and a method is proposed for obtaining minimal sets of basis functions for the representation of sets of signals. The design of electronic equipment that will obtain basis functions and measure expansion coefficients by an analogue computing technique is discussed. . . . (see also AD 232 540)

EMPIRICAL BASES FOR STATIONARY TIME SERIES, II
W. C. Kellogg, Cruft Lab., Harvard U., Cambridge, Mass., Nov. 1959, p. 1/13, Scientific rept. no. 3, AD 232 540.

. . . constructing . . . a set of signals from samples of the signal set, . . . studied for the case of a single continuous signal. . . . found to be applicable provided the signal is a solution of an ordinary linear homogeneous differential equation with constant coefficients.

ENCODER MEASURES RANDOM EVENT TIME INTERVALS
R. J. Kelso, et al., Electronics, vol. 32, no. 20, March 1959, p. 48/51.

REPETITIVE ANALOG COMPUTER FOR ANALYSIS OF SUMS OF DISTRIBUTION FUNCTIONS
F. W. Noble, et al., Proc. IRE, vol. 47, Nov. 1959, p. 1952/1956.

EXPERIMENTAL INVESTIGATION OF THE DURATION OF NOISE PEAKS
A. I. Velichkin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 28/35.

The probability density of the duration of peak periods and intervals between peaks is experimentally determined at different levels of Gaussian noise and Rayleigh noise. . . .

CONSTRUCTION OF PROBABILITY DENSITIES FROM THEIR MOMENTS (Correspondence)
P. A. Clavier, Proc. IRE, vol. 49, Oct. 1961, p. 1580.

MEASUREMENTS OF PROBABILITY DENSITIES OF SMALL ENSEMBLES OF PERIODIC WAVEFORMS (Correspondence)
H. L. Fox, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2118.

A NEW METHOD TO COMPUTE CORRELATION FUNCTIONS
P. Jespers, et al., IRE Trans. Inform. Th., (Intern, Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 106/107.

. . . extends the method of the computation of the polarity correlation function. The polarities of both signals to be correlated are determined at given instants separated to τ seconds, each one with respect to a varying reference level. Both these levels can occupy any possible value between limits located symmetrically around zero . . .

PROCESSING OF RANDOMLY FLUCTUATING DATA BY ANALOG ANALYSIS METHODS
C. H. Linden, National Aero-and Astronautical Research Inst. Amsterdam, Netherlands, March 1962, 70 p., 28 refs., N63-21255.

. . . A number of analog data reduction possibilities for random type signals are reviewed with respect to the determination of amplitude probability distributions, power spectrum, and cross power spectrum. A number of computation schemes and equipment required are discussed. Error sources and accuracy aspects are considered in some detail.

AUTOCORRELATION BY MAGNITUDE OF THE DIFFERENCE (Correspondence)
T. A. Martin, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2499.

For reasons of ease of implementation it is sometimes desirable to use functions other than the linear correlation function to examine data for coherence. One such function is the "comparison correlation function" . . . The comparison autocorrelation function may be readily calculated for a random pulse train such as the one shown in Fig. 1. . . .

ON THE PROBLEM OF THE MEASUREMENT OF THE CHARACTERISTIC FUNCTION OF A STATIONARY ERGODIC PROCESS
P. V. Mel'nikov, Elektrosvyaz', no. 12, 1962, p. 19/25, AD 400 997.

A METHOD OF MEASUREMENT AND DISPLAY OF PROBABILITY FUNCTIONS OF ERGODIC RANDOM PROCESSES BY ORTHOGONAL SERIES SYNTHESIS (Correspondence)
A. A. Wolf, et al., Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2503/2504.

. . . Heretofore these displays have been carried out by one or two methods both involving digitizing the range of the random signal into very narrow cells and employing counting or time measurement techniques. . . . to introduce a new method of displaying probability density and cumulative probability distribution functions simultaneously and in real time by utilization of orthogonal series synthesis. The method was previously reported upon in its application to the measurement and display of instantaneous and short-term correlation functions in real time. . . .

TEST FOR A CIRCULAR DISTRIBUTION AND A TABLE OF PROBABILITIES
C. Asano, Catholic U. of America, Washington, D.C., June 1963, 12 p., AD 409 104.

A method is suggested for testing whether two samples observed on a circle are drawn from the same distribution. The proposed test is a modification of the well-known Wald-Wolfowitz runs test for a distribution on a straight line . . .

STUDIES IN RESEARCH METHODOLOGY VI. A SAMPLING STUDY OF THE CENTRAL LIMIT THEOREM AND THE ROBUSTNESS OF ONE SAMPLE PARAMETRIC TESTS
J. V. Bradley, Behavioral Sciences Lab., Aerospace Medical Div. Wright-Patterson Air Force Base, Ohio, Final rept., March 1963, 305 p., AD 411 439.

. . . the time to operate an instrument control is likely to have a distribution with a distinctive, extremely nonnormal shape . . . sampling study upon a population representing time scores for the operation of a push button. Ten thousand samples were drawn at each of the sample sizes, 2, 4, 8, 16, 32, 64, 128 . . .

THE DETERMINATION OF LAWS OF DISTRIBUTION ON THE BASIS OF A SMALL NUMBER OF OBSERVATIONS
V. V. Chavchanidze, et al., Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, March 1963, 18 p., (Trans. no. FTD-TT-62-1048 from Russian book, Primenenive Vychislitel' noy Tekhniki dlya Avtomatizatsii Prozvodstva, Mashgiz, Moskva, p. 129-139, 1961), AD-299 643.

STATISTICAL INSTRUMENTATION STUDY
A.W. Crooke, et al., Litton Systems, Inc., Waltham, Mass., March 1963, 84 p., AD 405 925.

. . . techniques for estimating n-th order statistics of signals . . . including curve fitting methods . . . and success counting methods . . . a breadboard model . . . device will calculate fourth (and lower) order joint and conditional probability density functions and distribution functions for signals with bandwidth less than 10 Kcps . . .

COMPUTER GENERATION AND TESTING OF RANDOM NUMBERS
L. J. Gannon, et al., Phillips Petroleum Co., Idaho Falls, Idaho, Atomic Energy Div. AEC, Natl. Reactor Testing Station, Aug. 1963, 43 p., N64-11093.

. . . two methods most commonly used to obtain random numbers. These methods are the multiplicative congruential method and the mixed congruential method, and both methods involve somewhat arbitrary parameters . . .

ESTIMATION OF THE ACCURACY OF THE CROSS-CORRELATION FUNCTION AS IT DEPENDS ON THE TIME DURATION OF THE EXPERIMENTAL RECORDING (Translation)

I. A. Gelfanbein, Engineering Cybernetics, Jan.-Feb. 1963, p. 54/60, A64-15929.

Evaluation of the error occurring in the calculation of the cross-correlation functions of two stationary random processes, on the assumption that the duration of the experimental recording is finite and equal. . . .

EXPERIMENTAL INVESTIGATION OF THE PEAKS OF THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE

V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 3, March 1963, p. 1/8.

An experimental setup is described for obtaining samples (oscillograms) of the smoothed envelope of quasi-sinusoidal noise. A method of processing the oscillograms to determine the statistical characteristics of the peaks of the smoothed envelope is given. Experimental results are presented, showing the distribution of the highest maxima, of the lowest minima and of the vertical distance between a minimum and the following maximum in samples of the smoothed envelope of the sum of a sinusoidal signal and Gaussian noise. . . .

HYBRID ANALOG-DIGITAL RANDOM-NOISE GENERATION

R. Hampton, et al., Arizona U., Tucson, 1963, 3 p., Memo no. 71, AD 416 387.

Random-noise generators for random-process and statistical studies with analog and hybrid analog-digital computer should produce noise signals whose amplitude distribution, d-c unbalance, spectrum, and RMS level is specified within the computer-accuracy limits (0.1 to 0.5 per cent) . . .

REGRESSION ESTIMATION FOR AN AMPLITUDE-LIMITED-RANDOM VARIABLE

E. F. Harding, Royal Armament Research and Development Establishment, Gt. Brit., Feb. 1964, 8 p. RARDE M4 64, AD 430 931.

. . . fitting formulae to empirical data which are subject both to random deviations and overriding bounds on magnitude. . . . for use when the fact that many of the data lie on these boundaries interferes with the routing application of such usual methods as the "least-squares" technique. . . . definition of "Quadratic Expectation of Error". . . . In the absence of bounds on the size of the data, the method given here is identical with the usual least-squares estimation technique.

CONFIDENCE INTERVALS AND SAMPLE SIZES IN THE MEASUREMENT OF SIGNAL AND NOISE POWERS, SIGNAL-TO-NOISE RATIOS AND PROBABILITY OF ERROR

J. Holsinger, Lincoln Lab., Mass. Inst. of Technology, Lexington, Jan. 1963, 42 p. incl. illus., 9 refs., Rept. no. 34G-9, AD 295 133.

The estimation errors involved in both discrete and continuous estimates of certain parameters of a Gaussian random process is considered. . . .

MATHEMATICAL METHODS FOR PROCESSING STATISTICAL DATA: BOOK REVIEW

G. Kil'kishev, et al., Joint Publications Research Service, Washington, D.C., Trans. of #Voprosy Ekonomike (USSR) 1962, no. 12, p. 114/117, AD 404 674.

COMBINATIONS OF LEAST-SQUARES APPROXIMATIONS IN THE CASE OF CORRELATED VARIABLES

P. L. Kadakia, Smithsonian Astrophysical Observatory, Cambridge, Mass., April 2, 1963, 13 p., 6 refs., N63-19543.

The problem of estimating a mean vector of n independent sample mean vectors of the same population or the same physical quantity with their corresponding n variance-covariance matrices (or weight matrices) for which off-diagonal elements are nonzero, e.g., when fitting an equation of polynomial of some degree to a large number of observations by the least squares. The method of solution discussed is based on the statistical estimation theory . . .

SOME RELATIONS BETWEEN DIGITIZING PARAMETERS AND CALCULATED STATISTICS OF A WAVEFORM

R. McAulay, U. of Illinois Engineering Experiment Station, Urbana, Rept. no. RRI208, Aug. 1963, 36 p., AD 417 243.

A FAST PROCEDURE FOR GENERATING EXPONENTIAL RANDOM VARIABLES (Mathematical Note No. 283)

M. D. MacLaren, et al., Boeing Scientific Research Labs., Seattle, Wash., Mathematics Research Lab., Jan. 1963, 12 p., 3 refs., N63-21696.

. . . in decimal and binary digital computers. Theoretically, the method is very exact; however, practically, the results are approximations . . .

SOME OBSERVATIONS ON MEASURABLE PROPERTIES OF RANDOM PROCESSES AND FIELDS. I

D. Middleton, Litton Systems, Inc., Waltham, Mass., Rept. no. TR63 4BF, March 1964, 54 p., AD 434 120.

A number of useful, measurable properties of random processes and random fields are defined and discussed, and it is shown how these results may be applied to observations necessarily finite in time and in space. . . .

AN ANALYZER FOR MEASURING THE WIENER COHERENCY MATRIX OF TWO SIGNALS (Correspondence)

N. G. Parke, III, Proc. IEEE, vol. 51, no. 6, June 1963, p. 951/952.

The density form of the Wiener coherency matrix is equivalent from an information theoretical standpoint to the matrix of auto- and cross-correlations of two signals. A technique for measuring a two-by-two Wiener coherency matrix using four multiple-filter spectrum analyzers has been worked out. . . .

ANALYSIS OF NONSTATIONARY DATA USING AN AIRBORNE SPECTRUM ANALYZER (Correspondence)
A. G. Ratz, Proc. IEEE, vol. 51, no. 3, March 1963, p. 491/492.

Spectrum analysis of missile or aircraft vibration signals carried out in real time using on-board swept spectrum analyzers . . . One aspect . . . considerable interest is the very pertinent question of stationarity . . .

STUDENTIZATION OF TWO-STAGE MEANS FROM NORMAL POPULATIONS WITH UNKNOWN VARIANCES. I. GENERAL THEORY AND APPLICATION TO THE CONFIDENCE ESTIMATION AND TESTING OF THE DIFFERENCE IN POPULATION MEANS
H. Ruben, Columbia U., New York, Dec. 1960, 24 p., AD 412 319.

A two-stage sampling procedure is developed for the estimation of means, and functions of means, of unknown normal populations by means of confidence sets of predetermined dimensions, and concomitantly, for testing hypotheses relating to these means with power independent of the unknown variances. . . .

MEASUREMENT OF SUBJECTIVE PROBABILITY DISTRIBUTIONS
M. Toda, Institute for Research, State College, Pa., July 1963, 34 p., AD 416 405.

Five experimental one-person games are derived which promise both valid and efficient measurement of discrete and continuous subjective probability distributions. . . .

Related Publications:

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING - PART I
R. B. Blackman, et al., Bell Syst. Techn. J., vol. 37, no. 1, Jan. 1958, p. 185.

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING - PART II
R. B. Blackman, et al., Bell Syst. Techn. J., vol. 37, no. 2, March 1958, p. 485-569.

THE DESIGN OF CONDITIONAL PROBABILITY COMPUTERS
A. M. Uttley, Information & Control, vol. 2, no. 1, April 1959, p. 1/24.

STUDIES IN RESEARCH METHODOLOGY. IV. A SAMPLING STUDY OF THE CENTRAL LIMIT THEOREM AND THE ROBUSTNESS OF ONE-SAMPLE PARAMETRIC TESTS
J. V. Bradley, Behavioral Sciences Lab., Aerospace Medical Div., Wright-Patterson, AFB, Ohio, March 1963, 305 p., AMRL TDR63 29, AD 422 649.

. . . the approximate validity of certain normality-assuming statistical tests at various sample sizes, was investigated by performing a large sampling study upon a population representing time scores for the operation of a push button. Ten thousand samples were drawn at each of the sample sizes, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, and for each sample Z, t, and chi-square were calculated. The sampling distributions . . . departed from their normal-theory distributions . . . Even at N = 1024 these departures were quite appreciable at the testing. . . .

Section 1.12
Information Theory

The selections for this section have been made primarily from the communication branch of information theory. Within this restraint it was found advisable to concentrate references to communications channel models in section 1.13. Most of the fundamental papers in information theory originated prior to 1958 and the reader will find references from that period in the books and bibliographies quoted in this collection.

Information theory has recently found increasing applications in practical channel characterization. The reader will find in division 1.6 many contributions which could also be classified as papers in information theory, but references are not duplicated here.

Signal theory or, more accurately, the theory of signal space is frequently considered a branch of information theory. Here it is separated as section 1.14.

Detection theory is possibly the most important application of information theory in space communications. It is covered in vol. 2 of this series. The same applies to coding theory and in particular to the theory of error correcting codes.

Adaptive communications systems are of great interest to space communications engineers. The theory and practice is referenced and division 2.9.

1.120: Books and Surveys on Information Theory

Included: Books on communications theory; General treatment of noise immunity; Cybernetics and information theory.

Not Included: Theory of automata; Bionics and its theory (3B).

Principal Publications:

THE THEORY OF OPTIMUM NOISE IMMUNITY
V. A. Kotel'nikov, New York, McGraw-Hill, Book Co., Inc., 1959, 140 p.

. . . first English-language account of Dr. Kotel'nikov's 1947 doctoral dissertation at the Molotov Energy Institute. . . . interesting addition to . . . the statistical theory of signal detection . . . a study of considerable historical interest.

INFORMATION THEORY AND STATISTICS
S. Kullback, New York, John Wiley & Sons, Inc., 1959, 395 p.

GRUNDLAGEN UND ANWENDUNGEN DER INFORMATIONSTHEORIE IN: KOMMUNIKATION UND KYBERNETIK IN EINZELDARSTELLUNGEN) (BAND 1) (Fundamentals and Applications of Information Theory) (In: Communications and Cybernetics, a Series of Separate Volumes) (Volume 1)
W. Meyer-Eppler, Berlin, Springer-Verlag, 1959, 446 p.

INFORMATION TRANSMISSION, MODULATION, AND NOISE
M. Schwartz, New York, McGraw-Hill Book Co., Inc., 1959, 454 p.

PROBABILITE ET INFORMATION (Probability & Information) (Monographies Dunod, No. 20)
A. M. Yaglom and I. M. Yaglom, Paris, Dunod, 1959, 175 p.

AN INTRODUCTION TO STATISTICAL COMMUNICATION THEORY
D. Middleton, New York, McGraw-Hill Book Co., Inc., 1960, 1070 p.

. . . Few technical books can claim to be packed with such a weight of material as this one. . . . A knowledge of Fourier- and Laplace-transform methods, contour integration, matrices, simple integral equations, and the usual techniques of advanced calculus courses is also required, along with the elements of circuit theory and the principles of radio, radar, and other types of electronic communications systems. . . . it must be admitted that almost all the points of interest are covered. . . .

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . The book is essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." The 18 authors are recognized authorities in their respective specialities, and the reader can appreciate the effort required to edit the contributed material into the 23 chapters which make up the book. . . .

INFORMATION THEORY—THE FOURTH LONDON SYMPOSIUM
C. Cherry (editor), London & Washington, Butterworths, 1961, 476 p.

. . . new and interesting results . . . no library of information theory would be complete without it. . . . table of contents. . . .

PROGRESS IN INFORMATION THEORY IN THE USA, 1957-1960
P. Elias, et al., IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 128/144

TRANSMISSION OF INFORMATION, A STATISTICAL THEORY OF COMMUNICATIONS
R. M. Fano, New York, John Wiley & Sons, Inc., and Cambridge, Mass., MIT Press, 1961, 389 p.

. . . presents an authoritative and extremely detailed development of the basic facts of Shannon's theory on coding for sources and channels. Particular emphasis is placed on the Gaussian channel, the binary symmetric channel, and bounds on the probability of error for discrete memoryless channels. Parity-check codes are introduced only briefly, in connection with the asymptotic theory. . . .

ENTROPIE (The Entropy) (In French)
J. D. Fast, Paris, Dunod, 1961, 326 p.
The understanding of the term "entropy" presents frequently some difficulties. The author presents an explanation of entropy in an elementary manner, starting with the fundamentals of thermodynamics, statistical mechanics, and quantum mechanics.

AN INTRODUCTION TO THE PRINCIPLES OF COMMUNICATION THEORY
J. D. Hancock, New York, McGraw-Hill Book Co., Inc., 1961, 253 p.

AN INTRODUCTION TO INFORMATION THEORY
F. M. Reza, New York, McGraw-Hill Book Co., Inc., 1961, 449 p.

. . . devoted primarily to problems of coding and the transmission of information . . . problem of detecting a radar target or the problem of optimum filtering. . . . fairly extensive discussion of group codes, including such subjects as Hadamard matrices and Bose-Chaudhuri codes. . . .

THEORY OF THE TRANSMISSION AND PROCESSING OF INFORMATION
A. G. Vitushkin, Oxford, Pergamon Press Limited, 1961, 230 p.

. . . a research monograph which deals, in an abstract and rigorous manner, with the estimations of the information content of various problems in tabulation. Translated from the Russian it defines mathematically the concept of the complexity of a tabulation problem. . . . The formal definition of a concept of this kind, apart from its purely theoretical interest, is required in machine mathematics, and in the first instance, in the automization of programming. . . . "Theory of Transmission" represents in clear and concise terms the Soviet thinking in this field. . . .

CYBERNETICS, OR CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE (Second edition)
N. Wiener, New York, John Wiley & Sons, Inc., and Cambridge, Mass., MIT Press, 1961, 212 p.

INFORMATION THEORY AND ITS ENGINEERING APPLICATIONS
D. A. Bell, London, Sir Isaac Pitman and Sons Ltd., 1962, 196 p.

. . . substance of developments published since 1948 in the theory of the performance of communication systems. . . . expressed comfortably within the range of mathematics associated with an honors degree in electrical engineering or physics . . . provides a convenient summary of information theory. . . .

SCIENCE AND INFORMATION THEORY
L. Brillouin, New York, Academic Press, Inc., 1962.

. . . differs from the first (1956) principally in the inclusion of two additional final chapters on "Inevitable Errors, Determinism, and Information" and "The Problem of Very Small Distances." . . .

AN INFORMATION THEORY FOR TIME-CONTINUOUS PROCESSES
R. Y. Huang, Syracuse U. Research Inst., N.Y., (Rept. no. EE 894-625TN1; Technical rept. no. 1), May 1962, 99 p. incl. illus., 25 refs., AD 276 697.

INFORMATION THEORY
B. McMillan, et al., Proc. IRE, vol. 50, May 1962, p. 1151/1157.

INFORMATION THEORY, AN ASTIA REPORT BIBLIOGRAPHY
H. W. Miles, Armed Services Technical Information Agency, Washington, D. C., Jan. 1962, 35 p., AD 269 800.

. . . References are included for documents catalogued by ASTIA from 1953 through 1 January 1962 . . . channel, capacity, coding, communication systems, and theory, data transmission systems, and computer design.

CODING THEOREMS OF INFORMATION THEORY (Vol. 31 of "Ergebnisse der Mathematik und ihrer Grenzgebiete, N. F.")
J. Wolfowitz, Englewood Cliffs, N.J., Prentice-Hall, Inc., and Berlin, Springer-Verlag, 1962, 124 p.

The author is concerned with information theory in the narrow sense, i.e., the proof of Shannon's fundamental coding theorem and its converse for a wide variety of channel models. The book is strictly a formal mathematical development; there is no discussion of applications or of the construction of error-correcting codes. . . .

PRINCIPLES OF THE STATISTICAL THEORY OF COMMUNICATION
W. W. Harman, New York, McGraw-Hill Book Co., Inc., 1963, 291 p.

. . . textbook for classroom use. . . . An admirable series of exercises punctuates the text. Far from simply asking the student to substitute numbers into formulas, they are skillfully designed to make him think about the subject at hand and to guide him in applying it. . . .

ENGINEERING CYBERNETICS
A. G. Ivankhnenko, Joint Publications Research Service, Washington, D. C., Jan. 1963, 625 p., AD 406 020.

INFORMATION UND ENERGIE (Information and Energy) (In German)
F. L. Stumpers, (NTG-Fachtagung "Informationstheorie," Stuttgart, Germany, April 5, 1963.), NTZ - Nachrichtentechnische Zeitschrift, vol. 17, Jan. 1964, p. 35/41, 16 refs., A64-14749.

Discussion of the relationship between information and energy, on the basis of Shannon's formula in the theory of information. Specifically examined are certain paradoxes encountered in the interpretation of Shannon's formula, as well as a new interpretation of the interpolation theorems. The analysis illustrates the changes in the information-energy relation which take

place when the strict bandwidth limitations are lifted. . . .

FOUNDATIONS OF INFORMATION THEORY
(This is part of "Report on Progress in Information Theory in the USA 1960-1963", edited by L. A. Zadeh.)
A. J. Thomasian, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 221/223, 43 refs.

Related Publications:

RANDOM PROCESSES IN CONTROL AND COMMUNICATIONS
R. F. Drenick, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 4, Oct. 1963, p. 275/280.

. . . surveys the main results of information theory, and of related theories . . . written originally for the audience of Science . . . reprinted here at the suggestion of the Editor of these Transactions, in the hope that it will be diverting, and perhaps also instructive, to an audience of engineers. . . .

THEORY OF ADAPTIVE MECHANISMS
M. K. Hu, et al., Syracuse U., Research Inst., N. Y., Dec. 1963, 110 p., Rept. no. EE894 6307F, AD 429 935.

. . . four different but related tasks. . . . (1) Information Contents of Time Continuous Processes. (2) Visual Pattern Recognition by Moment Invariants. (3) Control and Communication Systems in the Blood. (4) Experiments on the Use of Threshold Logic for Learning Machines. . . .

1.121: Information Theory and Communications Techniques

Included: Information theory and physical measurements; Theory of experimental errors; Lattice theory of information; Concept of coherence.

Not Included: Theory of coherent detectors; Theory of power law detectors (2); Systems theory; Learning processes; Theory of synchronization processes; Theory of radar detection (2).

Cross References: Uncertainity principle (1.141); Quantum channels (1.123).

Principal Publications:

A MATHEMATICAL THEORY OF COMMUNICATION
C. E. Shannon, Bell System Tech. J., vol. 27, Oct. 1948, p. 623/656.

THE LATTICE THEORY OF INFORMATION
C. E. Shannon, Proc. Symp. Information Theory, 1950, p. 105/107.

TELEMETERING AND INFORMATION THEORY
F. W. Lehan, IRE Trans. Telem. Remote Contr., vol. TRC-1, no. 1, Aug. 1954, p. 15/19.

SOME APPLICATIONS OF DYNAMIC PROGRAMMING TO COMMUNICATION AND INFORMATION THEORY
R. Bellman, et al., Rand Corp., June 1958, 37 p., AD 207 450.

THE FUNDAMENTAL THEOREMS OF INFORMATION THEORY PARTICULARLY IN TELECOMMUNICATIONS
H. Wolter, Arch. Elekt. Ubertragung, vol. 12, Aug. 1958, p. 335/345.

An ambiguity in the proof of Shannon's sampling theorem and the contradictions involved in the assumption of sharp frequency limits are discussed. . . . determining time function at the input . . . from the time function measured at the output. . . . therefore effectively expand the channel bandwidth to any desired value.

INEVITABLE EXPERIMENTAL ERRORS, DETERMINISM, AND INFORMATION THEORY
L. Brillouin, Information & Control, vol. 2, April 1959, p. 45/63.

Classical physics was based upon the assumption that experimental errors were just accidental and should be ignored by the theory. Modern physics realizes that errors are inevitable and that it is impossible to go to the limit of infinitly small errors. The uncertainty principle and the negentropy principle of information prove that the smaller the error, the greater the price that must be paid for the observation.

INFORMATION CAPACITY OF COMMUNICATION NETWORKS
L. S. Schwartz, Proc. Nat. Electronics, Conf., vol. 15, Oct. 1959, p. 414/420.

When circuits are put together to form communication networks of transmitters and receivers, as in air defense and missile systems, performance is measured in terms of parameters like information flow and error probability . . . topology can be a useful tool in establishing fundamental properties of communication networks. Information flow

is treated as the analogue of branch current. The information capacity of the network may be obtained from the minimum-valued cut-set theorem, knowing the branch capacities. By this means changes in overall network capacity with changes in circuit configuration or branch capacity may be determined.

COMMUNICATION APPLICATIONS OF INFORMATION THEORY
B. L. Basore, Dikewood Corp., Albuquerque, N. Mex., Final rept., Dec. 1960, 37 p., Rept. DRF-1004, AD 257 983.

A mathematical model of communication in a situation in which learning occurs . . . the equivocation measuring the uncertainty about what message was transmitted is greater in a learning situation than in the case covered by conventional communication theory . . . this increase is more than the amount of information which may be learned from the one transmission about the statistical description of the transmitter's message set.

A PRACTICAL LOOK AT INFORMATION THEORY
W. K. MacAdam, Electrical Engineering, vol. 79, no. 7, July 1960, p. 584/587.

INFORMATION THEORETIC ASPECTS OF PARTICLE LOCATION ON THE BASIS OF DATA FROM SEPARATED OBSERVERS
C. Pedersen, Electronics Research Labs., Columbia U., New York, Sept. 1961, 151 p., 5 refs., Tech. rept. no. T-4/161, AD 402 281.

A number of separated and isolated observers each record the distances between themselves and a number of spatially distributed particles, without identification of the distances with individual particles. The problem is to discover sets of observed data referring to individual particles in order that the particle locations may be computed.

DETERMINATION OF THE FUNCTION OF AN IDEAL RECEIVER
N. L. Teplov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 30/38.

Functions of an ideal receiver are defined, depending on the statistical structure of information and on the signal form. Parameters of an almost ideal receiver are shown. . . .

A NOTE ON THE FORMATION OF CONCEPT AND OF ASSOCIATION BY INFORMATION-THEORETICAL CORRELATION ANALYSIS
S. Watanabe, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 291/296.

. . . hereafter referred to as ITCA provides a powerful tool in producing mechanizable models of a certain type of cognitive and recognitive processes, such as concept formation, formation of association, pattern recognition, indexing, taxonomical and other classification, identification of "clusters," medical diagnoses, etc. . . .

MINIMUM-PHASE SYSTEMS (In German)
G. Wunsch, Nachrichtentechnik, vol. 11, no. 3, March 1961, p. 99/102.

A statement of basic principles leads to a discussion of the question whether or not it is possible for a loss of information to take place in a linear network forming part of a communication system. It is shown that no loss of information can take place if the network is of minimum-phase type.

OPTIMUM MESSAGE TRANSMISSION IN A FINITE TIME
S. S. L. Chang, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 215/224.

The basic problem of transmitting information through a noisy channel in a finite time with the least error is considered. The transmitted signals are either peak of average power limited, and the interference is presumed to be additive white gaussian noise. It is shown that the optimum signals are sequences of binary waveforms resembling a $(2^m - 1, m)$ Slepian group code, the generators of which can be obtained from a modified Reed Code.

An analysis is also made of near-optimum codes which allow some inequality in the distance between code words in signal space. The advantage of these near-optimum codes is that for a small sacrifice in error probability, either the information rate can be substantially increased, or the bandwidth of the system greatly reduced. The details of these systems are given and the results show that a many-fold improvement is obtained. . . .

INFORMATION TRANSMISSION WITH ADDITIONAL NOISE
R. L. Dobrushin, et al., IRE Trans. Inform. Th., (Intern, Symp. Brussels 1962), vol. IT-8 no. 5, Sept. 1962, p. 293/304.

. . . the message . . . is mapped onto the random signal . . . requirement that the distribution of the input signal . . . should belong to a certain selected class of distributions . . . there is given the space of output signal values

. . . and the channel transition function . . . Finally there is the space . . . of the message values on the output. . . .

COMMUNICATION THEORY VS COMMUNICATIONS (Correspondence)
R. M. Lerner, IRE Trans. Inf. Theory, vol. IT-8, no. 4, July 1962, p. 325.

In a recent book review, J. P. Costas levels a blast at communication theory: it has had little impact on real communication . . . Since my name appears prominently in Costas' discussion, perhaps I may be permitted a few comments. . . .

SPAN: A PRACTICAL COHERENT SYSTEM ANALYSIS METHOD
J. C. O'Brien, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 56/62.

The need for an exact, universal performance measure, suitable for expressing the dynamic laws of system behavior, is generally recognized. For several years, Nortronics . . . has been actively engaged in research to define such a unit for use in systems engineering and design projects. . . . a measure is currently to be found in various limited areas of scientific technology. Examples are the entropy measure of availability of heat energy in thermodynamics, the Laplacian equation for the flow rate of energy density in classical physics, and the subjective measure of availability of decisions which is called information content flow or "negentropy" rate, in information and communication theory. . . . The result has been designated the SPAN (System Performance Analysis) method. It still requires considerably more validation to merit acceptance as a rigorous analytical tool. . . .

INFORMATION THEORY - A BASIC COMMUNICATION SYSTEM
C. G. Shonerd, Army Signal Missile Support Agency, White Sands Missile Range, N. Mex., July 1962, 12 p. incl. illus., 11 refs, (Technical rept. no. EID-121), AD 284 580.

A basic communications system is redefined in terms of modern information theory. This report is aimed, basically, at those users who may be new to this particular discipline. Because of the complexity of the discipline no attempt is made towards complete analysis or coverage. A bibliography is presented for those users who require more sophisticated approaches or applications.

ON SYNCHRONIZATION IN COMMUNICATION THEORY
I. S. Reed, RAND Corp., Santa Monica, Calif., March 1963, 12 p., (Memo no. RM-3561-PR), AD 299 700.

GROUP SYNCHRONIZATION AS AN INFORMATION DETERMINING PROCESS (Correspondence)
D. R. Rhodes, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 249/250.

Group synchronization in time-division communication is a special case of the general problem of transmission of information, and, as such, can be treated by the methods of information theory. The information to be communicated is the location of the sync position; i.e., the starting position of the group. . . .

CODING, FILTERING, AND INFORMATION THEORY
L. S. Schwartz, Md. U. Proc. of the Space Communications Inst., Md. U., College Park, June 23-28, 1963, p. 15/35, refs., See N64-17194, N64-17196.

. . . theory of communications . . . largely the work of two men, Claude Shannon and Nobert Wiener . . . recent developments . . . reliability improvement . . . method of decision in the receiver . . . feedback channel . . .

CONCERNING THE GREATEST AMOUNT OF INFORMATION FROM A SOURCE WHICH IS BEING REMOVED WHEN FLUCTUATION NOISES ARE PRESENT IN A RECEIVER WITH A UNIFORM FREQUENCY SPECTRUM
V. I. Siforov, Joint Publications Research Service, Washington, D. C., News of the Acad. of Sci. USSR, Dept. of Tech. Sci.; Tech. Cybernetics, no. 4, Dec. 1963, p. 115/119, refs., see N64-12451, N64-12457.

It is proved that, when using any wide frequency band for the information transmission channel during the course of an unlimited time, the total amount of information received is finite. An approximate expression for the largest amount of information is found.

MEASURING INSTRUMENT AS A SOURCE OF INFORMATION
I. M. Sorkin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 49/56.

The principles of information theory are used to analyze the operation of an indicating measuring instrument when the quantity to be measured is fluctuating, under the action of random factors, within a finite interval. . . .

Related Publications:

INVESTIGATION OF HIGH FREQUENCY LIMITATIONS IN MILLIMETER WAVE GENERATORS
J. Schwinger, Cambridge, Mass. Final rept., Jan.-June 1962, June 1962, 25 p., AD 276 940.

. . . relationship between the uncertainty principle and minimum amplifier noise is examined. . . . the concept of coherence is discussed . . . Harmonic oscillator states are examined for coherence. The concept of noise is then discussed and contrasted with incoherence.

. . . Spontaneous emission is examined both for coherence and noise. . . . amplifying mechanism is treated quantum-mechanically.

LEARNING PROCESS AND INVERSE H-THEOREM

S. Watanabe, IRE Trans. Inform. Th., Intern. Symp. Brussels 1962, vol. IT-8, no. 5, Sept. 1962, p. 246/251.

It is proposed to use the time rate of decrease of the entropy defined by the response probabilities as a measure of the speed of learning. An empirical formula . . . was introduced to describe the entropy as a function of the trial number, and the parameters involved in the formula are given intuitive meanings. . . .

SYSTEMS AND INFORMATION
W. R. Ashby, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 94/97.

Information theory is essentially a method for . . . cause-effect relations . . . Communication theory has been severely restricted by its original concentration on the ergodic and stationary. Adaptive systems, however, by leaving bad ways of behaving and changing permanently to other (and better) ways of behaving are necessarily nonergodic and nonstationary. The methods of uncertainty analysis (McGill and Garner) seem appropriate here. These methods give a new precision to such questions as: What is a "system"? . . .

1.122: Definitions and Terminology in Information Theory

Included: Entropy; Entropy power; Information transmission rate: Noise-proof factor; Instantaneous entropy; Negentropy; Redundancy in general; Equivocation; Quantity of information.

Not Included: Definitions of control theory and systems theory; Definitions of detection and decision theory (2).

Cross References: Channel capacity (1.130); Definitions of special channel models (1.130); Definitions of signal theory (uncertainty principle) (1.141).

Principal Publications:

IRE STANDARDS ON INFORMATION THEORY: DEFINITIONS OF TERMS
Proc. IRE, vol. 46, Sept. 1958, p. 1646/1648.

A PARADOX CONCERNING RATE OF INFORMATION: CORRECTIONS AND ADDITIONS
I. J. Good, et al., Information & Control, vol. 2, no. 2, Feb. 1959, p. 195/197.

SOME INEQUALITIES SATISFIED BY THE QUANTITIES OF INFORMATION OF FISHER AND SHANNON
A. J. Stam, Information & Control, vol. 2, no. 2, Feb. 1959, p. 101/112.

A certain analogy is found to exist between a special case of Fisher's quantity of information I and the inverse of the "entropy power" of Shannon.

DIE LOGISCHE VERKNÜPFUNG ALS EINHEIT DER NACHRICHTENVERARBEITUNG (The Logical Reaction as a Unit for Information Processing.) (In German)
K. Steinbuch, Nachrich. Zeitschrift, vol. 12, April 1959, p. 169/175.

PARADOXES RELATED TO THE RATE OF TRANSMISSION OF INFORMATION
P. Swerling, Inform. Control, vol. 3, no. 4, Dec. 1960, p. 351/359.

. . . such paradoxes are not necessarily dependent on the assumption of Gaussian statistics.

. . . in the case where signal and noise are assumed to be Gaussian, a different example of this type of paradox is derived; also, a necessary and sufficient condition for the avoidance of this form of the paradox is derived. This condition is shown to be satisfied in a class of plausible physical situations. . . .

NEGENTROPY REVISITED (Correspondence)
P. A. Clavier, Proc. IRE, vol. 49, Sept. 1961, p. 1438.

A NEW DERIVATION OF THE ENTROPY EXPRESSIONS
S. W. Golomb, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 166/167.

In the discrete case, the Shannon expression for entropy is obtained as a line integral in probability space . . . In the continuous case, the continuous analog of information density is integrated to obtain the entropy expression for continuous probability distributions.

BEGRIFFE UND DEFINITIONEN IN DER INFORMATIONSTHEORIE (Terms and Definitions in Information Theory) (In German)
P. Neidhardt, Elektronische Rundschau, vol. 15, no. 7, July 1961, p. 314/323.

UBER DIE WECHSELBEZIEHUNGEN VON BLIND-, WIRK- UND SCHEININFORMATION ZUR SYMBOL- UND KANALKAPAZITAT IN DER INFORMATIONSTHEORIE (On the Interrelation between Reactive- Resistive- and Apparent Information on the One Side and the Symbol and Channel Capacity on the Other Side) (In German)
P. Neidhardt, Nachrichtentechnik, vol. 11, no. 11, Nov. 1961, p. 481/483.

ON INSTANTANEOUS ENTROPY
W. H. Foy, Jr., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 267/274.

. . . In many communication and control problems. . . . the quantities of interest come from a class of signals. We can assign a probability distribution over function space, and the entropy of this distribution measures our uncertainty as to the occurrence of any given signal in the class. In many other problems, on the other hand, we are interested in the value of some function at a particular instant. A probability distribution is assigned over the function values, and the "instantaneous entropy" of this distribution measures our uncertainty as to the instantaneous function value. This interpretation finds useful application to a long list of problems in communication, data-processing, guidance and control. . . . We shall be concerned in this paper with the instantaneous entropy of continuously distributed quantities. . . .

FERRETING SIGNALS OUT OF NOISE
S. W. Golomb, International Science and Technology, Oct. 1963, p. 72/74, 77, 78, 80, 82, A64-10481.

. . . problems of statistical communications theory. . . . A reappraisal is made of the current forms of such basic notions as channels (and what they include), bits and error rates (and their significance), and noise (and the appropriateness of the statistical procedures applied to it).

O ZAKONAKH RASPREDELENIIA OGIBAIUSHCHEI SLUCHAINYKH PROTSESSOV, OBLADAIUSHCHIKH MAKSIMAL'NOI ENTROPIEI (Distribution laws of the Envelope of Random Processes with a Maximum Entropy) (In Russian)
L. E. Kopilovich, Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 339/346, A64-17134.

Study of the distribution laws of the envelope of radio signals with a maximum entropy, using the method proposed by Shannon. It is shown that certain known distribution laws of the envelope can be obtained as solutions of the special isoperimetric problem-i.e., as distributions with a maximum entropy in the presence of definite limitations on the random processes.

KRITERII TOCHNOSTI TELEIZMERENIIA PRI VOZDEISTVII POMEKH KANALA SVIAZ (Criterion for Telemetering Accuracy in the Presence of Communication-Channel Noise) (In Russian)
N. V. Pozin, Avtomatika i Telemekhanika, vol. 24, Dec. 1963, p. 1712/1717, A64-13120.

Determination of the telemetering error induced by channel noise and instability of telemetering devices. A dimensionless criterion, termed the noise-proof factor, is derived for the analysis of the effectiveness of interference killing in individual telemetering techniques.

Related Publications:

A NOTE ON MATHEMATICAL INDUCTION ON PHRASE STRUCTURE GRAMMARS
R. W. Floyd, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 353/358.

. . . A string is a finite nonempty sequence of characters chosen from a given alphabet. In particular, each character is itself a string. Strings will be represented by small Latin letters. A grammatical category is a (possibly infinite or empty) set of strings. Categories will be represented by Latin capitals. A language is a finite set of categories, of which one may optionally be singled out as the category of sentences or well formed formulas. . . .

AMOUNT OF DECIDING AND DECISIONARY EFFORT
I. J. Good, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 271/281.

. . . explicata are obtained for (1) the net amount of deciding contained in a mental event, F, in favor of an act or of a class of acts; (2) the decisionary effort contained in F, with respect to a class of acts. . . . It is found, for example, that much deciding can be done effortlessly, and on the other hand a small amount of deciding can consume a lot of effort. . . . A by-product of the discussion is a contribution to the axiomatics of what Kullback calls the "divergence" between two probability distributions.

. . . The meanings of "decision" and "conclusion" are briefly considered. . . .

POINCARE'S THEOREM AND UNCERTAINTY IN CLASSICAL MECHANICS
L. Brillouin, Inform. Control, vol. 5, no. 3, Sept. 1962, p. 223/245.

. . . This theorem was first stated for celestial mechanics, but it extends immediately to all problems of classical mechanics, provided such problems be conservative. . . . a great variety of examples have been selected. . . .

SOME PROPERTIES OF THE FINITE CONVOLUTION
J. A. Sheehan, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 283/284.

. . . finite convolution, . . . where f(x) and g(x) are square-integrable functions of the (not necessarily one-dimensional) variable x. By a finite convolution we mean that r (τ) vanishes outside some finite region of τ-space. . . .

Section 1.13
Channel Models

Space communications systems operate over all kinds of channels. Their terminals are either all on earth (passive satellites or ground-to-ground support communications) or they are partly on earth, partly in space (active satellites and links between satellites and ground stations). The future requirements call for a large variety of space-to-space links and of links between space craft and celestial bodies. Beyond that designers will have to worry about surface communications on the Moon and on planets.

The large variety of channel characteristics in all these applications calls for realistic theoretical models. The references in this section reflect the present thinking. A strong expansion of this field of communications theory may be expected. The reader may notice the interconnection of this section with the whole division 1.6 (channel characteristics).

The fast progress in channel theory makes it advisable to avoid a further subdivision of this section at this time. All references are therefore included in subdivision 1.130 with the same title as the section.

1.130: Channel Models

Included: Channels with memory; Quantum channels; Neuron channels; Bio-electronic channels; Compound channels; Time-continuous channels; Two-way channels in general; Finite state channels; Noiseless channels; Transmission rates; Channel capacity; Randomly time variant channels; Channels without capacity; Erasure channels; Limiting channels; Channels with threshold effects; Nonlinear channels.

Not Included: Bionics and space communications (3B); Channels with communications feedback (2); Theory of finite state automata; Simulation of channel models (3A); Design of limiters.

Cross References: Time variable practical channels (1.611); Distortions in practical channels (1.62); Special data transmission channels (Div. 1.3); Threshold effects in frequency modulation (1.232); Analysis of randomly time-variant linear channels (1.611).

Principal Publications:

PHILOSOPHY OF PCM
C. E. Shannon, et al., Proc. IRE, vol. 11, no. 36, Nov. 1948, p. 1324/1331.

COMMUNICATIONS IN THE PRESENCE OF NOISE
C. E. Shannon, Proc. IRE, no. 37, Jan. 1949, p. 10/22.

CAPACITY OF A CERTAIN ASYMMETRICAL BINARY CHANNEL WITH FINITE MEMORY
Sze-Hou Chang, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 152/159.

. . . 1) Blocks of equal numbers of binary digits are used as the transmitting symbols. 2) The channel resumes its quiescent state at the beginning of each block. 3) The memory of the channel is characterized by the dependence of the noise probabilities for each digit upon the preceding digit or digits in the same block.

THE UTILITY OF A COMMUNICATION CHANNEL AND APPLICATIONS TO SUBOPTIMAL INFORMATION HANDLING PROCEDURES
M. B. Marcus, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 147/151.

. . . . The Kelly concept—the gain of a gambler who wagers his capital on the outcome of a communication channel—is used to determine the information rate of the channel. The mathematical analysis follows the stochastic multistage decision process technique of Bellman and Kalaba.

THE OPTIMAL DISTRIBUTION OF SIGNAL POWER IN A TRANSMISSION LINK WHOSE ATTENUATION IS A FUNCTION OF FREQUENCY
G. Raisbeck, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 129/130.

CHANNEL CAPACITY WITH RANDOM ABSORPTION CHANGES
V. I. Siforov, Radio Engng., vol. 13, no. 5, 1958, p. 9/25.

The lower limit of the capacity of a channel with random absorption changes and the simultaneous action of added noise is determined. It is shown that single-channel lines with relatively slow random absorption changes have an extremely high capacity.

THE CAPACITY OF A CLASS OF CHANNELS
D. Blackwell, et al., Electronics Research Lab., U. of Calif., Berkeley, 16 Feb. 1959, 13 p., Series No. 60, Issue No. 282, AD-239 993, Reprint from the Annals of Mathematical Statistics 30:1229-1241, Dec. 1959.

Shannon's basic theorem on the capacity of a channel is generalized to the case of a class of memoryless channels. A generalized capacity is defined and is shown to be the supremum of attainable transmission rates when the coding and decoding procedure must be satisfactory for every channel in the class. (See also AD 239 992).

A PARADOX CONCERNING RATE OF INFORMATION: CORRECTIONS AND ADDITIONS
I. J. Good, et al., Information Control, vol. 2, no. 2, Feb. 1959, p. 195/197.

AN ADDITION TO SHANNON'S LAW (In Swedish)
S. Janson, Tele, no. 3, 1959, 146 p.

In Shannon's expression for the maximum information capacity of a transmission channel with optimum coding the echo power must be regarded as noise giving a term $S/(N + eS)$ for the signal to noise ratio to be used.

THE INFORMATION CAPACITY OF SYMMETRICAL LINKS WITH VARIABLE PARAMETERS FOR AN UNLIMITED FREQUENCY BAND
L. M. Fink, vol. 15, no. 7, 1960, p. 33/46.

. . . calculated for a given ratio of signal power to spectral density of white noise over as wide a frequency band as is convenient, provided the methods of coding are limited to discrete symmetrical codes. . . .

A NOTE ON THE CAPACITY OF A CHANNEL
H. Lars, et al., JPL Technical Release no. 34-123, Sept. 23, 1960, AD 244 199.

Stability considerations under change of time scale.

THE INFORMATION CAPACITY OF CHANNELS WITH GENERAL AND SELECTIVE FADING
I. A. Obseevich, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 1/10, 14 refs.

Approximate methods are given for calculating the information capacity of multi-path radio channels with strong (Rayleigh) and weak (Gauss) general fading. They are also applicable to selective fading. The information capacity of a channel in the present of feedback is calculated.

STUDY OF SYSTEM RELIABILITY ENTROPY OF A CONTINUOUS CHANNEL
F. M. Reza, Syracuse U. Research Inst., N.Y., Final rept. Jan. 1960, 36 p. incl., illus. 14 refs., (Rept. no. EE507-6001F), AD 237 512.

. . . Topological considerations were used to study the error in systems due to the error in their components values . . . The second part of the report presented the basic concepts of Information Theory for finite memoryless schemes . . . The third part, was concerned with some properties of reliability functions. The fourt part discusses in detail Shannon's mathematical model of a simple continuous channel operating under additive noise. See also AD 160 799, AD 266 373.

SOME QUANTUM EFFECTS IN INFORMATION CHANNELS
T. E. Stern, IRE Trans. Inform. Th., vol. IT6, no. 4, Sept. 1960, p. 435/440.

CODED, DIVERSIFIED, RAYLEIGH-FADED BINARY SYMMETRIC THRESHOLD CHANNELS
Research Lab. of Electronics, MIT, Cambridge, 4 Dec. 1960, 32 p. (Tech, rept. 384), AD 264 722.

The expressions for the probabilities associated with a Rayleigh-faded channel with null-zone detecting and diversity used are derived

. . . Quantitative results are presented for various word lengths and transmission rates

. . . A few hypothetical tropospheric scatter links are set up to investigate the practicality of the combination.

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . apparent void between the engineer and the theorist in communication work. . . . A refreshing example of . . . combining . . . theory, and engineering may be found in a recent publication by Kotel'nikov. . . . It would be pleasant to report that the book being reviewed continues the good work of Kotel'nikov in bringing theory and practice more closely together. Such is not the case . . . The book is essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." The 18 authors are recognized authorities in their respective specialities, and the reader can appreciate the effort required to edit the contributed material into the 23 chapters which make up the book. . . . Book review by John P. Costas, in IRE Trans., vol. IT-7, no. 4, Oct. 1961, p. 284-285.

(No Title)
Sze-Hou Chang, et al., Electronics Research Lab., Northeastern U., Boston, Mass., 31 May 1961, 126 p., Final rept., AD 264 765.

The basic factors in multipath . . . some existing systems of reducing these defects, are examined together with conjectures on possible modifications of these systems to improve bandwidth-time utilization . . . two special classes of 2-3 channels, the complete erasure channel, . . . fractional erasure channel, are presented . . . A slope method for 3-3 and 2-3 channels is also discussed. . . .

CAPACITY OF 2-3 AND 3-3 CHANNELS
Sze-Hou Chang, et al., IRE Intern. Conv. Rec., vol. 4, March 1961, p. 106/125.

SOME REMARKS ON THE CAPACITY OF COMPOUND CHANNELS IN THE SEMI-CONTINUOUS CASE
H. Kesten, Information Control, vol. 4, nos. 2/3, Sept. 1961, p. 169/184.

. . . standard terminology . . . as it can be found in Feinstein (1958) or Wolfowitz (1961)

. . . a sender can transmit n symbols over a (noisy) channels. . . . The symbols received by the receiver belong to an output alphabet which may depend on s but which (by definition of the term semicontinuous) may be infinite.

THREE PROOFS FOR THE FUNDAMENTAL THEOREM OF INFORMATION THEORY: DISCRETE MEMORYLESS CHANNELS
F. M. Reza, Syracuse U. Research Inst., N.Y., June 1961, 54 p. (Scientific rept. 3, Rept. EE 747-6109SR3), AD 262 848.

. . . Subsequent to some preliminary preparations, describing the decision scheme and average error probability, three proofs of the basic theorem are presented: Feinstein's Proof, Shannon's Proof and Wolfowitz's Proof. A discussion of the bounds of error probability and their relations to the word length and the converse of the fundamental theorem is included.

THE CHANNEL CAPACITY OF ONE- AND TWO-PATH COMMUNICATION CHANNELS WITH POLARIZATION (In Russian)
L. Khai-Tsyuan', Radiotekhnika i Elektronika, vol. 6, no. 2, Feb. 1961, p. 200/203.

The channel capacity of the received signal is calculated for a uniform distribution of the angle between the electric field and a horizontal vibrator, with additive Gaussian noise. Particular cases given are for small signal to noise power ratios and for a high signal to noise power ratio. . . .

ON "SOME QUANTUM EFFECTS IN INFORMATION CHANNELS" (Correspondence)
D.A. Bell, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 57/58.

THE EFFECT OF STATISTICALLY DEPENDENT INTERFERENCE UPON CHANNEL CAPACITY
N. M. Blachman, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 53/57, 10 refs.

Bounds are derived and plotted for the capacity of a band-limited communication channel that accepts signals of specified average power as input, adding to them white gaussian noise and interference of specified average power which may depend on the signal being sent and on all of the other signals in the code book.

ON THE CAPACITY OF A BAND-LIMITED CHANNEL PERTURBED BY STATISTICALLY DEPENDENT INTERFERENCE
N. M. Blachman, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 48/55.

THE RATE OF INFORMATION TRANSMISSION THROUGH SYMMETRIC CHANNELS
L. F. Borodin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 10 Sept. 1962, 27 p. incl. illus. 9 refs. (Trans. no. FTD-TT-62-878 from Sto Let so Dnya Rozhdeniya A. S. Popova, Yubileynaya Sessiya, Izdatel'stvo Akademii Nauk SSSR, p. 57/73, 1960, AD 286 603.

. . . A graphical method is given for determining the optimum value of the probability of symbol erasure (in the sense of the maximum traffic capacity of a channel) . . . . It is shown that the optimum code of an erase channel in the presence of a sufficiently large number of symbols in a code combination allows information to be transmitted through an erase channel with a previously assigned uncertainty and rate, close to the traffic capacity of the channel. A method is indicated for setting up codes which have properties close to those of the optimum code of an erase channel, and also codes in which all combinations differ from one another exactly by d = a to the m-1 positions.

PARTIAL ORDERING OF DISCRETE CHANNELS
T. T. Chang, et al., IRE Intern. Conv. Rec. Pt. 4, vol. 10, March 1962, p. 190/199.

APPROXIMATE CALCULATION OF THE TRAFFIC CAPACITY OF RADIO CHANNELS HAVING RANDOM PARAMETERS
R. L. Dobrushin, et al., Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. 26 Sept. 1962, 9 p. 10 refs. (Trans. no. FTD-TT-62-1016 from Trudy Vsesoyuznogo Soveshchaniy po Teorii Veroyatnostey i Matematicheskoy Satistike, Izdatel'stvo AN Armyanskoy SSR, Yerevan, p. 164/171, 1960), AD 288 528.

UPPER BOUND TO THE CAPACITY OF A LINEAR TIME-VARYING CHANNEL WITH ADDITIVE GAUSSIAN NOISE
G. D. Forney, Jr., Lincoln Lab., Mass. Inst. of Tech., Lexington. 26 Sept. 1962, 15 p. incl. illus., 10 refs. (Rept. no. 34G-10), AD 287 453.

. . . evaluation of the upper bound to the capacity of a linear time-varying channel obtained by finding the capacity of the same channel when its behavior at all times is known a priori. Numerical evaluation turns out to depend on the distribution of the eigenvalues of a random infinite-dimensional matrix, which is apprently an unsolved mathematical problem. . . .

QUANTUM EFFECTS IN COMMUNICATIONS SYSTEMS
J. P. Gordon, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1898/1908.

. . . information capacity of various communications systems is considered. . . . The entropy of an electromagnetic wave having the quantum statistical properties of white-noise in a single transmission mode is found . . .

INFORMATION CAPACITY OF TIME-CONTINUOUS CHANNELS
R. Y. Huang, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 191/198.

. . . In the case where the channel introduces additive independent Gaussian noise of known correlation function, the capacity is evaluated subject to the constraint that the signal process have a given correlation function. . . . The channel capacity is shown to be directly related to results in the theory of optimum filtering over a finite time interval.

CHANNELS WITH ARBITRARILY VARYING CHANNEL PROBABILITY FUNCTIONS
J. Kiefer, et al., Information Control, vol. 5, no. 1, March 1962, p. 44/54.

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J. M. Kirshner, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

1. The concept of signal space . . . 2. Orthogonality of Functions . . . 3. Modulation, Demodulation, and the Sampling Theorem . . . 4. The Sampling Theorem and Separation of Channels . . . 5. Noise and Channel Capacity . . . 8. Orthogonality of Gaussian Noise Signals. . . .

INFORMATION TRANSMISSION RATE AT VERY LOW SIGNAL AND NOISE POWER
P. Leliak, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 4, Dec. 1962, p. 407/415.

. . . calculations are made using the assumption that the signal energy received is a Poisson-distributed random variable. . . . for communication from earth to a very deep space . . . near-space (earth satellite) relay . . . transmission from the relay to outer space. . . .

PROBABILISTIC NETWORK STUDY - SYSTEM RELIABILITY
F. M. Reza, Syracuse U. Research Inst., N.Y., Final rept., Aug. 1962, 43 p. incl. illus., refs., Rept. no. EE 747-6208FR, AD 296 975.

. . . presents a note on a new sampling theorem using Bernstein's orthogonal polynomials . . . contains a new relation between positive real functions of Circuit Theory and the h(p) functions of Reliability Theory. Part IV contains merely the formulation of a new problem concerning "nearly normal channels" and the evaluation of their information transmission.

COMMUNICATION IN RANDOM OR UNKNOWN CHANNELS
C. K. Rushforth, Stanford Electronics Lab., Stanford U., Calif., July 1962, 62 p. incl. illus., 19 refs., Rept. no. SEL-62-086, Technical rept. no. 2004-6, AD 283 083.

. . . problem of communicating in the presence of random or unknown multiplicative disturbances . . . signal selection . . . design and evaluation of the associated receiver. . . . Evaluation of the error probability for the transmitted-reference system for various situations indicates that, for a fixed signal-to-noise ratio, the error probability increases as the time-bandwidth product increases.

THE THRESHOLD EFFECT IN MODULATION SYSTEMS THAT EXPAND BANDWIDTH
D. Slepian, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 122/127.

. . . presents curves which are believed to represent the best thresholds obtainable with practical modulators that expand bandwidth and operate instantaneously on the baseband signal. The model from which the curves are obtained is described in detail.

COMMUNICATION AND INFORMATION THEORY ASPECTS OF THE NERVOUS SYSTEM
E. Agilides, General Dynamics/Electronics, Rochester, N.Y., Annual summary rept., 1 Oct. 1962-30 Sept. 1963, 30 Sept. 1963, 57 p., AD 437 348.

. . . Multicoding-Unichannel and Multicoding-Multichannel Coding Theories of the Nervous System; Piezo-electric Mechanical Transducer System and Terminology Used in Shannon's Theorem.

CAPACITY AND ERROR BOUNDS FOR A TIME-CONTINUOUS GAUSSIAN CHANNEL
R. B. Ash, Information Control, vol. 6, no. 1, March 1963, p. 14/27.

A model proposed by Fortet for a time-continuous Gaussian channel is analyzed. The model differs from that of Shannon in that a different constraint is imposed on the allowable input signals, and in addition the transmission of a code word in a given time interval is not assumed to interfere with the transmission of a word in any

other interval. . . . It is shown that the probability of error of an optimal code approaches zero exponentially with the time duration of the code words, provided the transmission rate is below channel capacity. . . .

PHRASE STRUCTURE LANGUAGES, FINITE MACHINES, AND CHANNEL CAPACITY
R. B. Banerji, Information Control, vol. 6, no. 2, June 1963, p. 153/162.

The concept of channel capacity is applicable and useful in the study of languages with structures more general than those generated by the finite state channels discussed in Information Theory. A technique has been developed in this paper whereby the channel capacity of a class of phrase structure languages can be calculated. . . .

CHARACTERIZATION OF RANDOMLY TIME-VARIANT LINEAR CHANNELS
P. A. Bello, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 360/393.

. . . it is demonstrated that time varying linear channels (or filters) may be characterized in an interesting symmetrical manner in time and frequency variables by arranging system functions in (time-frequency) dual pairs. . . . results are specialized by considering three classes of channels. These are the wide-sense stationary (WSS) channel, the uncorrelated scattering (US) channel, and the wide-sense stationary uncorrelated scattering (WSSUS) channel. . . . Several new canonical channel models are derived in this paper, some of which are dual to those of Kailath. . . .

ON INFORMATION RATES FOR FINITE-STATE CHANNELS
J. J. Birch, Information Control, vol. 6, no. 4, Dec. 1963, p. 372/380.

This paper presents sufficient conditions for the direct computation of the entropy for functional (nonMarkovian) processes and thus also of the rate of information for finite-state channels. . . .

ON THE COMPARISON OF COMMUNICATION CHANNELS (Correspondence)
T. T. Chang, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 97/98.

. . . Among the criteria for comparison of performance, the expected loss and the average rate of transfer of information are frequently considered. In a previous paper, we have shown that for these criteria and certain channels one can unequivocally state that one channel is superior to the other, while for other pairs of channels one cannot make such a statement. Therefore, these criteria lead to partial orderings. . . .

INFORMATION CAPACITY OF FADING CHANNELS UNDER CONDITIONS OF INTENSE INTERFERENCE
J. P. Costas, Proc. IEEE, vol. 51, no. 3, March 1963, p. 451/461.

. . . such systems must receive and process two distinct types of information. The first, and quite obvious, type of information concerns the intelligence signal which is provided as an output from the receiving terminal of the system. The second, and much less obvious, type of information concerns medium variations. . . . This paper is concerned with the limiting case of very small channel SNR's that are below the level required for analysis of the medium at the receiver. . . .

AN INFORMATION-THEORETICAL MODEL APPLIED TO COMPUTER PROGRAMS
W. R. Cowell, Argonne National Lab., Ill., Applied Mathematics Div., June 1963, 20 p., 5 refs., AN L-6722, N63-21206.

. . . to describe the match between a message and a communication channel. Also the model is interpreted so as to describe the match between a particular computation and a given instruction repertoire for a computer . . . a series of measurements which were made with IBM 704 programs are described.

IMPROVED COMPUTATIONAL BOUND FOR THE BINARY ERASURE CHANNEL (Correspondence)
M. A. Epstein, IEEE Trans. Inform. Th., vol., IT-9, no. 1, Jan. 1963, p. 51.

OSNOVNYE TEOREMY KONSTRUKTIVNOI TEORII OPTIMAL'NOGO KODIROVANIIA DLIA DISKRETNOGO KANALA S SHUMAMI (Basic Theorems in the Theory of Optimum Coding for a Discrete Channel in the Presence of Noise) (In Russian)
B. S. Fleishman, Radiotekhnika i Elektronika, vol. 8, Aug. 1963, p. 1291/1300, 18 refs., A63-25285.

. . . transmission over . . . channel with the zero memory . . . Construction of an optimum code according to Shannon is described. It is shown that, with the growing length of coding words, the probability of obtaining such a code, by a proposed random procedure, approaches unity faster than the probability of correct decoding.

EIN ISOMORPHISMUS ZWISCHEN DER NICHTBINÄREN LERNMATRIX UND SHANNONS KONTINUIERLICHEM KANAL (An Isomophism between the Non-Binary Learning Matrix and Shannon's Continuous Channel) (In German)

The non-binary learning matrix is an electrical circuit configuration of matrix structure which can store and recognize vectors (even after multiplication with an arbitrary positive scalar quantity). This matrix can be used, apart from technical applications, as a model for perception processes, in particular for the recognition of gestalts. . . .

MAXIMUM-LIKELIHOOD DETECTION IN A BINARY CHANNEL WITH MEMORY
R. A. Gonsalves, et al., Northeastern U., Boston, Mass., July 1963, 42 p., refs., AFCRL-63-313; AD 425 602, N64-12610.

. . . for binary signals transmitted sequentially over a channel with memory . . . The channel memory is assumed short enough so that there is intersymbol interference between adjacent symbols only . . . With the aid of a simplifying assumption, upper and lower bounds of the per symbol error probability are derived. These bounds check reasonably well with the results of a digital "Monte Carlo" experiment.

QUANTUM ELECTRONICS AND COMMUNICATION
J. P. Gordon, Md. U. Proc. of the Space Communications Inst., Md. U., College Park, June 23-28, 1963, p. 65/72, refs., N64-17199.

Entropy . . . Information . . . quantum-mechanical limitations on measuring processes . . . These ideas are applied to a basic communication system that consists of a transmitter, a transmission medium, and a receiver.

INFORMATION CAPACITY AND QUANTUM EFFECTS IN PROPAGATION CIRCUITS
T. Hagfors, Lincoln Lab., Mass. Inst. of Tech., Lexington, 24 Jan. 1964, 41 p., TR344, ESD TDR 64 23, AD 436 639.

. . . to establish an upper bound on the information capacity of an electromagnetic wave propagation circuit between two apertures when quantum effects come into play. . . . evaluating the channel capacity under average and peak power constraints. Due to mathematical difficulties we are only able to establish the channel capacity explicitly when the radiative losses become extreme. . . .

INFORMATION TRANSMISSION WITH TIME-CONTINUOUS RANDOM PROCESSES
R. Y. Huang, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 84/94, 21 refs.

. . . Shannon's definition for the information content of a Gaussian, time-continuous process in Gaussian noise is extended to the case where the observation interval is finite, and where the processes may be nonstationary, in a straightforward way. . . . Limiting relations are derived, to show that this reduces to previously established results in some cases, and to enable one to obtain rule-of-thumb estimates in others. . . .

LOSS IN INFORMATION TRANSMISSION THROUGH TWO-WAY CHANNELS
F. Jelinek, Information and Control, vol. 6, Dec. 1963, p. 337/371, A64-12159.

Analysis of a transducer-channel combination as a derived two-way channel whose inputs are the strategy functions and whose outputs are the outputs of the underlying channel. Expressions for the information transmission rate through the two directions of the derived channel are developed and are compared to the expressions for the average information about outputs of the equivalent signal sources, transmitted through the underlying two-way channel . . .

CODING FOR AND DECOMPOSITION OF TWO-WAY CHANNELS
F. Jelinek, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 5/17.

The present topic was first considered by Shannon. For the most part, he treated the discrete memoryless case, although one of his coding theorems applies also to discrete channels with finite memory. In this paper we shall restrict our attention to the discrete, memoryless two-way channel . . . Under certain natural restrictions, the binary two-way channel can be canonically decomposed into an interconnection of pairs of oppositely oriented memoryless one-way channels connected in cascade to special channels that are noiseless whenever the signal transmitted in the opposite direction is an appropriate one. Three distinct categories are defined into which the totality of all binary channels can be partitioned. . . .

A NOTE ON A CERTAIN THEOREM STATED BY KULLBACK (Correspondence)
A. K. Joshi, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 93/94.

In this communication we will introduce a capacity-like quantity using the symmetric divergence and then prove a simple relationship between this quantity and the capacity, C, of a channel. Using this relation we will show that Theorem 5.6 stated by Kullback follows at once as a special case. . . .

A THEORY OF QUANTUM COMMUNICATIONS
J. B. O'Neal, Florida U., Engineering and Industrial Experiment Station, Gainesville, 5 Dec. 1963, 66 p., Rept. no. SR2, N64-15808, AD 429 721.

A model for a bandlimited quantum communications channel and the channel capacity of such a channel in the absence of external and thermal noise are investigated. . . . The mere fact of

quantization itself, i.e., that a quantized signal is restricted to a finite number of states which it can assume, limits the ability of the signal to contain information. The other factor which degrades the performance of a channel is that every bandlimited signal contains an irreducible uncertainty which is due to the uncertainty principle. This report represents an attempt to construct a reasonable model which takes these two factors into consideration.

MAXIMUM LIKELIHOOD ESTIMATION IN FINITE STATIONARY ERGODIC MARKOV CHAINS AND A STRONG CONVERSE TO THE CODING THEOREM FOR CONTINUOUS MEMORYLESS CHANNELS
U.V.R.Rao, Michigan U., Ann Arbor, 1963, 70 p., refs., N64-17164.

NOTE ON "VERY NOISY" CHANNELS
B. Refifen, Lincoln Lab., Mass. Inst. of Tech., Lexington, June 1963, 5 p., AD 416 195.

a 'very noisy' channel is defined. This definition corresponds to many physical channels operating at low signal-to-noise ratio. . . . the computation cutoff rate for sequential decoding, R (comp), is shown to be one-half the capability, C . . .

A NOTE ON THE CAPACITY OF DISCRETE NOISELESS CHANNELS
F. M. Reza, Eidgenossische Technische Hochschule, Institut fur Fernmeldetechnik, Zurich, Switzerland, Zeitschrift fur Angewandte Mathematik und Physik, vol. 14, March 25, 1963, p. 175/178, A63-17890.

Presentation of a mathematical proof for a statement by Shannon concerning the channel capacity of a class of simple memoryless channels.

QUANTUM EFFECTS AND NOISE IN OPTICAL COMMUNICATIONS (Correspondence)
M. Ross, Proc. IEEE, vol. 51, no. 4, April 1963, p. 602/603.

In reference to Gordon's paper on quantum effects in communications, it appears he did not discuss the case for channel capacity when the black-body background noise N is very much less than hfB, the quantum noise . . .

TRANSMITTED-REFERENCE TECHNIQUES FOR RANDOM OR UNKNOWN CHANNELS
C. K. Rushforth, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 39/42.

. . . A particular set of signals is chosen, each member of which is partitioned into a known reference or sounding signal and a message signal. The channel is assumed to be linear, and is divided into a multiplicative and an additive portion. The multiplicative portion is assumed to have the same response to both message and reference components, while the additive noises associated with these components are assumed to be independent. The channel outputs and the additive noises are further assumed to be Gaussian. . . .

BOUNDS ON COMMUNICATION
D. Slepian, Bell Syst. Tech. Journal, vol. 42, no. 3, May 1963, p. 681/707.

Six parameters of importance in many communication systems are: (a) the rate at which digital information is transmitted; (b) the bandwidth of the system; (c) the signal power of the transmitted signals; (d) the noise power of disturbances in transmission; (e) the error probability in digits recovered at the receiver output; (f) the length of time that the transmitter and receiver can store their inputs . . .

A NOTE ON THE WORD ERROR PROBABILITY ASSOCIATED WITH A SEQUENCE OF DIGITS HAVING UNEQUAL ERROR PROBABILITIES (Correspondence)
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 492/493.

. . . in cases where the interference is nonstationary or where a quantized frequency modulation (QFM) transmission is perturbed by colored noise, the digit error probabilities will be unequal. These unequal digit error probabilities lead to cumbersome expressions for the probability distribution function for the number of ones in the error sequence and the word error probability. It is to the simplification of these problems that this note is addressed. . . .

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 19, 1963, 51 p., 9 refs., N63-23350.

. . . optimum way to divide the available energy between the channel measurement and information transfer functions. Specifically considered is a binary symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise . . . Under a wide variety of conditions, the best strategy is to devote all the available power to modulation, and to obtain the synchronizing information by performing some operation on the incoming signal which removes its dependence on the data.

THE ASYMPTOTIC BEHAVIOR OF LINEAR DECODING FOR THE BINARY SYMMETRIC CHANNEL (Correspondence)
T. J. Wagner, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 47/48.

One asks if in the binary symmetric channel it is possible to have a sequence of codes with linear decoders such that 1) the maximum probability of error tends to zero with block length and 2) the code rates converge to a positive rate less than channel capacity. The answer, unfortunately, is no. . . .

ON CHANNELS WITHOUT A CAPACITY
J. Wolfowitz, Information Control, vol. 6, no. 1, March 1963, p. 49/54.

CAPACITY OF TWO CLASSES OF INFORMATION CHANNELS WITH RANDOMLY VARYING PARAMETERS
N. A. Zheleznov, Telecommunications and Radio Engineering. Part I - Telecommunications, Translation, Oct. 1962, p. 1/7, A63-16480.

. . . a random change in parameters is interpreted as the appearance of additive noise, either correlated or not correlated with the signals. . . .

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, Massachusetts Inst. of Tech., Cambridge, Research Lab. of Electronics, 31 Jan. 1963, 108 p., refs., RLE-TR-399, AD 299 016, N64-18366.

A scheme for constructing a discrete signal space, for which sequential encoding-decoding methods are possible for the general continuous memoryless channel, is described. Random code selection is considered from a finite ensemble. The engineering advantage is that each code word is sequentially generated from a small number of basic waveforms . . . The application of sequential decoding to the continuous asymmetric channel is discussed. A new decoding scheme for convolutional codes, called successive decoding scheme for convolutional codes, called successive decoding, is introduced . . .

Related Publications:

ON COMMUNICATION PROCESSES INVOLVING LEARNING AND RANDOM DURATION
R. Bellman, et al., Rand Corp., Santa Monica, Calif., 23 Jan. 1958, rept. P-1194, AD 244 750.

. . . problems within the framework of multistage processes of stochastic type, and as such may be treated by the theory of dynamic programming. The relations between utility and capacity, in Shannon's sense, are indicated. The problem of how to treat communication problems involving the use of a channel whose statistical properties are not completely known, and those involving processes of random duration is discussed. . . .

ON CODED PHASE-COHERENT COMMUNICATIONS
A. J. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-7, no. 1, March 1961, p. 3/14.

. . . this paper considers the result of encoding independent equiprobable binary words or sequences of independent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white Gaussian noise and detected by correlating them with their stored or locally generated replicas at the receiver . . . It is shown that in the limit as the code word length and the bandwidth approach infinity, the received information rate approaches the channel capacity for only one value of the above ratio.

SIGNAL POWER IMPROVEMENT THROUGH CODING AND DIVERSITY
J. Mott-Smith, et al., Air Force Cambridge Research Labs., Bedford, Mass., June 1962, 37 p. incl. illus., tables, 6 refs., Rept. no. AFCRL 62-383, AD 283 349.

. . . calculated as a function of bandwidth, capacity, and reliability for gaussian noise and independent Rayleigh fading on a binary symmetric channel.

ERROR CODING BOUNDS FOR THE BINARY ASYMMETRIC CHANNEL (Correspondence)
T. H. Gordon, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 206/208.

. . . results of an effort to find a quantitative estimate of the loss in reliability if group or linear codes are used on the binary asymmetric channel . . . instead of optimum codes . . .

CERTAIN ASPECTS OF THE PERFORMANCE OF MEMORYLESS NONLINEAR SYSTEMS
J. C. Munson, Naval Ordnance Lab., White Oak, Md., Doctoral Thesis, 28 Nov. 1962, Rept. no. NOL-TR-62-201, AD 299 428.

DESCRIPTORS: signal-to-noise ratio, Digital systems, sampling, . . .

CORRELATION PROPERTIES OF CYCLIC SEQUENCES
R. C. Titsworth, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, July 1, 1963, 88 p., 76 refs., NASA CR-51586; JPL-TR-32-388, N63-23043.

. . . In the unconstrained channel with additive Gaussian noise, where the optimum detector is based on correlation or matched filters, the quality of a code can be expressed as a function of the correlation values between code words. Methods are presented for determining cyclic sequences with given correlation properties. When the amount of equipment in the receiver is limited, matched filtering is no longer the optimal detection scheme. A better system is one which by the use of Boolean Function, combines several "component" sequences to generate the transmitted signal; the receiver consists of filters matched to each component . . .

Section 1.14
Signal Theory

Circuit theory has a history of more than 50 years, but it is nearly exclusively based on the response of circuits to d.c., sinusoidal a.c. waveforms and to a few ideal transient waveforms. It is only in relatively recent time that efforts have been under way to investigate the properties of more complex signals and their interaction with all kinds of circuits. This section contains a representative selection of references to results of this young signal theory. In addition to these more general references the reader will find many special results of signal theory spread over many subdivisions of this volume. The cross references should establish an adequate interconnection.

There is some justification in dividing signal theory into the six subdivisions 1.141 to 1.146 below. However, the reader is invited to check always more than one of them, as most publications overlap the interfaces between these subdivisions.

1.140: General Publications in Signal Theory

Included: Books; Surveys, Collections of reports; Statements by leading scientists in the art.

Not Included: Circuit theory; Transient behavior of circuits; Signal theory of control systems; Signal theory of radar systems.

Cross References: Transient behavior of communications channels (1.622); Signal theory for digital communications systems (1.311).

Principal Publications:

A THEORY OF SIGNALS
R. E. Wernikoff, Mass. Inst. of Tech., Tech. Rept. #331, no. 331, Jan. 1958, p. 1/98.

UBER GRUNDLAGEN DER THEORIE ELEKTRISCHER SIGNALE (On fundamentals of the Theory of Electrical Signals)
F. H. Lange, Hochfrequenztech. U. Elekt. Akust., vol. 68, May 1959, p. 25/35.

REPRESENTATION AND ANALYSIS OF SIGNALS PART XII. THE DESIGN OF PURE SYSTEMS.
W. H. Huggins, Johns Hopkins U., Baltimore, Md., Oct. 1962, 159 p., AD 411 401.

. . . devoted to a coordinate-free formulation using Dirac's notation as extended by Lai and Ross, of some of the central concepts of linear-system theory. The notation provides a clear distintion between signals (i.e., observables) and patterns (i.e., measurement processes) and the numerical representatives which describe these signals or patterns. . . .

EINFUHRUNG IN DIE THEORETISCHE ELEKTROTECHNIK (Introduction to Theoretical Electrotechnique; 7th edition) (In German)
K. Kupfmuller, Berlin, Springer-Verlag, 1962, 512 p.

REPRESENTATION AND ANALYSIS OF SIGNALS PART XVII. REPRINTS ON SIGNAL THEORY
Johns Hopkins U., School of Engineering, Baltimore, Md., Final rept. 30 Nov. 1963, AD 431 162.

. . . reprints of a group of published papers reporting some of the main accomplishments under the program. . . . four appendices . . . (I) . . . names of those who have contributed to this program: (II) abstracts of all technical reports . . . (III) list all relevant papers . . . (IV) summarize lectures and talks.

1.141: Signal Space

Included: Uncertainty principle; Hilbert space; Woodward's uncertainty function; Time frequency duality.

Cross References: Bandwidth-time product of digital waveforms (1.311); Special signals with large WT product (1.920); Hilbert transform (1.143).

Principal Publications:

A NOTE ON AN INFORMATION THEORETIC FORM OF THE UNCERTAINTY PRINCIPLE
R. Bourret, Information Control, vol. 1, 1958, p. 398/401.

STUDIES OF WOODWARD's UNCERTAINTY FUNCTION
W. M. Siebert, Mass. Inst. Tech. Quart. Prog. Rept., April 1958, p. 90/94.

UBER GEWISSE ASYMPTOTISCHE BEZIE HUNGEN ZWISCHEN FREQUENZ UND ZEITFUNKTIONEN (On Certain Asymptotical Relations between Frequency- and Time-Functions)
H. Dobesch, Nachrichtentech., vol. 9, Jan. 1959, p. 13/18.

ON THE UNCERTAINTY RELATION FOR REAL SIGNALS: POSTSCRIPT
I. Kay, et al., Information Control, vol. 2, no. 4, Dec. 1959, p. 396/397.

ENTROPY AND THE UNCERTAINTY PRINCIPLE
R. Leipnik, Information Control, vol. 2, no. 1, April 1959, p. 64/79.

ON A NEW THEORY OF THE LIMITATION OF THE SIGNAL SPECTRUM (In French.)
J. Oswald, Cables et Transm., vol. 14, no. 4, Oct. 1960, p. 249/261.

Examines critically the theory of limitation of the signal spectrum in transmission. . . . in particular the impossibility of localising a signal simultaneously both with respect to duration and bandwidth . . . The basic idea of the present work is the substitution of a distributed function for the continuous functions (linear network operators) generally used for representing signals. This results naturally from the theory of sampling. . . .

REMARKS ON A HILBERT SPACE OF ANALYTIC FUNCTIONS
V. Vargmann, Princeton U., N. J., AFOSR J813, 21 Dec. 1961, 6 p., AD 412 992.

MEASURE, LEBESGUE INTEGRALS, AND HILBERT SPACE
A. N. Kolmogorov and S. V. Fomin, New York, Academic Press, 1961, 147 p.

Very clear presentation of the fundamentals of measure theory. Can be useful in coding theory, in channel theory, and in many other applications. Very good presentation of the abstract Hilbert Space. Will be useful in signal theory.

THE INDETERMINACIES OF MEASUREMENTS USING PULSES OF COHERENT ELECTROMAGNETIC ENERGY
R. Madden, Proc. Instn. Elect. Engrs. Part C (London), vol. 108, no. 13, March 1961, p. 247/251.

. . . for the measurement of velocity and acceleration of objects . . . further perfection of equipment and further development of measuring techniques may not yield an increase in the quality of measurements because of the limitation inherent in the pulses themselves. . . .

POINCARE'S THEOREM AND UNCERTAINTY IN CLASSICAL MECHANICS
L. Brillouin, Information Control, vol. 5, no. 3, Sept. 1962, p. 223/245.

. . . This theorem was first stated for celestial mechanics, but it extends immediately to all problems of classical mechanics, provided such problems be conservative. . . . a great variety of examples have been selected. . . .

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J. M. Kirshner, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

The concept of signal space allows one to apply geometric principles to waveforms used in communication. . . .

INCOHERENCE, QUANTUM FLUCTUATIONS, AND NOISE
I. R. Senitzky, Phys. Rev., vol, 128, no. 6, Dec. 1962, p. 2864/2870.

. . . relationship between the uncertainty principle and minimum amplifier noise. . . . the concept of coherence is discussed, and an incoherence parameter is defined in terms of the uncertainty that enters into the uncertainty principle. . . .

TIME-FREQUENCY DUALITY
P. Bello, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 18/33.

. . . applicable to a class of networks called communication-signal-processing networks. Such networks consist of an interconnection of basic elements such as filters, mixers, delay lines, etc. . . . benefit to be obtained from time-frequency duality is the generation of new ideas for communication signal processing techniques. We illustrate this type of benefit by constructing the dual of the Kineplex communication system. . . .

RESOLUTION LIMITS OF ANALYZERS AND OSCILLATORY SYSTEMS
E. L. R. Corliss, National Bureau of Standards, Washington, D. C., Oct, 1963, 14 p., AD 421 733.

The resolution limits are considered of those analyzers and oscillatory systems whose performance may be represented by a second-order differential equation. The "signal uncertainty" product is shown to be controlled by the ability of a system to indicate changes in energy content. The discussion refers the functioning of the system to a signal space whose coordinates are energy, frequency, and time.

GRANDIENT PROJECTION IN HILBERT SPACE
A. A. Goldstein, Boeing Scientific Research Labs., Seattle, Wash., June 1963, 9 p., Mathematical note no. 306, DI 82 0266, AD 412 410.

. . . two simple ideas. The first is a natural generalization of constructive techniques employed by Kantorovich and Altman for the minimization of quadratic functionals defined on a real Hilbert space H. . . . sometimes we can approximate well behaved non-differentiable functionals by a differentiable functional. This is the second idea.

Related Publications:

REAL-TIME MEASUREMENT AND CORRECTION OF PHASE DISTORTION IN HIGH-FIDELITY RADARS
J. DeLorenzo, et al., IEEE Intern. Conv. Rec. Pt. 8, vol, 11, March 1963, p. 96/103.

. . . Phase distortion causes variations in the radar uncertainty function, that, in many cases, degrade the resolution capability of the system. This paper briefly describes the characteristics of the common forms of distortion in practical systems and deals with the analytical and experimental results of phase measurements using a multiplier-type phase-error detector. The relationship of this device to active correlators and uncertainty function plotters will be described. A discussion of real-time correction of phase distortion with experimental results also is included. . . .

SIGNAL PROPAGATION IN A POSITIVE DEFINITE RIEMANNIAN SPACE
C. Lanczos, Physical Review, 2nd Series, vol. 134, April 27, 1964, p. B476-B480, 10 refs., A64-17404.

. . . It is shown that a positive definite Riemannian space of fourfold lattice structure is well suited to the propagation of signals, if the components of the metric tensor assume very large values along some narrow ridge surfaces. The resulting signal propagation is strictly translational and has the behavior of a particle which moves at the speed of light. According to this theory, the discrepancy between classical and quantum phenomena is caused by the misinterpretation of a Riemannian metric in Minkowskian terms.

GENERALIZED FREQUENCY-RESPONSE CONCEPTS FOR TIME-VARYING, DISCRETE-TIME LINEAR SYSTEMS
A. W. Naylor, Institute of Science & Tech., Univ. of Michigan, Ann Arbor, Feb. 1963, 30 p., Rept. no. 4563 32T., AD 419 788.

. . . shows that many of the frequency-response concepts associated with time-invariant system can be meaningfully generalized so that they can be applied to time-varying discrete-time linear systems. Among these generalized concepts are a generalized frequency domain, a direct transform from the time domain to the frequency domain to the transformation from the frequency domain to the time domain, a conception of bandwidth and gain-bandwidth product, and a generalization of Parseval's (Plancherel's) theorem. . . .

1.142: Signal Representations

Included: Envelopes and pre-envelopes of real waveforms; Instantaneous frequency; Complementary signals; Discrete representations of random signals; Representation of band limited signals; Products of signals; Signal analysis in general; Negative frequencies.

Not Included: Fundamentals of signal conversion (heterodyning).

Cross References: Elementary signals and their theory (1.311); Theory of angle modulation (1.231); Orthogonalized exponentials (1.311); Modulated signals (1.2); Signal distortions (1.62); Dirac's delta function (1.143); Distortions of random signals in communications channels (1.624).

Principal Publications:

ENVELOPES AND PRE-ENVELOPES OF REAL WAVEFORMS
J. Dugundji, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 53/57.

. . . Rice's formula is very cumbersome . . . different formula . . . easier to handle analytically.

A NOTE CONCERNING INSTANTANEOUS FREQUENCY
D. A. Linden, Proc. IRE, vol. 46, Dec. 1958, p. 1970.

OSCILLATORY PHENOMENA ON THE PASSAGE OF FREQUENCY THROUGH ZERO
M. I. Dorman, Radio Engng: Transl. of Radiotekhnika vol. 15, no. 10, 1960, p. 36/43.

A study is made of the features of the formation and fine structure of "zero beats." The correct form of notation for oscillations is established on the passage of the frequency through zero. The concept of "frequency" is re-stated more precisely. The author advocates the generalization of this notion for negative values, even for oscillations in the form of real time functions. . . .

SECOND-ORDER PROPERTIES OF THE PRE-ENVELOPE AND ENVELOPE PROCESSES (Correspondence)
M. Zakai, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 556/557.

DISCRETE REPRESENTATIONS OF RANDOM SIGNALS
K. L. Jordan, Jr., Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Doctoral thesis, 14 July 1961, 87 p. incl. illus., 65 refs., Technical rept. no. 378, AD 274 492.

. . . a conversion is necessary between a signal of continuous form and a signal of discrete form. . . .

ON THE DISCRETE REPRESENTATION OF A SIGNAL LIMITED IN TIME
V. V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 1, 1961, p. 69/74, 13 refs.

The author discusses an interpolation function differing from that used by V. A. Kotel'nikov for the representation of a signal limited in time by a series of discrete values. He considers the relationship of the obtained series with the Kotel'nikov's series, the errors associated with expansion, and the characteristics of spectral representation. . . .

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS
E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

. . . a rather general and mathematically convenient formulation of analog-modulated signals which makes use of the analytic signal concept. Known types of modulation are readily identified as special cases. . . . a new type of modulation has been discovered - single sideband frequency modulation (SSB FM) - which can be derived from a conventional phase-modulated signal by an additional amplitude modulation, using the exponential function of the modulating signal's Hilbert transform. The resulting modulated signal will have a one-sided spectrum about the carrier frequency, will be compatible with existing FM receivers, and will cause a decrease in signal bandwidth.

SOME FORMULAS INVOLVING PRODUCTS OF TRIGONOMETRIC FUNCTIONS SPACED AT REGULAR INTERVALS
M. Blumberg, Lockheed Aircraft Corp., Sunnyvale, Calif., Dec. 1962, 106 p., Rept. no. 6-90-62-125, AD 401 223.

Functions of the complex variable $z = x + jy$ involving products of trigonometric functions spaced at regular intervals . . . A compilation of the important formulas derived in the text together with examples is given in the appendix.

ON COMPLETENESS OF BASIC FUNCTIONS USED FOR SIGNAL ANALYSIS
P. R. Clement, Princeton U., N.J., 7 May 1962, 3 Dec. 1962, 9 p., AD 416 556.

MEAN SQUARE APPROXIMATION OF BAND-LIMITED SIGNALS
C. Engelman, Mitre Corp., Bedford, Mass., June 1962, 21 p., 1 ref., Technical memo. no. TM-3316, AD 295 565.

. . . By this we mean signals both of finite energy and whose Fourier transforms vanish outside some interval.

SIGNAL SELECTION FOR CONTINUOUS CHANNELS
T. L. Grettenberg, Stanford Electronic Labs., Stanford U., Calif., Tech. rept. on communications, rept. no. 6-90-62-46, In cooperation with Lockheed Aircraft Corp., Sunnyvale, Calif, July 1962, incl. illus., 19 refs., AD 283 996.

A criterion for selecting a finite set of transmitter signals for a continuous communication channel is proposed. . . . The signal selection procedure may be applied without a knowledge of the priori message statistics and does not require an evaluation of error probabilities. Three examples of signal selection are included to illustrate the procedure.

SUR LA LIMITATION SPECTRALE ET LA FREQUENCE INSTANTANÉE DES SIGNAUX (On the Spectral Limitation and the Instantaneous Frequency of Signals)
J. Oswald, IRE Trans. Inform. Th., Intern. Symp., Bussels, 1962, vol. IT-8, no. 5, Sept. 1962, p. 275/282.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART IX. "COMPLEMENTARY" SIGNALS AND ORTHOGONALIZED EXPONENTIALS
T. Y. Young, et al., Johns Hopkins U. School of Engineering, Baltimore, Md., 1 Jan. 1962, 32 p., AD 271 107.

When a signal is approximated by a finite set of component signals which span a subspace, the least square approximation may be interpreted geometrically in signal space as the projection of the true signal vector upon this finite dimensional subspace. In case the component signals are one-sided exponentials, the projection operators may be realized by simple physical filters following Krauts' procedure for constructing orthogonalized exponentials. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS PART XII THE DESIGN OF PURE SYSTEMS
W. H. Huggins, Johns Hopkins U., Baltimore, Md., Oct. 1962, 190 p., 84 refs., Final rept., N63-19200.

Abstracts . . . of the technical reports that have been published since the inception of the program in 1956. The main portion of the report is devoted to a coordinate-free formulation using Dirac's notion as extended by Lai and Ross, of some of the central concepts of linear-system theory. . . .

SIGNAL SELECTION IN COMMUNICATION AND RADAR SYSTEMS
T. L. Grettenberg, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 265/275.

A criterion for selecting a finite set of transmitter signals for a continuous communication channel is proposed. The "optimum" signal sets using this criterion are selected to maximize the minimum divergence between hypothesis pairs being tested at the receiver. . . .

TWO-DIMENSIONAL SIGNAL REPRESENTATION USING PROLATE SPHEROIDAL FUNCTIONS
D. A. Landgrebe, et al., IEEE Trans. Commun. Electronics, vol. CE, no. 65, March 1963, p. 30/40, 13 refs.

. . . Two similar 2-dimensional signal representations are defined for use in signal analysis problems. The proposed procedure divides the time-frequency plane into rectangles of arbitrary length and width and assigns a certain portion of the represented signal to each such rectangle. Representations are based upon time-limited and band-limited forms of the angular prolate spheroidal functions for conceptual and mathematical reasons. Applications and numerical examples are provided. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS PART XV MATCHED EXPONENTS FOR THE REPRESENTATION OF SIGNALS
R. N. McDonough, John Hopkins U., Baltimore, Md., 30 April 1963, 174 p., AD 411 431.

Approximation by sums of exponentials is considered from various points of view, such as the time-domain approximation problem of network synthesis, . . . Prony's method for approximate determination of the exponents is exhaustively reviewed in all its forms . . . The procedure is illustrated for the continuous case, and extensions to the discrete case are discussed.

NON-UNIFORMLY-WEIGHTED ORTHONORMAL OVER-DAMPED EXPONENTIAL APPROXIMATIONS
J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif., Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., SM-45777, N64-17757.

THE IDENTIFICATION OF OVERDAMPED PROCESSES IN THE TIME-DOMAIN
J. M. Mendel, Polytechnic Inst. of Brooklyn, Microwave Research Inst., N.Y., April 19, 1963, 151 p., 34 refs., PIBMRI-1131-63, AD 407 687, N63-16592.

. . . by means of exponential functions . . . Particular attention is given to: (1) the choice of a suitable error criterion . . . (2) the choice of weighting functions . . . (3) the extension of the orthonormal exponential approximations of Kautz and Huggins to approximations of any asymptotic-order in the s-domain.

SIGNAL ANALYSIS II: ESTIMATION OF THE AMPLITUDES OF NARROW BAND DETERMINISTIC SIGNALS OBSERVED INCOHERENTLY IN NORMAL NOISE BACKGROUNDS
D. Middleton, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., Feb. 1963, 103 p., Technical rept. no. AF-100, AD 297 870.

Communications theory, statistical distribution, statistical functions.

HARMONIC SYNTHESIS METHOD
V. G. Osipenko, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 15/22.

. . . Methods of representing trigonometric series in closed form, i.e., methods of harmonic synthesis, have recently found application in radio engineering. . . . In the present paper we suggest a new approach to these problems, based on replacing the discrete variable n (the index of the term of a series) by a continuous variable η; under certain conditions this replacement enables us to pass from a sum to an integral. . . .

NOTE ON PHASE-AMPLITUDE RELATIONS (Correspondence)
E. J. Post, Proc. IEEE, vol. 51, no. 4, April 1963, p. 627.

. . . discusses an extended version of the phase-amplitude theorem in terms of delay and slope of gain. The latter quantities are better suited to a formulation of the causality restrictions on dispersive systems. . . .

CONTRIBUTIONS TO SIGNAL AND NOISE THEORY
D. Slepian, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 229/233, 115 refs.

NEGATIVE FREQUENCY
D. G. Tucker, J. Brit. Instn. Radio Engrs., vol. 25, no. 4, April 1963, p. 289/290.

ABBREVIATED REPRESENTATION OF SIGNALS BY MEANS OF SYSTEMS OF ORTHOGONAL FUNCTIONS
A. M. Zayezdywyy, et al., Radio Engng: Transl. of Radioteknika, vol. 18, no. 11, Nov. 1963, p. 3/11.

. . . Abbreviated description means the representation of assigned signals in the form of expansions in a new system of orthogonal functions with a smaller number of terms. A method of obtaining a new system of orthogonal functions that

provides an abbreviated representation of assigned signals with least root-mean-square error is given. . . .

Related Publications:

SAMPLING OF SIGNALS WITHOUT D.C. COMPONENTS
R. Billings, Electronic Radio Engr., vol. 36, Feb. 1959, p. 70/72.

FURTHER COMMENTS ON "A MARKOFF ENVELOPE PROCESS" (Correspondence)
C. T. Isley, IRE Trans. Inform. Th. vol. IT-5, Dec. 1959, p. 186/188.

SIGNALS WITH MAXIMUM AND MINIMUM PROBABILITY OF DETECTION
V. A. Kotel'nikov, Radio Engrg. Electronics, vol. 4, no. 3, 1959, p. 5/11.

. . . to explain the form of the signal which ensures a maximum or minimum probability of correct detection when it is received with an ideal receiver . . . the derivation of the extreme values enables us to establish the limits within which the signal form can affect the probability of its detection. . . . represent all signal forms by the expressions . . . where B_i (t) are some mutually orthogonal functions in the interval -T/2, +T/2 . . .

SIGNAL DETECTION IN A NOISY WORLD
W. H. Huggins, Rand Corp., Santa Monica, Calif., 3 May 1960, 82 p., AD 241 288.

. . . when interfering signals and noise of unpredictable form and widely varying intensities are present, linear filtration is no longer adequate. It is then necessary to accept or reject the signal on the basis of its signature or waveshape. This problem is discussed in terms of the geometrical notions of a signal space . . .

SPECTRAL REPRESENTATION OF RESIDUAL-SIDE-BAND TRANSMISSION IN VIEW OF POSSIBLE INTERCONNECTION BETWEEN SINGLE- AND DOUBLE-SIDEBAND SYSTEMS (In German)
N. Berger, Nachrichtentech., vol. 11, no. 1, Jan. 1961, p. 31/35.

The use of filters whose response is dissymmetrical with respect to the carrier frequency of an amplitude-modulated wave involves frequency spectrum which is a complex Fourier transform. This is discussed and a method suggested whereby complex frequency spectra can be represented diagramatically.

A GENERAL METHOD FOR CONTROLLING THE TIME AND FREQUENCY ENVELOPES OF FM SIGNALS
E. N. Fowle, Lincoln Lab., MIT, Lexington, 5 June 1961, 13 p., Rept. 41G-0008, AD 258 055.

Research was concerned with finding expressions for the phase characteristics, time and frequency, when the envelope of a time function and the modulus of its Fourier transform are given. The method applies when the product of the function's time duration and its frequency extent is large. The technique presented applies for arbitrary envelope functions, thus extending the previous technique which required that one envelope or the other be rectangular.

THE VISUALIZATION OF FREQUENCY-MODULATION TRANSIENTS BY MEANS OF MECHANICAL MODELS
M. J. E. Golay, IRE Trans. Circuit Theory, vol. CT-9, no. 1, March 1962, p. 78/82.

. . . It has long been known that electrical circuits have equivalent mechanical circuits. . . .

GENERALIZED RESOLUTION IN RADAR SYSTEMS
H. Urkowitz, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2093/2105.

A generalized theory of radar resolution has been developed to facilitate understanding of the fundamental resolution limitations of radar systems. . . . concept of an ambiguity function . . . has been extended to include simultaneous resolution in range, range rate, azimuth and elevation . . . led to the derivation of a four-dimensional ambiguity function. . . . A new concept, "angular dispersion and compression," has been evolved . . . . The technique of maximum likelihood estimation has been extended to angular measurement.

THE SIFTING PROPERTY OF A COMMON FUNCTION (Correspondence)
H. Urkowitz, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2505.

It is well known that the impulse function δ (t) has the "sifting" property . . . Other functions have the sifting property as well. One of these is the sin x/x function provided f(t) is appropriately bandlimited. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS. PART X. SIGNAL THEORY AND ELECTROCARDIOGRAPHY
T. Y. Young, Johns Hopkins U. School of Engineering, Baltimore, Md., 15 May 1962, 112 p. incl. illus., tables, 37 refs., AD 277 015.

. . . to demonstrate that some signal theory concepts are applicable to and greatly facilitate the digital-computer diagnosis of electrocardiograms. . . .

PULSE-COMPRESSION PAIRED-ECHO EXPERIMENTS (Correspondence)
C. E. Cook, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 383/384.

It is of interest to note that the linear FM pulse-compression technique offers a direct means for instrumenting a laboratory analysis device that graphically demonstrates the effects of the various parameters of the paired-echo theory of signal distortion. . . .

SOME RELATIONS BETWEEN DIGITIZING PARAMETERS AND CALCULATED STATISTICS OF A WAVEFORM
R. McAulay, U. of Illinois Engineering Experiment Station, Urbana, 15 Aug. 1963, 36 p., Technical rept. no. 18, Technical rept. no. 1, Rept. no. RRL208, AD 417 243.

A THEORY OF QUANTUM COMMUNICATIONS
J. B. O'Neal Florida U., Engineering and Industrial Experiment Station, Gainesville, 5 Dec. 1963, 66 p., Rept. no. SR2, AD 429 721.

A model for a bandlimited quantum communications channel and the channel capacity of such a channel in the absence of external and thermal noise are investigated. . . .

AN INDEX OF APPROXIMATIONS OF FUNCTIONS
B. Prasad, California Univ., La Jolla, Aug. 1963, 32 p., AD 424 809.

A summary is presented of the rational and polynomial approximations of mathematical functions that are used in scientific computations . . . The most important approximation techniques used are Maclaurin Power Series, Chebyshev Expansion, Modified Taylor's Expansion, Lanczo's Method, Pade's Method, Maehley's Method, Heuristic approach of Hastings.

1.143: Signal Transformations

Included: Z transform; Fourier transforms; Delta functions; Fourier series; Fourier integrals; Hilbert transforms; General integral transforms; Fourier analysis; Wiener-Hopf equations; Cumulant transformation; Mellin transform: Laplace Transform; Hilbert transforms; Heaviside operational calculus.

Not Included: Laplace transform for circuit analysis; Integral transforms for transient analysis.

Cross References: Hilbert space (1.141).

Principal Publications:

VARIOUS DEFINITIONS OF THE DELTA ENTITIES
O. Pankraz, Proc. of IRE, vol. 46, Sept. 1958, p. 1653/1654.

GRAPHICAL INTERPRETATIONS FOR FREQUENCY TRANSFORMATIONS
J. L. Stewart, IRE WESCON Conv. Rec., no. 2, Aug. 1958, p. 42/45.

THE Z TRANSFORMATION
H. A. Helm, Bell Syst. Tech. J., vol. 38, no. 1, Jan. 1959, p. 177/196.

The stieltjes integral is used to develop a rigorous derivation of the z transform. . . .

FOURIER TRANSFORMS OF POSITIVE FUNCTIONS
M. Schetzen, MIT Res. Lab. Quarterly, Progress Rept. no. 52, Jan. 1959, p. 79/86.

A FOURIER SERIES TIME DOMAIN APPROXIMATION
D. R. Anderson, IRE Trans. Circuit Theory, vol. CT-7, Aug. 1960, p. 18/25.

EXPERIMENTAL CORRELOGRAMS AND FOURIER TRANSFORMS
N. F. Barber, Pergamon Press, 1961, 136 p.

GUIDE TO THE APPLICATIONS OF LAPLACE TRANSFORMS
G. Doetsch, Princeton, N. J., D. Van Nostrand Co., Inc., 1961, 255 p.

. . . an excellent book both from the standpoint of mathematical rigor and from the standpoint of practical applications. The author is particularly careful to point out those topics for which the reader might possibly have a false impression of the ideas being conveyed. In fact, he goes so far as to cite reputable engineering texts where these ideas are falsely conveyed. . . . The second edition of the German original of this book is available from R. Odlenburg Publishers, Munich, 1961.

THE DELTA FUNCTION AND THE FOURIER INTEGRAL
A. W. McMurtrey, Proc. IRE, vol. 49, Nov. 1961, p. 1702/1703.

THE DELTA FUNCTION (Correspondence)
J. L. Brown, Jr., Proc. IRE, vol. 50, Feb. 1962, p. 217.

AREA TRANSFORMS
W. M. Brown, IRE Trans. Circuit Theory, vol. CT-9, no. 2, June 1962, p. 163/168.

. . . presents the theory of an operational calculus which is much more general than previously available theories. The theory is essentially all inclusive in that any operational analysis for which there is a multiplicative notion of transfer function for linear time-invariant systems is a special case of the general theory given here. The introduction reviews the foundations of operational analysis and then leads quite naturally to area transforms as the most general form.

SOME EXAMPLES OF THE APPLICATION OF DIFFERENCE EQUATIONS AND OF THE DISCRETE LAPLACE TRANSFORMATION IN PULSE TECHNIQUES. (In German)
A. Darre, Frequenz, vol. 16, no. 7, July 1962, p. 262/270.

Considered are cases of pulse-train switching where no assumption can be made that the network is linear and that the pulse source has nil internal impedance. . . . Examples concern a rectifier circuit, a capacitive and a transformer output coupling, and lastly a low-pass filter network.

HILBERT TRANSFORMS AND MODULATION THEORY
F. F. Kuo, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 51/58.

Hilbert transforms are important in representing certain modulated signals. In this tutorial paper we will explore the use of Hilbert transforms in the theory of amplitude modulation, especially single sideband . . .

COMMENTS ON THE DELTA FUNCTION AND THE FOURIER INTEGRAL (Correspondence)
A. W. McMurtrey, Proc. IRE, vol. 50, Feb. 1962, p. 218/219.

HILBERT TRANSFORMS AND POSITIVE-REAL FUNCTIONS (Correspondence)
R. W. Newcomb, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2516/2517.

In a recent communication Papoulis has given a proof of the angle constraint for positive-real functions along the lines of that which Bayard attributes to Leroy. . . . it is of interest to know the limitations . . . For instance, the Hilbert transform method cannot be directly applied to the positive-real functions. In contrast, the Schwarz's lemma proof holds for all positive-real functions. . . .

THE FOURIER INTEGRAL AND ITS APPLICATIONS
A. Papoulis, New York, McGraw Hill Book Co., Inc., 1962, 318 p.

. . . a teaching book principally for electrical engineering graduate students. As such, this book has very little competition, its nearest equivalent being . . . van der Pol and Bremmer. . . .

AN ESTIMATE OF THE TRUNCATION ERROR IN FOURIER INTEGRALS (Correspondence)
A. Papoulis, IRE Trans. Circuit Theory, vol. CT-9, no. 2, June 1962, p. 186.

HILBERT TRANSFORMS OF BAND-PASS FUNCTIONS (Correspondence)
H. Urkowitz, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2143.

OPERATORENRECHNUNG UND LAPLACESCHE TRANSFORMATION NEBST ANWENDUNG IN PHYSIK UND TECHNIK (Operational Calculus and LaPlace Transform with Applications in Physics and Engineering) (In German) (Third and enlarged edition)
K. W. Wagner and A. Thoma, Leipzig, Verlag J. A. Barth, 1962, 489 p.

THE DELTA FUNCTION AND THE FOURIER INTEGRAL (Correspondence)
L. Weiss, Proc. IRE, vol. 50, Feb. 1962, p. 217/218.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART XI. INTEGRAL TRANSFORMS AND TIME-VARYING SYSTEMS
L. Weiss, Johns Hopkins U. School of Engineering, Baltimore, Md., 21 May 1962, 187 p., 23 refs., AD 277 013.

. . . the fundamental character of the transform method within the framework of the general theory of eigenfunction expansions for linear differential operators . . .

THE FUNDAMENTAL IMPORTANCE OF THE HEAVISIDE OPERATIONAL CALCULUS
W. P. Wilson, et al., J. Brit. Instn. Radio Engrs., vol. 24, no. 6, Dec. 1962, p. 461/477.

APPROXIMATION TO A SPECIFIED TIME RESPONSE
W. C. Yengst, IRE Trans. Circuit Theory, vol. CT-9, no. 2, June 1962, p. 152/162.

. . . problem of translating the time response specifications into a form that is amenable to synthesis of a realizable network. . . . If the problem of obtaining the Laplace transform for a prescribed impulse response as the ratio of polynomials can be solved, then it is possible to

complete the realization of the network. . . . The purpose of this paper is to present a procedure by which data, given as a function of time, can be transformed directly to a rational fraction form while simultaneously providing a least-square approximation to the function of time that minimizes the effect of uncorrelated random noise.

A PRODUCT THEOREM FOR HILBERT TRANSFORMS
E. Bedrosian, Proc. IEEE, vol. 51, May 1963, p. 868/869. 10 refs., AD 294 704, A63-16795.

. . . a simple means of handling products of functions for extending tables of Hilbert transforms. The theorem states that the Hilbert transform of the product of a low-pass and a high-pass signal with nonoverlapping spectra is given by the product of the low-pass signal and the Hilbert transform of the high-pass signal.

AN APPLICATION AND GENERATING METHODS FOR MELLIN TRANSFORMS
B. R. Johnson, Oregon State Univ., Corvallis, June 1964, 55 p., AD 422 999

. . . establishment of certain properties of a generalization of Lerch's zeta function. Nine powerful methods of generating new tables of Mellin transforms from existing tables . . . are described . . .

(No Title)
W. E. Morrow, Jr., et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 36G 4, 16 July 1963, 18 p., AD 413 786.

A new technique is described which allows the Fourier transformation of a signal to be taken in real time. This technique makes use of signals and networks having linear frequency modulation properties. Its salient features are that the bandwidth of the signal being transformed is increased by no more than a factor of two during processing and that both the real and imaginary parts of the Fourier transform are obtained. An experimental demonstration of the method is included.

A FOURIER THEOREM AND ITS APPLICATION TO THE MEASUREMENT OF ELECTROMAGNETIC FIELDS AND QUANTUM MECHANICAL STATES
H. E. Moses, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, April 30, 1963, 9 p., 4 refs., Tech Rept. 310, N63-22941.

. . . A mathematical theorem is given by which a complex function of a real argument can be determined from its absolute value and the absolute values of the Fourier transform of the truncated function for all possible truncations . . . The theorem presented enables the assignment of electric fields to energy densities and quantum mechanical states to sets of probability densities.

NOTES ON FOURIER ANALYSIS AND SPECTRAL WINDOWS
E. Parzen, Applied Mathematics and Statistics Labs., Stanford U., Calif., 15 May 1963, 61 p., TR48, AD 404 890.

THE LAPLACE TRANSFORM OF THE SECTIONALLY-CONTINUOUS DERIVATIVE OF A SECTIONALLY-CONTINUOUS FUNCTION
B. Rasof, Franklin Institute, Journal, vol. 277, Feb. 1964, p. 119/127, Ford Foundation-supported research, A64 15307.

. . .the Laplace transform . . . is the straightforward and efficient manner with which sectionally-continuous functions can be treated. This feature of the Laplace transform is the basis for some of its most interesting and useful applications . . . In certain important applications, both the function and its derivative are sectionally-continuous, with a common abscissa of discontinuity. This matter is clarified and corrected in the present analysis.

WIENER-HOPF DIFFERENCE EQUATIONS
G. Strang, Journal of Mathematics and Mechanics, vol. 13, Jan. 1964, p. 85/96, 14 refs., A64-15507.

Development of a general theory of mixed problems for linear hyperbolic equations for the simplest situation, that is, for a scalar equation and one plane boundary. . . .

KUMULIANTNOE PREOBRAZOVANIE I VOZMOZHNOSTI EGO ISPOL'-ZOVANIIA DLIA ISSLEDOVANIIA DINAMICHESKIKH SISTEM (Cumulant Transformation and Its Possible Applications in the Investigation of Dynamic Systems) (In Russian)
A. M. Tsirlin, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Nov.-Dec. 1963, p. 93/100, A64-14242.

Discussion of an integral transform whereby a convolution of initial functions appears as a sum of the transformed functions. This type of transform is termed cumulant due to its analogy with the relations between moments and cumulants in the distribution law of a random quantity. An analysis of the properties of the cumulant transform shows that it is best suited for the solution of problems usually solved by means of logarithmic frequency characteristics, and yields substantial advantages over the latter technique.

ON THE SAMPLING PROPERTY OF THE DELTA FUNCTION
H. Urkowitz, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1057/1058.

The sampling property attributed to the delta function is usually expressed in . . . an integral expression . . . where f(t) is continuous at t = a.

In a recent communication Urkowitz asserts an apparently more general result which for clarity, we shall refer to as the sifting property . . . in case f(t) has at worst an ordinary discontinuity at t=a. The main prupose of the present communication is to point out that these two properties are genuinely distinct and that the sifting property does not apply to the delta function at all. . . .

DETERMINATION OF SOURCE FEATURES BY MEANS OF INTERFEROMETRY (Correspondence)
D. R. Wells, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1245.

. . . resolution properties of radar and radio telescopes . . . substantial simplification by means of the ambiguity function. However, other features of the energy source or reflector are available from the interferometer type of receiver . . . By separation of the received signal into even and odd components about the antenna axis, the real and imaginary components of the source can be directly extracted, and it is clear from the Hilbert Transform that both even and odd portions of the signal contain all the signal properties that are available.

Related Publications:

PULSE SYSTEM THEORY APPLICATIONS. II
K. Ikrath, Army Signal Research and Development Lab., Fort Monmouth, 1 March 1960, ASRDL technical rept. 2099, AD 246 075.

The wave shapes of pulse train responses of various filter networks under different operating conditions are accurately formulated on the basis of mathematical methods which are documented in AD 140 511. A quantitative insight into the shortcomings of ordinary Laplace Transform and Fourier Transform approach to pulse systems problems is given on the basis of numerical examples whose practical implications are discussed.

1.144: Signal Correlation Properties

Included: Spectral correlation theory (USSR); Autocorrelation of signals; Finite convolution; Quasi correlation methods (USSR); Integral equations of the convolution type; Correlation functions in general; Correlation electronics (Germany).

Not Included: Autocorrelation properties of binary sequences (2); PN-sequences (2).

Cross References: Pn-sequences as digital waveforms (1.314); Spectral analysis of signals; (1.145); Correlation properties of modulated waveforms (1.210); Correlation receivers for data transmission (1.373).

Principal Publications:

APPROXIMATION OF AUTOCORRELATION FUNCTIONS BY A SERIES OF DAMPED COSINE FUNCTIONS
D. T. Friest, et. al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 709/714.

Autocorrelation functions arrived at experimentally seldom have simple mathematical form and thus must be approximated somehow or other for analytical studies. . . . This technique of analyzing a random function is analogous to the conventional Fourier analysis of a nonsinusoidal wave, except that it leads to bands of frequencies which are integrally related rather than discrete frequencies. . . .

KORRELATIONSELECTRONIK (Correlation Electronics) (In German)
F. H. Lange, Berlin, VEB Verlag Technik, 1959, 320 p. (For second edition see 1962.)

SOME PROBLEMS OF THE SPECTRAL-CORRELATION THEORY OF NON-STATIONARY SIGNALS
N. A. Zheleznov, Radio Engrg. & Electronics, vol. 4, no. 3, 1959, p. 12/30.

. . . Relationships are formulated between the corresponding spectral and correlation functions in the form of Fourier transformation pairs. The ergodic theorems are proved for non-stationary signals and the physical content of the conditions for which these theorems are valid are explained. The spectral and correlational functions of a few classes of non-stationary signals are examined.

THE TIME CORRELATION INTERVALS OF SIGNALS AND ITS CONNECTION WITH THE PARAMETERS OF THE POWER SPECTRUM
N. A. Zheleznov, Telecommunications, no. 5, Oct. 1961, p. 478/488.

. . . calculation of the interval of time correlation for arbitrary non-stationary signals with respect to the spectrum of power. . . . As an example the interval of correlation of the signals of Russian speech is calculated. The connection between the number of measurements of a model with a limited spectrum and the number of degrees of freedom is considered. . . .

RAPID EVALUATION OF THE AUTO-CORRELATION FUNCTION OF THE OUTPUT OF SINGLE-VALUED NON-LINEARITIES IN RESPONSE TO SINUSOIDAL AND GAUSSIAN SIGNALS

D. P. Atherton, Proc. Instn. Elect. Engrs. London, (Part C), vol. 109, no. 16, Sept. 1962, p. 656/664.

. . . can be used for the rapid evaluation of the response of a single-valued non-linear element to a sinusoidal signal and Gaussian noise, applied separately or together. The technique used is to approximate the non-linear characteristic by a stepped or 'digitized' waveform; exact evaluation of the response of the digitized characteristic can easily be obtained. . . .

THE APPLICATION OF INVERSE CONVOLUTION TECHNIQUES TO IMPROVE SIGNAL RESPONSE OF RECORDED GEOPHYSICAL DATA

C. F. George, et al., Proc. IRE, vol. 50, no. 11, Nov. 1962, p. 2313/2319.

The process of restoring signal resolution to data recorded from a sluggish measuring device may be accomplished by appropriate mathematical operations on the data using a large digital computer. Smoothing techniques may be applied in the transform domain to derive an inverse convolver to be used in real space. The inverse convolver, a non-physically realizable filter function, when convolved with the output of the device, restores high-frequency components necessary for sharp detail. . . .

KORRELATIONSELEKTRONIK, GRUNDLAGEN UND ANWENDUNG DER KORRELATIONS-ANALYSE IN DER MODERNEN NACHRICHTEN-, MeB- UND REGELUNGSTECHNIK; (2 Aufl.) (Correlation electronics. Fundamentals and Applications of Correlation Analysis in the Modern Communications and Control Technique) (2d edition) (In German)

F. H. Lange, Berlin, Verlag Technik, 1962, 381 p.

SOME PROPERTIES OF THE FINITE CONVOLUTION

J. A. Sheehan, Mitre Corp., Bedford, Mass. 17 July 1962, 26 p., 9 refs., Technical memo no. TM-3346, AD 291 868.

. . . In this paper, we shall impose upon r(tau) and f(t) the restriction that they are members of the class of functions on compact support, that is, functions which vanish outside finite invervals of the tau- or t-axis. Our main results are a set of existence and uniqueness (or non-uniqueness) theorems on the solution of r(tau) in short functions. A short function is, of course, simply the Fourier transform of a band-limited signal, and a short auto-correlation function is simply the Fourier transform of the square of the envelope of a band-limited signal.

CORRELATION FUNCTIONS FOR THE RANDOM BINARY WAVE (Correspondence)

P. W. Cooper, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 496/497.

This note presents expressions for the auto-correlation function, its Hilbert Transform, and the associated "envelope" and "phase" functions for the band-limited random binary wave. Interest in these functions could arise, for example, in analysis of the "envelope" of a signal and in correlation detection of a single sideband waveform . . .

FREQUENCY RESPONSE MEASUREMENT BY CROSS CORRELATION (Correspondence)

E. R. Funke, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1253.

When measuring a system's amplitude and phase response with respect to frequency it is often found expensive or difficult to generate a 90^{o} phase shift of the sinusoidal input. It may be of interest to point out that the 90^{o} phase shift is not essential for this measurement and any known phase shifter will be sufficient for this purpose. . . .

CONSTRUCTION OF TIME-LIMITED FUNCTIONS WITH SPECIFIED AUTO-CORRELATION FUNCTIONS

E. M. Hofstetter, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 119/126.

A necessary and sufficient condition is derived for a function to be the autocorrelation function of a time-limited function of specified length. A constructive procedure for determining all possible time-limited functions having the same auto-correlation function as a given time-limited function is presented. . . .

ON THE APPROXIMATE SOLUTION OF INTEGRAL EQUATIONS OF THE CONVOLUTION TYPE

Y. L. Luke, Midwest Research Inst., Kansas City, Mo., Final rept., 1 Jan.-Dec. 1961, Feb. 1963, 23 p., AD 403 426.

Convolution integral equations have a simple representation in the form of a Laplace transform, and so solution follows by transform inversion . . . Approximations to an inverse Laplace transform are studied when the transform, which involves the exponential integral, is approximated by rational functions. The approximate solution is a sum of exponential functions, and numerics are presented to show the efficiency of our technique.

KVAZIKORRELATSIONNYI METOD ISSLEDOVANIIA PEREKHODNYKH PROTSESSOV V LINEINYKH SISTEMAKH (A Quasi-Correlation Method for Studying the Transient Response of Linear Systems) (In Russian)
I. N. Migulin, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1351/1359, A64-13217.

Presentation of an approximate method for calculating the delay period, transient period, and overshoot of a system from its frequency and phase characteristics. An expression is derived, using which the transient characteristic of a system can be calculated with any required accuracy.

AN ANALYZER FOR MEASURING THE WIENER COHERENCY MATRIX OF TWO SIGNALS (Correspondence)
N. G. Parke, III, Proc. IEEE, vol. 51, no. 6, June 1963, p. 951/952.

The density form of the Wiener coherence matrix is equivalent from an information theoretical standpoint to the matrix of auto- and cross-correlations of two signals. A technique for measuring a two-by-two Wiener coherency matrix using four multiple-filter spectrum analyzers has been worked out. . . .

1.145: Signal Spectra

Included: Amplitude spectra of signals; Phase spectra of signals; Power spectra in general; Instantaneous spectra; Spectra power density of signals; Pseudo-spectra; Limited spectrum functions (USSR); Complex spectra.

Not Included: Spectrum analysis; Spectra of speech waveforms (2); Ambiguity functions (2).

Cross References: Power spectra of modulated waveforms (1.210); Power spectra of pulse trains (1.413); Spectra of elementary waveforms (1.311); Spectral characteristics of noise (1.711).

Principal Publications:

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING—PART I
R. B. Blackman, et al., Bell Syst. Tech. J., vol. 37, no. 1, Jan. 1958, p. 185.

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING—PART II
R. B. Blackman, et al., Bell Syst. Tech. J., vol. 37, no. 2, March 1958, p. 485/569.

METHOD OF OBTAINING AMPLITUDE AND PHASE SPECTRA OF A TRANSIENT FUNCTION USING GRAPHICAL INPUT DATA
W. J. Remillard, J. Acoust. Soc. Amer., vol. 31, April 1959, p. 531/534.

Both amplitude and phase spectra are needed to characterize transient functions completely. Analysis shows how these spectra can be obtained from the envelopes of the line spectra of the even and odd parts of a transient function made to recur in time. Instrumentation is described for the convenient determination of these line spectra.

DER BEGRIFF DER LEISTUNG BEI KOMPLEXEN FREQUENZEN (The Definition of Power with Complex Frequencies) (In German)
G. Schilling, Frequenz, vol. 13, March 1959, 2036/2037.

CALCULATING THE SPECTRUM POWER DENSITY OF A SIGNAL
Proc. IRE, vol. 48, no. 12, Dec. 1960, p. 2036/2037.

. . . The Q of the filter is chosen to be compatible with the spectrum variations of the signal under test. . .

A NOTE ON INSTANTANEOUS SPECTRUM
Proc. IRE, vol. 49, no. 2, March 1961, p. 649.

(good bibliography)

ESTIMATION OF POWER SPECTRAL DENSITY BY FILTERS
E. J. Gauss, Association for Computing Machinery, Journal, vol. 11, Jan. 1964, p. 98/103, 8 refs., A64-14416.

Presentation of an algorithm which differs from previous methods by being more adaptable for searching over wide frequency ranges and which permits the estimation of spectral density as a function of time as well as of frequency . . .

A THEORY OF THE PSEUDOSPECTRUM AND ITS APPLICATION TO NONSTATIONARY DYNAMIC ECONOMETRIC MODELS
M. Hatanaka, et al., Princeton U., N. J., 31 Jan. 1963, 38 p., Research memo. no. 52, AD 299 585.

A METHOD OF CALCULATING COMPLEX SPECTRA OF IMPULSE FUNCTIONS BY MEANS OF AN AMPLITUDE ANALYZER (In Russian)
S. A. Kats, Akademiia Nauk SSSR, Izvestia, Seriia Geofizicheskaia, no. 10, 1963, p. 1544/1553., Academy of Sciences USSR, Bulletin, Geophysics Series, Oct. 1963, p. 932/937, Translation, A64-14817.

. . . determination of amplitude and phase spectra of impulse functions . . . permits the real and imaginary parts of a complex spectrum to be calculated by means of an amplitude analyzer. As an example, a sinusoid, shifted relative to the commencement of recording, is analyzed. It is shown that by varying the method of analysis, it is possible to impart to a

pulse-height analyzer the possibilities of a multi-purpose device which determines amplitude and phase spectra.

INSTANTANEOUS SPECTRA AND AMBIGUITY FUNCTIONS (Correspondence)
M. J. Levin, IEEE Trans. Inform. Theory, vol. IT-10, no. 1, Jan. 1964, p. 95/97.

A formulation of the "instantaneous spectrum" of a waveform is described which is a modification of that originally considered by Page and extended by Turner. It is shown that this function is the double Fourier transform of the complex-conjugate of the ambiguity function and has other interesting properties. . . .

THE STRUCTURE OF FUNCTIONS WITH A LIMITED SPECTRUM AND RELATED PROBLEMS IN COMMUNICATIONS THEORY
B. S. Tsybakov, et al., Joint Publications Research Service, Washington, D. C., 3 April 1963, 19 p., refs., Transl. into English of an article from Mosk. Fiz-Tekh Inst., Issled. P. Fiz. i Radiotekhn., Tr. Inst. (Moscow), no. 2, 1958, p. 13/29, N64-11057.

. . . Limited spectrum functions . . . and . . . their derivatives defined over some periodic sequence of arguments . . . meaning of representation of a limited spectrum as a Kotel'nikov series . . . relationship between limited spectrum functions and whole functions . . . solution of the interpolation problem for the whole function . . . expansion in the form of a Kotel'nikov series was sought . . .

Related Publications:

COMPARISON OF POWER SPECTRAL DENSITY TECHNIQUES AS APPLIED TO DIGITALIZED DATA RECORDS OF NON-STATIONARY PROCESSES, PART I
G. W. Evans, II, et al., Stanford Research Inst., Menlo Park, Calif., Sept. 1963, 141 p., Technical rept. no. 14, AD 419 493.

. . . discussion of harmonic analysis, power spectral analysis, stationary and nonstationary stochastic processes, and a description of twenty-seven techniques for power spectral density (PSD) analysis. . . . Part II of this report . . . uses the preferred technique to analyze actual data from recordings of radar backscatter from missiles.

1.146: Signal Theory of Circuits and Systems

Included: Signals in time-varying systems; Frequency synthesizing networks; Sideband algebra; Transfer function synthesis.

Not Included: Analysis of time-varying systems; Network analysis and synthesis; Theory of control systems.

Cross References: Fundamentals of pulse transmission over channels (1.622); Signal distortion in communication channels (1.62); Practical channels with time-variable parameters (1.61).

Principal Publications:

VARIABLE FREQUENCY ELECTRIC CIRCUIT THEORY WITH APPLICATION TO THE THEORY OF FREQUENCY MODULATION
V. Carson, et al., Bell Syst. Tech. J., vol. 16, Oct. 1937.

APPLICATION OF FOURIER TRANSFORMS TO VARIABLE-FREQUENCY CIRCUIT ANALYSIS
A. G. Clavier, Proc. IRE, vol. 37, Nov. 1949, p. 1287/1290.

THE INTERPOLATION OF FUNCTIONS BY EXPONENTIAL POLYNOMIALS AND ITS APPLICATION TO THE SYNTHESIS OF ELECTRICAL CIRCUITS WITH RESPECT TO TIME CHARACTERISTICS
N. S. Kochanov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 87/95.

A study is made of the make-up of exponential polynomials, with respect to the values of a time function and its first derivative at a number of equidistant points of interpolation. The use of this method is shown for the synthesis of a four-pole forming a sine-squared pulse. . . .

THEORY OF A FREQUENCY-SYNTHESIZING NETWORK
B. M. Wojciechowski, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 649/673.

The theoretical basis for designing frequency-combining and selecting circuits is developed. By the introduction of "sideband algebra" and of a frequency symbolic network, the new method offers formal design procedures in place of intuitive ones.

DISCRETE, FINITE REPRESENTATION OF A LINEAR, STATIONARY SYSTEM
P. J. Butterly, Johns Hopkins U., Carlyle Barton Lab., Baltimore, Md., May 1963, 50 p., 6 refs., AD 405 826, N63-16919.

This report describes a linear system representation suitable for use with signals of finite dimensionality. This representation takes the

form of a matrix with elements which depend both on the choice of signal basis and on the transmission properties of the system. . . . transformation formulas are established for a number of cases . . .

GENERALIZED FREQUENCY RESPONSE CONCEPTS FOR TIME-VARYING, DISCRETE-TIME LINEAR SYSTEMS
A. W. Naylor, IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 428/440.

. . . It is shown that many of the frequency response concepts associated with time-invariant linear systems can be extended in a meaningful manner to time-varying, discrete-time linear systems. Generalized frequency domain representations of the input and output are introduced along with a generalized frequency response or transfer function relating input and output. In addition, generalizations of bandwidth, gain bandwidth product, and Parseval's (Plancherel's) theorem are introduced. . . .

TRANSFER FUNCTION SYNTHESIS AS A RATIO OF TWO COMPLEX POLYNOMIALS
C. K. Sanathanan, et al., Argonne National Lab., Ill., May 1963, 37 p., 6 refs., ANL-6716, N63-19825.

Experimental data for frequency response obtained from a linear dynamic system is processed to obtain the transfer function as a ratio of two frequency-dependent polynomials. . . . The magnitude and phase angle of the transfer function are evaluated at various frequencies by means of the computed polynomial ratio, . . . The numerical solution of this problem was obtained by using an IBM-704 FORTRAN program. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS. PART XIV. TIME VARYING SYSTEMS WITH SEPARABLE SYSTEM FUNCTIONS
L. Weiss, Johns Hopkins U., School of Engineering, Baltimore, Md., 30 Jan. 1963, 94 p., AD 411 274.

The relationship of the differential equation of a system to the system's weighting pattern (impulse response) is discussed. The realization of linear differential systems is discussed, and some "tricks" regarding manipulation of the position of function generators in an analog computer type realization (without changing the input-output relation) are presented. . .

Related Publications:

THEORETICAL FUNDAMENTALS OF PULSE TRANSMISSION
E. D. Sunde, Bell Syst. Tech. J., May 1954, p. 729.

PHASE INTERCEPT DISTORTION
P. F. Ordung, Dunham Lab., Yale U., New Haven, Conn., Quarterly progress rept. no. 6, Oct. 1958, AD 207 085.

. . . attenuation shall be constant and the phase characteristic shall be a linear function of frequency throughout the passband of the message. . . . these conditions . . . are not sufficient to guarantee that the transmission

. . . will be distortion free. An additional requirement should be that the linear phase characteristic in the passband when extended to zero frequency shall have a phase angle intercept (or phase intercept) that is a multiple of π radians. When the phase intercept angle is other than a multiple of π radians, a form of distortion, which is known as phase intercept distortion is obtained. (See also AD 154 561)

GEOMETRIC-ANALYTIC THEORY OF TRANSITION IN ELECTRICAL ENGINEERING
E. F. Bolinder, Proc. IRE, vol. 47, June 1959, p. 1124/1129.

. . . applied to circuit theory. A transition from one state to another is represented in a complex plane by two points which, by variation of a parameter, approach each other, coalesce, and then separate along trajectories perpendicular to the original trajectories.

DIVISION 1.2
ANALOG MODULATION METHODS

The majority of important publications on analog modulation methods appeared prior to 1958, the beginning of the period covered in this bibliography. Some historically important papers of earlier dates are referenced and additional references will be found in books and surveys mentioned in this division and in subdivision 1.100.

It is interesting to note that many of the so-called digital systems, such as some phase shift keying systems, actually use a perfectly analog and linear modulation and transmission system (in this case phase modulation) and the only nonlinear element with discrete characteristics is a limiter or slicer after the phase demodulator. Thus the reader may expect to find that many publications in division 1.3 are closely related to the corresponding problems of this division. Thus it is advisable to relate FSK to FM, phase shift keying to phase modulation and vestigial sideband data systems to problems of asymmetric sideband modulation for analog channels.

Section 1.20

1.200: Analog Modulation Methods in General

Included: Problems common to all analog modulation methods; Generalized theory of frequency and amplitude modulation; Modulated carrier signals in general.

Cross References: Books and surveys on modulation methods (1.100); Comparison of modulation methods (Div. 1.8); Multiple modulation methods (Div. 1.9).

Principal Publications:

GENERALIZED THEORY OF FREQUENCY AND AMPLITUDE MODULATION
L. J. Giacoletto, Proc. IRE, July 1947.

DIE AMPLITUDE UND DIE FREQUENZ EINER MODULIERTEN TRAGERWELLE (The Amplitude and the Frequency of a Modulated Carrier Frequency) (In German)
A. Ditl, Hochfrequenztech. u. Elektakustik, vol. 66, March 1958, p. 160/167.

GENERAL PROPERTIES OF FREQUENCY-CONVERTING NETWORKS
S. Duinker, Philips Res. Rep., vol. 13, Feb. 1958, p. 37/78.

NEW MODULATION AND DETECTION METHODS
G. Guenther, RCA, Reprint of Lecture No. 4, (Mod. Comm.) Feb. 10, 1958, Held at Univ. of Philadelphia, RCA Review, Feb. 1958, p. 339.

MODULATION
S. Weber, Electronics, vol. 32, no. 43, Oct. 1959, p. 103/105.

Optimum modulation method is required for best use of the propagation medium.
Engineers are not always agreed on what is optimum.
Amplitude Modulation -
Frequency Modulation -
Pulse Modulation -
Single Sideband -

Costas on Double Sideband

Related Publications:

METHODS OF COMPARISON AND EVALUATION OF COMMUNICATION SYSTEMS
L. Valcik, et al., Armour Research Foundation, Chicago, Ill., 26 July 1960, AD 244 887.

. . . methods for comparing and evaluating long-range point-to-point communication systems . . . a review of factors affecting the choice of modulation for use with the various propagation modes. . . . a review of AM, FM, and PM principles, discussion of matched filters and correlation detectors, a short summary of propagation effects on some types of signals. Emphasis is on the theoretical performance of digital AM, FSK, and PSK systems under certain non-fading conditions. An extensive list of references is included.

RESEARCH ON THE THEORY AND UTILIZATION OF VARIOUS PHENOMENA IN THE PERFORMANCE OF CIRCUIT FUNCTIONS
C. Volz, et al., Solid Circuits Res. Lab., Penn. State U. Coll. of Engrg., University Park, Scientific rept. 6. 1 Nov. 1959 - 1 Feb. 1960, 57 p. AD 243 595.

. . . The carrier is a physical entity taking the form of a signal whose sole purpose is to serve as a vehicle for the transmission of information through the system. Ultimately these concepts should lead to a simplified mathematical procedure for handling circuit operations individually or in combination.

Section 1.21

1.210: Analysis of Analog Modulation Methods

Included: Power spectra of modulated signals in general; Autocorrelation function of modulated waveforms; Measurement of power spectra; Computer analysis of power spectra; Statistical description of modulated signals.

Not Included: Spectrum analyzers; Interference spectra of communications equipment.

Cross References: Spectra of signals in general (1.145); Power spectra of pulse trains (1.413); Fundamentals of correlation processes (1.111); Signal correlation properties (1.144); Power spectra of FM signals (1.232); Comparison of various analog modulation systems (1.820).

Principal Publications:

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING. PT. I AND PT. II
B. Blackman, et al., Bell Systems Tech. J., vol. 37, pt. I, Jan. 1958, p. 185/282; vol. 37, pt. II, March 1958, p. 485/569.

ZUR MESSUNG DER WAHRSCHEINLICHKEITSDICHTE UND DES SPEKTRUMS VON STATIONAREN ZEITPROZESSEN (Measurment of the Probability Density and of the Spectrum of Stationary Time-Processes) (In German)
P. Fey, Hochfreq. & Elektroakustik, vol. 66, March 1958, p. 141/142.

FM MULTIPLEX SPECTRA AND INTERFERENCE (Correspondence)
L. Arguimbau, Proc. IRE, vol. 47, Aug. 1959, p. 1372/1373.

COMBINED AM AND PM FOR A ONE-SIDED SPECTRUM (Correspondence)
N. Chakrabarti, Proc. IRE, vol. 47, Sept. 1959, p. 1663.

FURTHER COMMENTS ON "A MARKOFF ENVELOPE PROCESS" (Correspondence)
C. T. Isley, et al., IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 186/188.

ON THE COMPUTER REALIZATION OF AN ORTHONORMAL SPECTRUM OF A GIVEN SIGNAL FUNCTION
E. Mishkin, Proc. IRE, vol. 47, May 1959, p. 1003/1004.

SPECTRAL MEASUREMENTS OF SLIDING TONES
W. Gersch, et al., IRE Trans. Circuit Theory, vol. CT-7, Aug. 1960, p. 26/39.

SPECTRUM ANALYSIS IN AMPLITUDE-PHASE MODULATION
L. E. Kliagin, Radio Engng: Transl. of Radiotekhnika, vol. 15, Aug. 1960, p. 96/106.

. . . Exact theoretical formulae are produced which make it possible to evaluate the spectra produced in the Kahn-type transmitter by amplitude-phase modulation. It is shown that oscillations with optimum amplitude-phase modulation cannot be produced and that the second sideband can only be partially suppressed; in this respect, the system has no advantages over the quadrature modulation system. . . .

R. F. SPECTRA OF WAVES FREQUENCY MODULATED WITH WHITE NOISE
R. G. Medhurst, Proc. Instn. Elect. Engrs. Part C, London, vol. 107, no. 12, Sept. 1960, p. 314/323., 26 refs.

. . . Although comprehensive sets of curves are available giving the radio-frequency spectra of waves phase modulated with band-limited white noise (simulating f. d. m. telephone signals), the corresponding problem for frequency modulation turns out to be much more intractable. In the present paper the frequency-modulation problem is attacked using a method employed in an earlier paper, in conjunction with numerical devices for improving the convergence rate of very slowly converging series. . . .

SECOND-ORDER PROPERTIES OF THE PRE-ENVELOPE AND ENVELOPE PROCESSES (Correspondence)
M. Zakai, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 556/557.

SPECTRAL REPRESENTATION OF RESIDUAL-SIDE-BAND TRANSMISSION IN VIEW OF POSSIBLE INTERCONNECTION BETWEEN SINGLE- AND DOUBLE-SIDEBAND SYSTEMS (In German)
N. Berger, Nachrichtentechnik, vol. 11, no. 1, Jan. 1961, p. 31/35.

. . . The use of filters whose response is dissymmetrical with respect to the carrier frequency of an amplitude-modulated wave involves a frequency spectrum which is a complex Fourier transform. This is discussed and a method suggested whereby complex frequency spectra can be represented diagramatically.

A GENERALIZATION OF WOODWARD'S THEOREM AND THE SPECTRUM OF A HIGH HARMONIC OF A SINUSOID PLUS NARROW-BAND GAUSSIAN NOISE

N. M. Blachman, Electronic Defense Labs., Mountain View, Calif., 28 March 1961., 12p. Technical memo. EDL-M367, AD263 056.

. . . Woodward's theorem asserts that the power spectrum of a slowly frequency-modulated signal is given by the first-order probability density of the modulation. It can be extended to cover the case where there is slow amplitude modulation as well (correlated or uncorrelated and deterministric or random) by weighting each frequency by the mean square amplitude associated with it . . . It is applied to the case of a sinusoid plus narrow-band gaussian noise that has been passed through a power-law device to generate a high harmonic.

AN INTRODUCTION TO FOURIER ANALYSIS

R. D. Stuart, London, Methuen & Co. Ltd., 1961, 126.

POWER SPECTRA OF SIGNALS MODULATED BY RANDOM AND PSEUDORANDOM SEQUENCES

R. C. Titsworth, et al., Jet Propulsion, Lab., Calif. Inst. of Tech., Pasadena, Oct. 1961, 45p. (Rept. 32-140), AD 268 119

. . . concerned with the spectral distribution of signals coherently modulated by discrete random and randomlike sequences which change state only at integral multiples of some basic time division t sub 0. In general, a sequence may modulate signals randomly or in some fixed deterministic fashion. Furthermore, deterministic processes may be constructed to possess certain randomlike qualities. Special attention is directed to Markov chains and linear pseudorandom sequences: the signals selected by the modulation process are not restricted to any one class, and examples are given for sinusoids and square waves. Specifically, the effects of carrier-signal waveform and type of sequence upon the over-all power spectrum are considered. In the case of sinusoidal modulation, the effect of phase shift is investigated.

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS

E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

. . . a rather general and mathematically convenient formulation of analog-modulated signals which makes use of the analytic signal concept. Known types of modulation are readily identified as special cases. . . . a new type of modulation has been discovered - single sideband frequency modulation (SSB FM) - which can be derived from a conventional phase-modulated signal by an additional amplitude modulation, using the exponential function of the modulating signal's Hilbert transform. The resulting modulated signal will have a one-sided spectrum about the carrier frequency, will be compatible with existing FM receivers, and will cause a decrease in signal bandwidth.

A GENERALIZATION OF WOODWARD'S THEOREM ON FM SPECTRA

N. M. Blachman, Information Control, vol. 5, no. 1, March 1962, p. 55/63.

Woodward's theorem . . . can be extended to cover the case where there is slow amplitude modulation as well . . . correlated or uncorrelated and deterministic or random . . . The modulation can be regarded as slow if its bandwidth is small compared to the frequency excursion. . . .

DETERMINATION OF THE SPECTRUM OF A CARRIER PHASE-MODULATED BY A BI-PHASE SUBCARRIER

R. Chin, et al., Philco Corp., Palo Alto, Calif., 25 Jan. 1962, 18 p. incl. illus., table (Rept. no. WDL-TR1900), AD 296 415.

. . . spectrum of a bi-phase subcarrier, that switches phase every bit period, phase-modulating a carrier . . . worst case with regard to bandwidth . . . the minimum IF bandwidth is twice the sum of the subcarrier frequency and one-half the switching frequency . . . components beyond the third harmonic are appreciably small and may be neglected . . .

SPECTRA AND ANALYSIS (In Russian) (Fourth Edition)

A. A. Kharkevich, Moscow, Fizmatgiz, 1962, 236p.

MEASUREMENTS OF PROBABILITY DENSITIES OF SMALL ENSEMBLES OF PERIODIC WAVEFORMS (Correspondence)

H. L. Fox, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2118.

The monograph deals with a selection of spectral representations used in the theory of oscillations, acoustics, and radio engineering . . . aims to widen the theoretical horizons of engineers working in the fields of radio and acoustics. . . .

KORRELATIONSELEKTRONIK. GRUNDLAGEN UND ANWENDUNG DER KORRELATIONS-ANALYSE IN DER MODERNEN NACHRICHTEN-, MeB- UND REGELUNGSTECHNIK; (2 Aufl.) (Correlation Electronics. Fundamentals and Applications of the Correlation Analysis in Modern Communications and in Control Technique. Second Edition). (In German)

F. H. Lange, Berlin, Verlag Technik, 1962, 381 p.

PROCESSING OF RANDOMLY FLUCTUATING DATA BY ANALOG ANALYSIS METHODS

C. H. v. d. Linden, National Aero-and Astronautical Research Inst. Amsterdam (Netherlands), Mar. 1962, 70p. 28 refs., N63-21255.

. . . A number of analog data reduction possibilities for random type signals are reviewed with respect to the determination of amplitude probability distributions, power spectrum and cross power spectrum. A number of computation schemes and equipment required are discussed. Error sources and accuracy aspects are considered in some detail.

A TECHNIQUE FOR THE DIRECT ANALYSIS OF ALTERNATING ELECTRICAL SIGNALS INTO THEIR RESOLVED COMPONENTS

P. G. Pugh, National Physical Lab., Great Britain, 2 July 1962, 15p. 4 refs., NPL AERO rept. 1026, AD 401 507.

. . . using devices based on operational amplifiers . . . The technique enables the inherently high sensitivity of vector addition phase measurements, to changes in phase angle at 0 and 180, to be exploited at all phase angles. . . . sources of error and their practical minimization . . . prototype instrument . . . distortion has a very small effect on the range of phase angles (6 to 78 in the first quadrant) for which an accuracy of 1% in both components is obtained.

THE POWER SPECTRUM PRODUCED BY THE LINEAR MIXING OF SIGNALS FREQUENCY MODULATED BY GAUSSIAN NOISE

L. M. Tozzi, Harry Diamond Labs., Washington, D. C., 15 Nov. 1962, 26p. Rept. no. TR-1093, AD 298 088.

SPEKTRAL'NYE I FAXOCHASTOTNYE KHARAKTERISTIKI IMPUL'SNYKH NULEVYKH BIENII DLIA ODNOGO CHASTNOGO SLUCHAIA (Spectral and Phase-Frequency Characteristics of Pulsed Zero Beat for a Special Case) (In Russian)

A. A. Abramian, et al., Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 219/233, A64-17126.

BANDWIDTH AND SPECTRA OF PHASE-AND-FREQUENCY-MODULATED WAVES

N. Abramson, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 407/414, 14 refs.

The spectrum of a sinusoid, angle-modulated by a stationary Gaussian random process (GRP) of almost arbitrary spectrum, is investigated.

ASYMPTOTIC BEHAVIOR OF THE SPECTRA OF RF PULSES WITH LINEAR FREQUENCY MODULATION

S. L. Borison, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 9 Oct. 1963, 29 p., refs., Rept. 41G-5, AD 421 872.

. . . It is specifically shown that at frequencies (measured from the carrier frequency) much larger than the maximum FM deviation the effect of the FM is small. In particular, at a frequency 50 mc higher than the carrier frequency, the envelope of the spectrum of a 10μ sec rectangular pulse with 10-mc FM deviation is less than 1% above the envelope of the spectrum of a pulse with no FM. The spectrum of a cosine pulse with these same characteristics is increased by less than 3%.

COMPARISON OF POWER SPECTRAL DENSITY TECHNIQUES AS APPLIED TO DIGITALIZED DATA RECORDS OF NONSTATIONARY PROCESSES, PART I.

G. W. Evans, II, et al., Stanford Research Inst., Menlo Park, Calif., Sept. 1963, 141 p., Technical rept. no. 14.

. . . discussion of harmonic analysis, power spectral analysis, stationary and nonstationary stochastic processes, and a description of twenty-seven techniques for power spectral density (PSD) analysis. . . . Part II of this report . . . uses the preferred technique to analyze actual data from recordings of radar backscatter from missiles.

ESTIMATION OF POWER SPECTRAL DENSITY BY FILTERS

E. J. Gauss, Association for Computing Machinery, Journal, vol. 11, Jan. 1964, p. 98/103., 8 refs., A64-14416.

Presentation of an algorithm which differs from previous methods by being more adaptable for searching over wide frequency ranges and which permits the estimation of spectral density as a function of time as well as of frequency . . . is based on the analogy between a broadly tuned filter and a truncated cross correlation. . . . to compare . . . this algorithm with that of Blackman and Tukey. . . . it was found that the two algorithms are on the same order of efficiency for record lengths of 10^3 to 10^4 samples.

For longer records the filter algorithm was favored, while for shorter records it was disfavored.

A PROGRAM FOR THE DETERMINATION OF THE AUTOCORRELATION FUNCTION AND POWER SPECTRUM ON THE IBM 650 TAPE-RAMAC COMPUTER SYSTEM

R. S. Huntzinger, Aeronautical Computer Lab., Naval Air Development Center, Johnsville, Pa., 26 March 1964, 42 p.

. . .

. . . computing the auto-correlation, or more precisely the autocovariance, function for a set of raw data comprising a stationary time series and, on the basis of these computations, determining the power spectrum. The storage capabilities of the IBM 650 tape RAMAC system have made this program useful for the analysis of large quantities of data from a variety of sources. . . .

(No Title)

W. E. Morrow, Jr., et al., Lincoln Lab., Mass. Inst. of Tech., Lexington. 16 July 1963, 18p., Rept. no. 36G 4, AD 413 786.

A new technique is described which allows the Fourier transformation of a signal to be taken in real time. This technique makes use of signals and networks having linear frequency modulation properties. Its salient features are that the bandwidth of the signal being transformed is increased by no more than a factor of two during processing and that both the real and imaginary parts of the Fourier transform are obtained. An experimental demonstration of the method is included.

FREQUENCY-MODULATED SIGNALS AND THEIR POWER SPECTRA

G. H. Nitta, Naval Ordnance Lab., Corona, Calif. Feb. 1964, 139p. NOLC TM74 208 AD 436 407.

. . . a condensation and interpretation of mathematical analyses that relate to frequency-modulated signals, their spectra, and the effect of passing such signals through linear filters . . . involve almost-periodic and aperiodic signals. Formulas are also given which show the effects of processing frequency-modulated signals through rectangular, RC, and Gaussian-shaped low-pass filter, and Gaussian passband and linear narrowband filters.

ON STATISTICAL SPECTRAL ANALYSIS

E. Parzen, Applied Mathematics and Statistics Labs., Stanford U., Calif., 6 June 1963, 47p., Technical rept. no. 49, AD 411 131.

NOTES ON FOURIER ANALYSIS AND SPECTRAL WINDOWS

E. Parzen, Applied Mathematics and Statistics Labs., Stanford U., Calif., 15 May 63, 61p., TR48, AD 404 890.

SPECIAL DENSITY DISTRIBUTIONS OF SIGNALS FOR BINARY DATA TRANSMISSION

H. J. Pushman, J. Brit. Instn. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

. . . Where information rates are of the order of magnitude of the bandwidth available, the particular waveforms used become significant with regard to the bandwidth utilization of the link. On the assumption that all messages are equally likely, it would appear reasonable to use the average spectral density distribution of a random message as one basis for formulating the bandwidth requirement of a particular transmission system.

In this paper, a general method of determining the average spectral density distribution directly in the frequency domain is developed .

PRACTICAL EXPERIENCE WITH POWER SPECTRAL METHODS ON A SMALL DIGITAL COMPUTER

F. Snoodijk and J. Yff, Royal Netherlands Aircraft Factories Fokker, Amsterdam, (Presented to the Intern. Symp. on Analogue and Digital Tech. Appl. to Aeron. Liege, Sept. 9th-12th, 1963), 1963, 14 p., refs., N64-10214.

. . . applying power spectral methods . . . when only a small digital computer is available . . . frequency response functions . . . by firstly calculating the response to a step function input and finally applying the Fourier transform to these responses . . . accuracy of the numerical integration method . . .

A NEW APPROACH TO THE SPECTRUM ANALYSIS OF NON-STATIONARY SIGNALS

W. W. Wierwille, (IEEE Winter General Meeting, New York, N.Y., Jan. 27-Feb. 1, 1963, Paper 63-63.), IEEE Trans. on Applications and Industry, Nov. 1963, p. 322/327, 26 refs., A64-12332.

. . . allows proper spectral measurements of time-nonstationary signals. The power spectrum is defined on the basis of ensemble averages and therefore contains a time variation when the signals are nonstationary. It is shown that a spectrum analyzer can be designed which measures these time-varying spectra in a nearly optimum manner . . .

THE AUTOCORRELATION FUNCTION OF THE OUTPUT OF A NONLINEAR ANGLE MODULATOR

P. H. Wittke, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 67/72.

The calculation of the autocorrelation function of the output of a randomly frequency-modulated oscillator with a nonlinear tuning characteristic

is similar to the calculation of . . . a functional . . . that has arisen in a number of other stochastic problems, and so the techniques which have been applied to these problems may be used to obtain results for the nonlinear frequency-modulator . . .

Related Publications:

APPROXIMATION OF AUTOCORRELATION FUNCTIONS BY A SERIES OF DAMPED COSINE FUNCTIONS
D.T. Friest, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 709/714.

EXPLICIT FORM OF F.M. DISTORTION PRODUCTS WITH WHITE-NOISE MODULATION (Extension and Correction)
R.G. Medhurst, et al., Proc. Instn. Elect. Engrs. Part C, London, vol. 107, no. 12, Sept. 1960, p. 367/369.

THE OPTIMUM PASSBAND OF A SPECTRUM ANALYSER
N.I. Ur'ev, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 92/101. p. 92/101.

Simple formulae are given which make it possible to carry out preliminary practical calculations in the design of an analyzer. The formulae establish the relationship between the fundamental design parameters of an analyser, i.e., the speed of analysis, and the static and dynamic passbands . . .

THEORY OF A FREQUENCY-SYNTHESIZING NETWORK
B.M. Wojciechowski, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 649/673.

The theoretical basis for designing frequency-combining and selecting circuits is developed. By the introduction of "sideband algebra" and of a frequency symbolic network, the new method offers formal design procedures in place of intuitive ones.

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS—COMMUNICATION TYPE
R.N. Bailey, et al., Georgia Inst. of Tech. Engineering Experiment Station, Atlanta, Quarterly rept. no. 5, 1 March 1931 May 1962, 31 May 1962, 73 p. incl. illus. tables, 10 refs. (Rept. no. 19), AD 282 528

. . . spectra of harmonics of modulated signals are discussed and illustrated with photographs . . . It is concluded that the spectrum . . . is influenced greatly by transmitter tuning. Errors in the measurement of spurious and harmonic emissions are discussed and methods are given for data verification and preclusion of errors . . .

A METHOD OF MEASUREMENT AND DISPLAY OF PROBABILITY FUNCTIONS OF ERGODIC RANDOM PROCESSES BY ORTHOGONAL SERIES SYNTHESIS (Correspondence)
A.A. Wolf, et al., Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2503/2504.

A PRODUCT THEOREM FOR HILBERT TRANSFORMS
E. Bedrosian, IEEE Proceedings, vol. 51, May 1963, p. 868/869, 10 refs.

. . . a simple means of handling products of functions for extending tables of Hilbert transforms. The theorem states that the Hilbert transform of the product of a low-pass and a high-pass signal with nonoverlapping spectra is given by the product of the low-pass signal and the Hilbert transform of the high-pass signal.

SPECTRAL DENSITY AND AUTOCORRELATION FUNCTIONS ASSOCIATED WITH BINARY FREQUENCY-SHIFT KEYING
W.R. Bennett, et al., Bell Syst. Tech. Journal, vol. 42, no. 5, Sept. 1963, p. 2355/2385.

POWER SPECTRAL DENSITY ESTIMATION WITH A COHERENT MEMORY FILTER (Correspondence)
J. Capon, IEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 461/462.

. . . The coherent memory filter (CMF) is an active time variable network which provides a means for measuring the spectrum of a signal in real time and with fine resolution. This device can, therefore, be used as a replacement for a bank of filters to estimate the power spectrum of a stationary random process . . .

CORRELATION FUNCTIONS FOR THE RANDOM BINARY WAVE (Correspondence)
P.W. Cooper, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 496/497.

This note presents expressions for the autocorrelation function, its Hilbert Transform, and the associated "envelope" and "phase" functions for the band-limited random binary wave. Interest in these functions could arise, for example, in analysis of the "envelope" of a signal and in correlation detection of a single sideband waveform . . .

ELECTRON TUBE RESEARCH
N. De Claris, et al., Cornell U., School of Electrical Engineering, Ithaca, N.Y., Nov. 1963, 73p., Progress rept. no. 4. AD 434 849.

The expansion of autocorrelation functions of stationary time-processes in a series of orthogonal functions is discussed together with the realization of an autocorrelator as a novel

application of the link structure. . . . A Fourier analysis for ambiguity functions is developed which includes a derivation of the Fourier transform of an ambiguity function.

INSTANTANEOUS SPECTRA AND AMBIGUITY FUNCTIONS (Correspondence)
M. J. Levin, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 95/97.

A formulation of the "instantaneous spectrum" of a waveform is described whith is a modification of that originally considered by Page and extended by Turner. It is shown that this function is the double Fourier transform of the complex-conjugate of the ambiguity function and has other interesting properties . . .

AN EXPERIMENTAL CORRELATION ANALYZER FOR MEASURING SYSTEM DYNAMICS
C. W. Ross, et al., IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 554/562, 16 refs.

. . . This paper describes an experimental analyzer which utilizes a modified form of the sine-wave correlation principle to measure the dynamic characteristics of systems including industrial processes and instruments.

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Quarterly progress rept. no. 3, 11 Mar. 1963-10 June 1963, 10 June 1963, 38p; rept. no. 7, AD 417 754.

Photographs of the frequency spectra generated by each modem at the various bit rates are presented and used to discuss the relative bandwidth requirements of the modems.

A DIGITAL SPECTRAL ANALYSIS TECHNIQUE AND ITS APPLICATION TO RADIO ASTRONOMY
S. Weinreb, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge 30 Aug. 1963, 119p. Technical rept. no. 412, AD418 413, N63-22274.

Doctoral thesis . . . for the measurement of the autocorrelation function and power spectrum of Gaussian random signals . . . greatly reduces the amount of digital processing that is required. A review of the measurement of power spectra through the autocorrelation function method is given. The one-bit technique of computing the autocorrelation function is presented . . .

Section 1.22
Amplitude Modulation

1.221: Envelope Modulation in General

Included: Common problems of all kinds of amplitude modulation; Sideband intermediate frequency radio communications system; Envelope processes of modulated waveforms; Peak to average power ratios of envelope modulated waveforms.

Not Included: Synchronous detection: Theory of power law detectors (2); Modulation circuits; Frequency diversity systems (2).

Cross References: Double sideband modulation (1.222); Single sideband modulation (1.223); Vestigial sideband modulation (1.224); Combined amplitude and phase modulation (1.228).

Principal Publications:

ENVELOPES AND PRE-ENVELOPES OF REAL WAVEFORMS
J. Dugundji, IRE Trans, Inform. Th. vol. IT-4, no. 1, March 1958, p. 53/57.

. . . Rice's formula is very cumbersome . . . Different formula . . . easier to handle analytically.

BEEINFLUSSUNG EINES NACHRICHTEN-BANDES BEI AMPLITUDENMODULATION DURCH UNSYMMETRISCHE HOCH-FREQUENZKREISE (Effects on the Spectral Distribution of Amplitude Modulated Signals by Unsymmetrical RF Circuits) (In German)
R. Hofer, Entwicklungs-Berichte Geb. Fernseht. vol. 21, Dec. 1958, p. 288/300.

OVERMODULATION OF A CARRIER BY SINE WAVE AND GAUSSIAN NOISE
D. R. Rothschild, Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 724/735.

This paper discusses all degrees of amplitude modulation of a carrier by sine wave and Gaussian noise. The analysis is based on formulation of a basic model of an AM transmitter and an idealized modulation characteristic. Appropriate parameters are defined to characterize the degree of modulation, including over-modulation. The increase in r-f power due to modulation is calculated and is shown to approach 3 decibels for complete over-modulation, for which modulation by a square wave is the limiting case. . . .

A Carrier signal is amplitude-modulated by a sensing device such that its rms amplitude changes in direct proportion to the magnitude of the sensed variable. If the polarity of the variable reverses, the phase of the carrier signal changes by 180 degrees as the signal amplitude passes through zero. The time derivative will be similar, differentiation is taking place when amplitude increases in direct proportion with frequency.

IMAGINARY AXIS TRANSLATION OF TRANSFER FUNCTIONS
J. L. Ryerson, IRE Nat. Conv. Rec., March 1958, p. 236/245.

COMBINED AM AND PM FOR A ONE-SIDED SPECTRUM (Correspondence)
N. Chakrabarti, Proc. IRE, vol 47, Sept. 1959, p. 1663.

POISSON, SHANNON, AND THE RADIO AMATEUR
J. P. Costas, Proc. IRE, vol. 47, Dec. 1959, p. 2058/2059.

. . . the relative merits of . . . SSB and DSB. . . . in spite of the bandwidth economy of SSB this system can claim no over-all advantage with respect to DSB for this service. . . . definite advantages to the use of very broadband techniques in the amateur service. . . . significant work of Shannon is reviewed . . . this famous formula. . . . cannot be used meaningfully in the analysis and design of practical, present day communications systems. A more suitable channel capacity formula is derived for the practical case.

COMPARISON TESTING OF MODULATION MODES FOR HIGH-FREQUENCY GROUND-TO-AIR VOICE COMMUNICATIONS
D. E. LeBrun, et al., May, 1959, 15 p., USAF RADC TR59-55, AD 213 785 .

Test results providing a comparison between (1) single sideband suppressed carrier (SSBSC); (2) double sideband amplitude modulated (DSB-AM); (3) double sideband suppressed carrier (DSBSC); and (4) pilot carrier or synchronous single sideband (SSSB).

CRITICAL ANALYSIS OF SOME COMMUNICATIONS SYSTEMS DERIVED FROM AMPLITUDE MODULATION
W. D. Nupp, Proc. IRE, vol. 47, May 1959, p. 697/704.

WIDE-BAND CARRIER COMMUNICATIONS. VOL I. AMPLITUDE MODULATION.
J. J. Spilker, Jr. Lockheed Aircraft Corp., Sunnyvale, Calif., Rept. no. LMSD-704011, vol. 1, AD 253 281.

. . . Wide bandwidth carriers are defined as time functions with unmodulated bandwidths much wider than that of the intelligence to be transmitted. Both predictable and random carriers are considered in some detail. Optimum demodulation (Bayes estimation) is compared with other forms of demodulation on the basis of output signal-to-noise ratios. Special forms of wide-band carriers are shown to have a bandwidth utilization equal to that of single-sideband sine wave carrier systems.

SECOND-ORDER PROPERTIES OF THE PRE-ENVELOPE AND ENVELOPE PROCESS (Correspondence)
M. Zakai, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 556/557.

ENVELOPE MODULATION
J. M. Dixon, Proc. IRE, Australia, vol. 22, no. 8, Aug. 1961, p. 481/486.

A study of envelope modulation by signal synthesis reveals three minimum bandwidth solutions to the generation of wave modulation with no appreciable distortion. In each case three signals are required for distortion free sine wave modulation. One solution corresponds to double-sideband transmission while the other two correspond to single-sideband transmission. Signals produced in the Kahn compatible single-sideband system are calculated and the system performance evaluated according to the developed criterion.

THE SIDEBAND INTERMEDIATE FREQUENCY RADIO COMMUNICATIONS SYSTEM
C. M. Hyde, IRE Trans. Commun. System, vol. CS-9, no. 3, Sept. 1961, p. 232/238.

. . . eliminates oscillator-frequency drift problems by incorporating an amplitude modulated transmitter modulated by an oscillator tuned to have the intermediate frequency of the receiver. The use of a balance modulator eliminates the carrier and allows energy at the two sideband frequencies to be propagated to a receiver. In the receiver these two sidebands are beat against each other to produce the IF signal. No receiver local oscillator is required.

Only one high-frequency oscillator, the transmitter carrier oscillator, is used in the entire system . . . a bandwidth of twice that of a regular communications system is required in most cases. . .

VOICE MODULATED SSB & DSB PEAK TO AVERAGE ENVELOPE POWER RATIOS
J. D. Griffits, IRE Intern. Conv. Rec., vol 8, March 1961, p. 85/101.

A SURVEY OF SINGLE-SIDEBAND AND ASSOCIATED TECHNIQUES FOR VOICE COMMUNICATION
A. L. Rock, et al., Research Inst., U. of Michigan, Ann Arbor, Jan. 1961, 103 p., (Tech. rept. 117; 3899-42-T), AD 257 017.

. . . synchronous communication, compatible single-side-band, exalted carrier reception, etc. were included to make the report more comprehensive and to emphasize the importance of these alternative techniques for radio-telephone communications . . . advantages of savings in power and spectrum, improved propagation, and other features are weighed against increases in cost and complexity of equipment . . . Various methods of signal generation and reception are illustrated . . . power comparison between single-sideband and conventional amplitude and double-sideband modulations is discussed at some length . . . Finally, the effects of noise and interference in some of the basic receivers are analysed.

Related Publications:

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

AM RADAR
O.K. Nilssen, et al., East Coast Conf. Aerosp. Navig. Electronics, vol. 8, Oct. 1961, p. 1/6.

AMPLITUDE MODULATED CW RADAR
O.K. Nilssen, et al., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 4, Dec. 1962, p. 250/254.

. . . Significant features of this AM radar system are simplicity and capability of accurately measuring very short ranges. For instance, an experimental unit ranges from zero to 50 feet with maximum error of six inches . . .

COHERENT AND NON-COHERENT DEMODULATION OF ENVELOPE-MODULATED RADIO SIGNALS WITH PARTICULAR REFERENCE TO THE ENCHANCED-CARRIER SYSTEM
P.V. Indiresan, et al., Radio Electronic Engr. (GB), vol. 25, no. 1, Jan. 1963, p. 65/72.

The ordinary "linear detector" and the coherent demodulator are briefly discussed . . . The synchrodyne and enhanced-carrier systems are regarded as intermediate cases in which the switching is effected by an impure carrier derived from the incoming signal. The enhanced - carrier system, using filters to extract the carrier from the incoming signal, appears to have received little attention in the literature . . .

MEAN-SQUARE ERROR IN CORRELATION DEMODULATORS (In German)
B.F. Ludovici, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 278/288.

. . . shows that the autocorrelation demodulator offers no significant improvement over the simple square law demodulator. . . .

1.222: Double Sideband Modulation

Included: DSB - modulation; Suppressed carrier double sideband amplitude modulation; CO - modulation; Complementary orthogonal modulation; Phase quadrature modulation; Standard amplitude modulation.

Not Included: Synchronous detectors; Homodyne detection system.

Cross References: Comparison SSB vs. DSB (1.223); Asymmetric sideband modulation (1.224); Double sideband data transmission systems (1.322); Co-modulation in teletype systems (1.382).

Principal Publications:

DOUBLE-SIDEBAND SUPPRESSED-CARRIER MULTIPLEX EQUIPMENT FOR CABLE AND MICROWAVE APPLICATION
W.S. Chaskin, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 92/94.

POISSON, SHANNON, AND THE RADIO AMATEUR
J.P. Costas, Proc. IRE, vol. 47, Dec. 1959, p. 2058/2059.

. . . the relative merits of . . . SSB and DSB. . . .

THE RECEPTION OF DOUBLE-BAND AM SIGNALS WITH SUPPRESSED CARRIER
V.N. Arzumanov, et al., Radio Engng: Transl. of Radiotekhnika vol. 15, no. 11, 1960, p. 70/78.

. . . A study is made of a system of synchronization for local oscillators in the reception of speech signals. The effect on reception of certain types of interference is investigated. Experimental results are given. . . .

AN EVALUATION OF AM DATA SYSTEM PERFORMANCE BY COMPUTER SIMULATION
R.A. Gibby, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 675/704.

. . . suitable for programming on a high-speed digital computer. These equations contain expressions that specify in general terms the transmission-frequency characteristics of a transmission medium. A data signal composed of a train of raised-cosine shaped pulses is generated in the stimulating process. . . . performance of a double-sideband AM data system is evaluated from measurements of the maximum vertical opening, or aperture, of the eye pattern formed by the received signal. This aperture is related to the system performance in terms of signal-to-noise ratio and error rate of the system.

CO-MODULATION, A NEW METHOD FOR HIGH-SPEED DATA TRANSMISSION
F. de Jager, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 285/290.

. . . primary objective is to increase the speed of transmission in a given bandwidth. . . . lower frequencies . . . are suppressed . . . using two carrier-voltages differing 90° in phase. . . . pilot signal . . . for phase-reference, . . . The name CO-modulation stands for complementary orthogonal modulation, . . .

ON THE NOISE IMMUNITY OF SINGLE AND DOUBLE SIDEBAND COMMUNICATION SYSTEMS

I.A. Tsikin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 4, April 1962, p. 1/10.

The signal-to-noise ratio in reception of single sideband (SSB) and double sideband (DSB) signals with supressed carrier is analyzed. . . . values are found for mean-square error in reproducing the signals at the output of SSB and DSB receiving systems. . . .

Related Publications

COMPARISON TESTING OF MODULATION MODES FOR HIGH-FREQUENCY GROUND-TO-AIR VOICE COMMUNICATIONS
D. E. LeBrun, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., May 1959, 15 p., (Rept. no. RADC TR-59-55), AD 213 785.

Tests are described which were conducted to obtain a practical comparison between (1) single sideband suppressed carrier (SSBSC); (2) double sideband amplitude modulated (DSB-AM); (3) double sideband suppressed carrier (DSBSC); and (4) pilot carrier or synchronous single sideband (SSSB). These tests were conducted over a period of one year. Data were gathered by means of sequentially transmitting phonetically-balanced (PB) word lists via the various modes, and analyzing the recorded results for intelligibility. The transmissions were between Rome, New York, and a C-131 aircraft which was flown extensively in the United States and the West Indies.

. . . Results obtained were significantly in favor of the SSBSC.

A SYNCHRONOUS COMMUNICATIONS RECEIVER FOR THE MILITARY UHF BAND
R.H. Wood, et al., IRE Trans. Commun. Syst., vol. CS-1, no. 2, June 1959, p. 129/133.

. . . for double-sideband suppressed carrier signals in the 225-mc to 400-mc band . . .

1.223: Single Sideband Modulation

Included: Compatible single sideband system; Square-law single sideband system; Quadratic single sideband system; Kahn's single sideband system; Third method of single sideband modulation; Synchronous single sideband systems; Birdcall system.

Not Included: TICOSS - time compressed single sideband system (2); Optical single sideband modulation (3B); Rectifier modulators for SSB; SSB modulators; SSB demodulators; Phase shifters for SSB modulators.

Cross References: Independent sideband system in teletype (ISB) (1.382); Asymmetrical sideband modulation (1.224).

Principal Publications

STUDY OF JAMMING EFFECTS OF SINGLE SIDEBAND COMMUNICATIONS SYSTEMS
N. Balabanian, et al., Syracuse U. Reasearch Inst., vol. 1, July 1958.

A WORLD-WIDE HIGH FREQUENCY SINGLE SIDEBAND RADIO NETWORK
E. Bray, IRE Nat. Conv. Rec., vol. 6, March 1958, p. 245/253.

A MATHEMATICAL ANALYSIS OF THE KAHN COMPATIBLE SINGLE-SIDEBAND SYSTEM
J.P. Costas, Proc. IRE, vol. 46, July 1958, p. 1396/1401.

A COMPATIBLE SINGLE-SIDEBAND MODULATION SYSTEM
L.R. Kahn, Proc. Radio Club America, vol. 34, March 1958, p. 3/9.

COMMENT ON A MATHEMATICAL ANALYSIS OF THE KAHN COMPATIBLE SINGLE-SIDEBAND SYSTEM
L.R. Kahn, Proc. IRE, vol. 46, July 1958, p. 1429/1430.

THE GENERATION OF SINGLE SIDEBAND CARRIER TELEPHONE CHANNELS BY POLYPHASE MODULATION
J.R. Mensch, IRE Nat. Conv. Rec., vol. 6 March 1958, p. 305/313.

SINGLE-SIDEBAND MODULATION
B. Rassadin, Radio, Moskow, June 1958, p. 25/27.

. . . Description of a system operating at the range of 7.0-7.1 mc.

ANALYSIS OF SSB POWER AMPLIFIERS
F. Assadourian, IRE Trans. Commun. Syst., vol. CS-7, no. 1, May 1959, p. 53/57.

THE "THIRD METHOD"
J.F. Aspinwell, Wireless World, Jan 1959, p. 39/43

. . . principles in the three types of single sideband operations. . . . filter . . . outphasing method and duplicated filter circuit method.

SS-FM: A FREQUENCY DIVISION TELEMENTARY SYSTEM WITH HIGH DATA CAPACITY
W.O. Frost, et al., Nat. Symp. Space Electronics Telem., pt. 7.2, Sept. 1959, p. 1/14.

. . . results of a theoretical study . . . preliminary design . . . single sideband AM subcarriers on an FM carrier . . . An analytical comparison with FM-FM is made of the S/N performance of a 15 channel SS-FM system. . . .

ODNOPOLOSNAIA MODULIATSIIAS POMOSHCH'I U FAZOVYAKH SKHEM (Sine Band Modulation by Means of Phase Systems) (In Russian)
B.B. Shtein and N.A. Cherniak, Moscow, Sviazizdat, 1959, 164 p.

This book is devoted to an analysis of a number of methods of forming a single band signal using phase-shifting systems. A study is made of the main possibilities of producing one side band together with a quantitative evaluation of the suppression of the second side band. The theory of wide band phase-shifting devices based on RC and LC is given in detail together with practical methods of calculation. The book contains considerable experimental data useful for designing phase systems. . . .

NORTH ATLANTIC S.S.B. TRIALS IN B.O.A.C. AIRCRAFT NOVEMBER, 1957-March, 1958
T.E. Wynne, et al., Royal Aircraft Establishment, Gt. Brit., March 1959, 26 p., AD 225 103.

. . . have clearly shown that the introduction of the S.S.B. into civil aircraft could greatly improve long range communication efficiency in the ground to air direction. . . . it failed to prove an equal gain in the reverse direction . . .

AIR FORCE BUYS NEW RADIO GEAR
Electonics, vol. 32, no. 48, Nov. 1959, p. 45.

Birdcall systems pass legibility and reliability tests with flying colors, are now going into field use. . . new synchronous single-sideband system. . . . built by Collins Radio.

. . . suppressed-carrier system designed for voice communications only . . . known . . . as Birdcall, . . .

A METHOD OF COMBINING TWO FREQUENCIES (Correspondence)
L.R. Kahn, Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 118/119.

CONSIDERATIONS IN SSB AND ISB SYSTEMS FOR LONG-DISTANCE RADIOTELEGRAPH COMMUNICATIONS
W. Lyons, Communication Electronics, no. 46, Jan. 1960, p. 921/924.

PERFORMANCE OF A 640-MILE, 24-CHANNEL UHF - SSB EXPERIMENTAL COMMUNICATION SYSTEM
B.E. Nichols, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 26/33.

PRE-MODULATION AND POST-MODULATION CLIPPING IN SINGLE SIDEBAND TRANSMISSION
L.R. Spogen, et al., Applied Research Lab., U. of Arizona, Tucson, Final rept. Dec. 1960, 46 p., AD 264 260.

The transmitted power of a single sideband (SSB) system is governed by the peak value of the input signal to the final amplifier. Pre-modulation and post-modulation clipping reduce the peak-to-average characteristics of this input signal. The benefits are examined of pre-modulation and post-modulation clipping.

THE COMPUTATION OF SINGLE-SIDE-BAND PEAK POWER (Correspondence)
W.K. Squires, et al., Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 123/124.

COMPATIBLE SINGLE SIDEBAND
L.R. Kahn, Proc. IRE, vol. 49, Oct. 1961, p. 1503/1527.

A SURVEY OF SINGLE-SIDEBAND AND ASSOCIATED TECHNIQUES FOR VOICE COMMUNICATION
A.L. Rock, et al., Research Inst., U. of Michigan, Ann Arbor, Jan. 1961, 103 p. (Tech. rept. 117; 3899-42-T), AD 257 017.

. . . compatible single-side-band, . . . included . . . advantages of savings in power and spectrum, improved propagation, and other features are weighed against increase in cost and complexity of equipment . . .

SINGLE-SIDEBAND COMMUNICATIONS
Proc. IRE, vol. 49, no. 2, March 1961, p. 632.

The remarks concerning the SAC communications briefing ("SAC" (Poles and Errors), Proc. IRE, vol. 48, p. 1373; August, 1960) are very disturbing to me as a communications engineer. They typify . . . that single-sideband (SSB) modulation techniques are pre-eminently suited for the majority of communication systems. . . .

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS
E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

. . . a rather general and mathematically convenient formulation of analog-modulated signals which makes use of the analytic signal concept. Known types of modulation are readily identified as special cases. . . . a new type of modulation has been discovered - single sideband frequency modulation (SSB FM) - which can be derived from a conventional phase-modulated signal by an additional amplitude modulation, using the exponential function of the modulating signals Hilbert transform. The resulting modulated signal will have a one-sided spectrum about the carrier frequency, will be compatible with existing FM receivers, and will cause a decrease in signal bandwidth.

COMPATIBLE SINGLE SIDEBAND - (Correspondence)
L.R. Kahn, Proc. IRE, vol. 50, no. 4, April 1962, p. 467/468.

HILBERT TRANSFORMS AND MODULATION THEORY
F.F. Kuo, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 51/58.

Hilbert transforms are important in representing certain modulated signals. In this tutorial paper we will explore the use of Hilbert transforms in the theory of amplitude modulation, especially single sideband . . .

A SOLUTION TO PROBLEM OF COMPATIBLE SINGLE-SIDEBAND TRANSMISSION
B.F. Logan, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol IT-8, no. 5, Sept. 1962, p. 252/259.

The problem of compatible single sideband transmission is given a precise mathematical formulation. The problem is then recognized as a combination of two problems, each of which has previously been solved. Iterative methods are required for the solution of the second problem. . . .

ON THE NOISE IMMUNITY OF SINGLE AND DOUBLE SIDEBAND COMMUNICATION SYSTEMS
I.A. Tsikin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 4, April 1962, p. 1/10.

The signal-to-noise ratio in reception of single sideband (SSB) and double sideband (DSB) signals with supressed carrier is analyzed. . . . values are found for mean-square error in reproducing the signal at the output of SSB and DSB receiving systems. . . .

A METHOD FOR OBTAINING COMPATIBLE SINGLE-SIDEBAND MODULATION (Correspondence)
T.J. van Kessel, et al., Proc IRE, vol. 50, no. 9, Sept. 1962, p. 1998.

Recently Kahn published an article . . . methods to obtain CSSB modulation . . . rather complicated . . . seems to be useful to refer to our article . . . which a new, simpler method is described. The principle of this method consists of multiplication of a full-carrier SSB signal by itself and suppression of all the frequency components except those around the double-carrier frequency. . . .

THE SQUARE-LAW SINGLE-SIDEBAND SYSTEM
C.A. Von Urff, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 257/267.

A new method of generation of a single-sideband signal has been developed which provides distortionless reception with a square-law envelope detector. This performance is achieved through a new system design rather than a less subtle method, such as carrier reinsertion. . . . the amplitude and phase-modulation components are generated separately and have a specific functional relationship with each other. The amplitude-modulation envelope is the square root of the waveform to be transmitted and the phase modulation is the Hilbert transform of the logarithm of the envelope. A signal generated in this manner will occupy a bandwidth equal to the bandwidth of the original modulating signal and may be received without distortion with a square-law envelope detector. . . .

CORRELATION FUNCTIONS FOR THE RANDOM BINARY WAVE (Correspondence)
P. W. Cooper, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 496/497.

This note presents expressions for the autocorrelation function, its Hilbert Transform, and the associated "envelope" and "phase" functions for the band-limited random binary wave. Interest in these functions could arise, for example, in analysis of the "envelope" of a signal and in correlation detection of a single sideband waveform, . . .

ON A PROBLEM IN SINGLE-SIDEBAND COMMUNICATIONS
J. Dutka, RCA Rev., vol. 24, no. 3, Sept. 1963, p. 391/405.

. . . A problem in the design of a single-sideband modulation system is considered which reduces to the determination of the distribution function of the sum of an infinite series of independent random variables. An approximation is obtained in the form of a distribution of a finite sum of independent uniform (but not necessarily equidistributed) random variables which is useful here and for broader classes of problems. Five-decimal-place tables of the original distribution function are computed, and some analytic properties of the distribution function are obtained.

Related Publications:

TIME-COMPRESSED SINGLE-SIDEBAND SYSTEM (TICOSS)
M. I. Jacob, et al., IRE Trans. Commun. Syst., vol CS-6, no. 1, June 1958, p. 2/8.

. . . Ticoss has been proposed that provides the performance required of mobile multichannel short-to-medium-range communication systems . . . Ticoss handles all transmission with one transmitter, one receiver, and one antenna at each station. The sub-channels to be multiplexed are arranged in sequential time slots to form a frame.

SPECTRUM ANALYSIS IN AMPLITUDE-PHASE MODULATION
L. E. Kliagin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 96/106.

Exact theoretical formulae are produced which make it possible to evaluate the spectra produced in the Kahn-type transmitter by amplitude-phase modulation. It is shown that oscillations with optimum amplitude-phase modulation cannot be produced and that the second sideband can only be partially suppressed; in this respect, the system has no advantages over the quadrature modulation system. . . .

NOISE AND FADING ACCUMULATION IN SINGLE SIDEBAND RADIO COMMUNICATION RELAY STATIONS
V. I. Siforov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 1/4.

. . . It is shown that the noise and fading accumulation process in a single sideband communication line is similar to the process in a line employing frequency modulation. . . .

SINGLE SIDEBAND TRANSPORTABLE EQUIPMENT
G. N. Wetzel, et al., Collins Radio Co., Dallas, Tex., Final rept. for 1 April 1961, 15 Oct. 1961, 1 vol., Rept. no. AER 136, RADC TDR-62-169, AD 400 712.

ACTIVE SINGLE-SIDEBAND PHASE SHIFTERS
N. Jagoda, Air Force Cambridge Research Labs., Bedford, Mass., Research rept. July 1962, 11 p. incl. illus., 7 refs., AFCRL 62-511, AD 285 005.

A method of realizing audio frequency 90 degrees phase shifters for use in single-sideband modulators is described. . . .

BETTER SUPERHETS FOR SIDEBAND RECEPTION
W. Bruene, et al., Electronics, vol. 36, May 10, 1963, p. 39/45, A63-16926.

. . . single-sideband (SSB) receivers for improving HF communications. . . . sensitivity . . . the noise factor . . . blocking and cross modulation . . . RF amplifier . . . mixing . . . IF amplifiers . . . automatic gain control . . . sideband selection . . . SSB demodulations. . . .

TELEMETRY SINGLE SIDEBAND, AMPLITUDE MODULATION, ALL SOLID STATE, S BAND RECEIVER DESIGN AND DEVELOPMENT PROGRAM
F. Carroll, Sylvania Electric Products, Inc., Buffalo, N.Y., Final rept. June 1963, 129 p., ASD TDR63 472, AD 417 035.

. . . all solid state, single sideband microwave (2.15 - 2.35 gc) receiver . . . synchronous detection r-f carrier tracking filter type of operation and crystal switching for channel selection. .

AN ANALYSIS OF PCM TRANSMISSION VIA SINGLE SIDEBAND
R. Gardner, et al., RCA Defense Electronic Products, New York, 1 May 1963, 191 p., AD 406 700.

. . . to determine the relative merits of single-sideband transmission as against FM transmission of multichannel (e.g. 12-channel) PCM signals . . .

DIRECT WIDE-BAND PHASE SHIFTERS
P. V. Indiresan, J. Brit. Instn. Radio Engrs., vol. 26, no. 3, Sept. 1963, p. 227/229.

Two functions which differ only in phase and that by 90 deg. are related to each other by the Hilbert transform and to derive one from the other it is necessary to know the values of the input function at all times, past as well as future, right up to infinity. However, the amplitude error will be less than ± 1 db if the input values are considered up to a time duration equal to the period of the lowest frequency component in the signal. . . . A direct wide-band phase shifting circuit which utilizes these ideas to give an arbitrarily small error in phase and an amplitude response constant to within ± 1 db. over a 14:1 range of frequencies, is described. . . .

1.224: Vestigal Sideband Modulation

Included: Asymmetrical sideband modulation; Asymmetrical sideband PPM system.

Not Included: Television transmission equipment.

Cross References: Vestigial sideband data transmission systems (1.324); Distortions in vestigial sideband systems (1.624).

Principal Publications:

VERZERRUNGEN BEI RESTSEITENBANDUBER-TRAGUNG (Distortions in Vestigal Sideband Transmission) (In German)
N. Berger, Hochfrequenztech. Elekt. Akust., vol. 66, May 1958, p. 189.

DETECTION OF ASYMMETRIC SIDEBAND SIGNALS IN THE PRESENCE OF NOISE
T. Murakami, et al., RCA Rev., vol. 19, no. 3, Sept. 1958, p. 388/417, 19 refs.

The first part of this paper analyzes three methods of detection of signals contaminated by fluctuation noise:
(1) Linear Envelope Detectors
(2) Product Detectors
(3) Exalted Carrier Detectors
A new ratio, the "video-to-noise-error ratio" is proposed for a more adequate quantitative evaluation of detector performance. . . . The second part of this paper analyzes the effects of impulse noise on the detection of asymmetric sideband signals. It is shown that product detectors eliminate the rectification of the noise envelope found in envelope detectors. This is of particular interest in asymmetric sideband systems where the noise output will be at relatively high frequencies. These can often be separated from lower frequency signals, making possible efficient impulse noise suppression.

ANALYSIS OF DIODE-DETECTOR CIRCUITS FOR SIGNALS WITH ASYMMETRICAL SIDEBANDS
A. van Weel, Philips Res. Rept., vol. 13, Aug. 1958, p. 301/326.

THE USE OF VESTIGIAL SIDEBANDS IN HIGH-SPEED DATA TRANSMISSION
Lenkurt Demodulator, vol. 7, Aug. 1958, p. 1/6.

EFFECTS OF FREQUENCY CUTOFF CHARACTERISTICS ON SPIKING AND RINGING OF TV SIGNALS
A. D. Fowler, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 173/179.

The spiking and ringing of TV signals depend upon amplitude and delay characteristics associated with frequency cutoff of transmission. The effects of a variety of cutoff characteristics of both ideal and practical systems on rectangular and sine-squared pulses are illustrated by computed waveforms. . . .

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

A detailed analytical study . . . Various signal conditions and detection methods are considered. The transient crosstalk in both an idealized system and in a practical system is determined. Calculations show that the peak amplitude of the transient cross modulation can be many times as large as the steady-state cross modulation. It is shown that product or synchronous detectors can eliminate the effects of cross modulation. . . .

A QUADRATURE NETWORK FOR GENERATING VESTIGIAL-SIDEBAND SIGNALS
G. G. Gouriet, et al., Proc. Instn. Elect. Engrs., Part B, London, vol. 107, no. 33, May 1960, p. 253/260.

SPECTRAL REPRESENTATION OF RESIDUAL-SIDE-BAND TRANSMISSION IN VIEW OF POSSIBLE INTERCONNECTION BETWEEN SINGLE- AND DOUBLE-SIDEBAND SYSTEMS (In German)
N. Berger, Nachrichtentech., vol. 11, no. 1, Jan. 1961, p. 31/35.

ASYMMETRICAL SIDEBAND TRANSMISSION OF POSITION MODULATED PULSES
G. I. Lukatela, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 102/108.

. . . It is shown that the synchronously detected component of the envelope of an asymmetrically transmitted impulse can possess a steeper slope than the envelope itself and that over-all transient time of this component may be reduced. . . . The effect of various degrees of transmission asymmetry is calculated for "squared cosine" type transmission-frequency characteristics. The conclusion is reached that for a given channel capacity an asymmetrical sideband transmission in PPM systems should be distinctly superior to a symmetrical one. . . .

SOME ASPECTS OF V.S.B. TRANSMISSION OF COLOUR TELEVISION WITH ENVELOPE DETECTION
G. F. Newell, J. Brit. Instn. Radio Engrs., vol. 23, April 1962, p. 316/320.

Related Publications:

A 2500-BAUD TIME-SEQUENTIAL TRANSMISSION SYSTEM FOR VOICE-FREQUENCY WIRE LINE TRANSMISSION
G. Holland, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 180/184.

The Sebit-25 is a full duplex terminal equipment designed to transmit digital data at rates up to 2500 baud. . . . binary information . . . is converted to minimum bandwidth and used to amplitude modulate a 2500 cycle carrier. The resulting signal is converted to vestigial sideband prior to transmission, to further compress the bandwidth. . . .

A NEW TYPE OF VESTIGIAL-SIDEBAND FACSIMILE SYSTEM
K. Kubota, et al., Rev. Elect. Commun. Lab., vol. 9, no. 1-2, Jan.-Feb. 1961, p. 85/90.

. . . performing homodyne detection and eliminating quadrature distortion. At the transmitter, the maximum modulation factor is set at a small value, and a carrier frequency is transmitted. At the receiver, phase and amplitude-modulated components of the received signal are respectively eliminated by a band-pass filter and a limiter. The limiter output serves as the carrier for homodyne reception, obviating the need for an a.f.c. system.

AN AM VESTIGIAL SIDEBAND DATA TRANSMISSION SET USING SYNCHRONOUS DETECTION FOR SERIAL TRANSMISSION UP TO 3,000 BITS PER SECOND
F. K. Becker, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 97/101.

. . . The system is asynchronous and will operate at any bit speed up to its maximum. Satisfactory operation has been achieved at 2,000 bits per second over the switched telephone network, and at 3,000 bits per second over equalized voice band circuits. . . .

A 1,650-BIT-PER-SECOND DATA SYSTEM FOR USE OVER THE SWITCHED TELEPHONE NETWORK
S. Brand, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 652/661.

. . . The principal transmission features . . . are: 1. Two levels only—no framing. 2. Vestigial sideband (VSB), or amplitude modulation. . . .

PROBLEMS OF TELEVISION RELAY/MONITORING RECEPTION. I. GENERAL RECEPTION PROBLEMS. (In German)
W. Strossenreuther, et al., Radio Mentor, vol 5, no. 28, May 1962, p. 494/498.

Discusses the fundamentals of residual sideband transmission/reception, mainly from the point of view of types of picture modulation . . .

OPERATING CONDITIONS OF THE ANODE CIRCUIT OF THE FINAL MCW AMPLIFIER STAGE OF A UHF TELEVISION TRANSMITTER
A. I. Lebedev-Karmanov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 3, March 1963, p. 40/51.

. . . ensuring the partial suppression, envisaged by the standards, of one of the sidebands in the spectrum of the output radio signal. . . .

Section 1.23
Angle Modulation Systems

Frequency modulation is established as a transmission system which can trade bandwidth for signal contrast (SNR) improvement. It has wide applications in space communications, particularly since the introduction of improved demodulation circuits (phase and frequency lock loops), which helped to lower the so-called noise threshold.

Phase modulation is closely related to frequency modulation. It demonstrated a more economical performance than the latter in many space applications. Synchronous phase demodulators are used in the receivers of deep space communications links to best advantage.

The common theoretical basis of both these angle modulation systems calls for their presentation in a common section. The basis of selection of material for this volume results in the exclusion of actual circuits and subsystems. Therefore, references to phase-lock demodulators are not included.

1.231: Common Problems in Angle Modulation

Included: Instantaneous frequency; Random modulating signals in angle modulation; Noise threshold problems in general.

Not Included: Angle modulation detectors; Synchronous detection circuits.

Cross References: Threshold problems in frequency modulation (1.232); Threshold problems in phase modulation (1.233); Comparison of modulation systems with coherent detection (1.860).

Principal Publications:

A NOTE CONCERNING INSTANTANEOUS FREQUENCY
D. A. Linden, Proc. IRE, vol. 46, Dec. 1958, p. 1970

RADIO FREQUENCY POWERS AND NOISE LEVELS IN MULTI-CHANNEL RADIO-TELEPHONE SYSTEMS USING ANGULAR MODULATION
J. D. Thomson, Proc. IRE Australia, vol. 19, May 1958, p. 211/220.

TRANSIENT PROCESSES IN FREQUENCY MODULATION
A. Ditl, Ministry of Aviation (Gt. Brit.), Dec. 1959, p. 1/19. (Trans. no. TIL/T.5008 of Hochfrequenztech. U. Elektroakust 64:184-193, 1956) AD 232 613.

A definition of "instantaneous frequency" has been evolved which meets practical requirements: the definitions of different authors have been critically evaluated and compared with experimental results.

A NOTE ON ANGLE MODULATION BY A MIXTURE OF A PERIODIC FUNCTION AND NOISE
P. R. Karr, IRE Trans. Inform. Th., vol. IT-5 no. 3, Sept. 1959, p. 140/143.

POWER IN AN ANGLE-MODULATED WAVE
W. C. Vaughan, Electronic Radio Engr., vol. 36, Aug. 1959, p. 289/291.

ESTABLISHING THE FREQUENCY AT THE OUTPUT OF AN IDEAL NARROW BAND FILTER WITH FREQUENCY-PHASE MODULATION
L. I. Iaroslavskii, et al., Radio Engng: Transl. of Radiotekhnika vol. 15, no. 7, 1960, p. 72/83.

. . . study of transient processes, or, more accurately, the establishment of the instantaneous frequency and instantaneous amplitude at the output of a narrow band system with a frequency-phase modulated input signal . . . Purely frequency and purely phase modulation are regarded as special cases of frequency-phase modulation. . . .

A SUPERPOSITION PROPERTY OF ANGLE MODULATION
Proc. IRE, vol. 49, no. 6, June 1961, p. 1084.

TRANSIENT RESPONSE OF NARROW-BAND BAND NETWORKS TO ANGLE-MODULATED SIGNALS
J. J. Hupert, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 458/468.

. . . Narrow-band approximation applies but asymmetric pole pattern is admissible. Network response to a step in frequency is first obtained in a convenient form; next, the response to a function other than a step is developed by the use of convolution integral with the answer represented as a sum of quasistationary response and of transient response of the network overshadows its quasistationary response or is a sizeable proportion of this response. . . . Once the natural modes of the network are known, multiple-tuned circuits may be analyzed without much more complication than a single-tuned circuit. . . .

THE THRESHOLD EFFECT IN MODULATION SYSTEMS THAT EXPAND BANDWIDTH
D. Slepian, IRE Trans. Inform. Th. (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 122/127.

. . . presents curves which are believed to represent the best thresholds obtainable with practical modulators that expand bandwidth and operate instantaneously on the baseband signal. The model from which the curves are obtained is described in detail.

THRESHOLDS FOR SEVERAL ANALOG MODULATION SYSTEMS
B. Reiffen, Lincoln Lab., Mass. Inst. of Tech., Lexington, 6 May 1963, 5 p., AFESD TDR 63 69.

Threshold is defined as an abrupt degradation in performance when the s/n ratio at the input to the detector falls below some more or less critical level. Two common examples are: (1) the conventional FM threshold when a discriminator is the detector for angle-modulated signals, and (2) the small-signal suppression effect when power law detectors are used for AM signals. One threshold curve derived from information theory considerations may be interpreted as representing the best possible performance of a broad class of modulation-demodulation schemes.

THE AUTOCORRELATION FUNCTION OF THE OUTPUT OF A NONLINEAR ANGLE-MODULATOR
P. H. Wittke, Queens' U., Kingston, Canada, Research report no. 63-1, Jan. 1963, 17 p., refs.

The usual technique for finding the distribution of power of a random signal with frequency is to find first the autocorrelation function of the signal, and then take the Fourier transform of the autocorrelation function to obtain the power spectral density. The statistical part of the problem is the calculation of the autocorrelation function.

THE AUTOCORRELATION FUNCTION OF THE OUTPUT OF A NONLINEAR ANGLE MODULATOR
P. H. Wittke, Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 67/72.

1.232: Frequency Modulation

Included: Noise threshold problems in FM; Fundamentals of FM receivers with feedback; Frequency compressive feedback threshold improvement in FM; Swept frequency modulation; AM suppression in FM systems; Power spectra of FM signals; Capture effects in FM.

Not Included: Frequency compression in FM (2); Variable bandwidth FM systems (2); Multi-channel FM systems (2); Telemetry systems with frequency modulation; FM demodulators; Limiter circuits; Discriminator circuits; Phase lock circuits; Pre-emphasis (2); Frequency modulators; VCO = voltage controlled oscillators.

Cross References: Instantaneous frequency (1.231); Distortion of FM signals in transmission channels (1.623); Quantized frequency modulation (1.333); Interference problems in FM systems (1.732); Pulse compression techniques with FM pulses (1.316); Spread spectrum techniques using FM (1.920); Frequency shift keying systems (1.322); Multiple modulation systems with FM (Div. 1.9).

Principal Publications:

VARIABLE FREQUENCY ELECTRIC CIRCUIT THEORY WITH APPLICATION TO THE THEORY OF FREQUENCY MODULATION
V. Carson, et al., Bell Syst. Tech. J., vol. 16, Oct. 1937.

FREQUENCY MODULATION
K. R. Sturley, Proc. Instn. Elect. Engrs (London). vol. 92, Sept. 1940, p. 197/207.

FM DISTORTION CAUSED BY MULTIPATH TRANSMISSION
M. S. Corrington, RCA Rev., vol. 6, 1946, p. 522.

VARIATION OF BANDWIDTH WITH MODULATION INDEX IN FREQUENCY MODULATION
M. S. Corrington, Proc. IRE, vol. 35, Oct. 1947, p. 1013/1020.

THE DISTORTION OF FREQUENCY-MODULATED WAVES BY TRANSMISSION NETWORKS
A. S. Gladwin, Proc. IRE, vol. 35, Dec. 1947, p. 1436/1445.

INTERFERENCE IN FM RECEPTION
J. Granlund, Tech. Report, Res. Lab. Electronics, M.I.T., no. 42, Jan. 1949.

THEORY OF STRONGER-SIGNAL CAPTURE IN FM RECEPTION
E. Baghdady, Proc. IRE, vol. 46, April 1958, p. 728/738.

CAPTURE OF THE WEAKER SIGNAL: FEEDFORWARD TECHNIQUE
E. J. Baghdady, Quarterly Progress Report. Res. Lab of Elect. MIT, Sept. 1958, p. 56/62.

TABLE OF FIRST 700 ZEROS OF BESSEL FUNCTIONS—$J_1(X)$ and $J'_1(X)$
C. L. Beattie, Bell Syst. Tech. J., vol. 37, no. 3, May 1958, p. 689/697.

A METHOD OF IMPROVING RECEPTION IN FM COMMUNICATIONS
H. D. Hern, et al., IRE WESCON Conv. Record, Los Angeles, California, no. 8, Aug. 1958, p. 46/52.

Proportionally reducing the receiver bandwidth when the input signal level drops toward the level which would normally produce the threshold effect.

UBER DIE MODULATION DER EIGENFREQUENZ EINES VERLUSTFREIEN SCHWINGKREISES, TEIL I (On the Modulation of the Resonance Frequency of a Loss-Less Tuned Circuit Part I) (In German)
E. Kettel, Telefunken Ztg., vol. 31, Dec. 1958, p. 254/262.

UBER DIE MODULATION DER EIGENFREQUENZ EINES VERLUSTFREIEN SCHWINGKREISES, TEIL II (On the Modulation of the Resonance Frequency of a Tuned Circuit, Part II) (In German)
E. Kettel, Telefunken Ztg., vol. 32, March 1959, p. 29/38.

AMPLITUDE MODULATION SUPPRESSION IN FM SYSTEMS
C. L. Ruthroff, Bell Syst. Techn. J., vol. 37, no. 4, July 1958, p. 1023/1046.

Inadequacies of some limiter concepts are discussed and a limiter analysis in terms of low-index modulation theory is presented. Experimental data . . .

ACTION OF WEAK PULSE INTERFERENCE ON FREQUENCY-MODULATION RECEIVERS
V. M. Sidorov, Radio Engng., vol. 13, no. 13, 1958, p. 26/47.

PRACTICAL CONSIDERATIONS IN THE DESIGN OF MINIMUM BANDWIDTH DIGITAL FREQUENCY MODULATION SYSTEMS USING GAUSSIAN FILTERING
W. L. Glomb, IRE Trans. Commun Syst., vol. CS-7, no. 4, Dec. 1959, p. 284/290.

. . . The relationship between peak deviation and system threshold is explored and an optimum deviation established. The location of the Gaussian filters in the system is discussed . . . These results have been applied to a 2000-mc communication equipment.

. . . The system under discussion will be assumed to be a PTM-FM or a PCM-FM system.

PROBLEMS ENCOUNTERED IN WIDE-BAND FREQUENCY MODULATION
D. D. Wilcox, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 173/181.

. . . using a frequency modulation system for the recording of very wide-band signals in which the modulating frequency closely approaches the carrier frequency. The difficulties involved in detecting the frequency modulated components, and the various factors which contribute to the problem are discussed . . . Use of transistors in the circuits is discussed . . .

A SURVEY OF SOME RECENT DEVELOPMENTS IN RELIABLE FM COMMUNICATIONS
E. J. Baghdady, Proc. Nat. Aeron. Electronics Conf., vol. 8, May 1960, p. 453/463.

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1960, p. 1613/1629.

SPECTRAL MEASUREMENTS OF SLIDING TONES
W. Gersch, et al., IRE Trans. Circuit Theory, vol. CT-7, Aug. 1960, p. 26/39.

NONLINEAR LEAST-SQUARES FILTERING AND FREQUENCY MODULATION
A. D. Hause, Research Lab. of Electronics, MIT, Cambridge, 25 Aug. 1960, 49 p. (Tech rept. 371), AD 258 225.

The low S/N performance of communication systems is shown to be related in a simple way to the structure of the optimum filter polynomial. The use of . . . non-linear filter theory confirms the notion that conventional FM produces somewhat less than optimum reception at low S/N. This study indicates that the type of FM that has potentially the best performance in this range is narrow-band FM with a phase-synchronized carrier.

THRESHOLD IMPROVEMENT IN AN FM SUBCARRIER SYSTEM
B. D. Martin, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 1, March 1960, p. 25/33.

FM WEAKER-SIGNAL SUPPRESSION WITH NARROW-BAND LIMITERS
R. J. McLaughlin, Research Lab. of Electronics, MIT, Cambridge, 1 Feb. 1960, AD 246 280.

. . . suppressing cochannel interference by the method of narrow-band limiting. A design procedure specifying sufficient properties for each section of the receiver is presented. The amplitude disturbances that are caused by the interference before and after narrow-band limiting of the resultant signal are evaluated, in order to determine the limiting threshold requirements for their suppression. The results of an

extensive study of the potentialities of the gated-beam limiter are presented, and its suitability for use as a narrow-band limiter is discussed.

R.F. SPECTRA OF WAVES FREQUENCY MODULATED WITH WHITE NOISE
R.G. Medhurst, Proc. Instn. Elect. Engrs. Part C, London, vol. 107, no. 12, Sept. 1960, p. 314/323, 26 refs.

Although comprehensive sets of curves are available giving the radio-frequency spectra of waves phase modulated with band-limited white noise (simulating f.d.m. telephony signals), the corresponding problem for frequency modulation turns out to be much more intractable. In the present paper the frequency-modulation problem is attacked using a method employed in an earlier paper, in conjunction with numerical devices for improving the convergence rate of very slowly converging series. . . .

OPTIMUM PASSBAND OF A FILTER IN THE RECEPTION OF FREQUENCY-MODULATED SIGNALS WITH FOLLOW-UP TUNING
Ya. G. Rodionov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 9, 1960, p. 63/73.

. . . from the point of view of ensuring maximum interference resistance in reception and the highest quality reproduction of the useful signal. . . .

ENERGY SPECTRA OF FM SYSTEM WITH LOW BETA, HIGH DEVIATION RATIO, AND MF WHICH APPROACHES CARRIER FREQUENCY
S.L. Simmons, Trans. IRE Space Electronics Telemetry, vol. SET-6, no. 1, March 1960, p. 17/19.

. . . this technique may be used for analysis of any FM wave and yields theoretical results which conform closely to actual operating results.

WIND-BAND CARRIER COMMUNICATIONS. VOLUME II. FREQUENCY MODULATION OF RANDOM CARRIERS
J.J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., 1 Jan. - 18 March, 1960, (Tech. rept. on Communications) Oct. 1960, 1 v. (Rept. no LMSD-704 16, Vol. 2) AD 253 282.

Random-carrier communications using frequency-shift modulation, is described. This is accomplished by transmitting a frequency band of random energy in two forms; a reference carrier is transmitted on one frequency band, and a frequency-shift modulated version of the reference carrier is transmitted on a second band not overlapping the first. A basic description of this communication channel is presented, and its performance is computed and experimentally verified in terms of the output signal-to-noise ratio.

SPECTRAL ANALYSIS OF VOICE-MODULATED FM SIGNAL
L.R. Spogen, Jr., et al., Applied Research Lab., U. of Arizona, Tucson, Final rept. Dec. 1960, 30p., AD 256 535.

. . . calculation and measurement of the carrier and sideband spectrum of an electromagnetic wave when frequency modulated by a non-periodic wave such as ordinary speech. The spectra for various deviation ratios were calculated and measured. Only the vowels and diphthongs were used for calculated spectra . . .

THEORY AND METHODS OF FREQUENCY MODULATION (In Russian)
A.D. Artym, Moscow-Leningrad, Gosenergoizdat, 1961, 244 p.

. . . contains a systematic explanation of the methods of frequency and phase modulation as well as a theoretical analysis of these methods which permit an estimate of their possibilities, achievements and inadequacies . . . Special attention is paid to new, most effective methods of frequency and phase modulation, which have been slightly or not at all explained in existing literature. . . . intended for engineers working in radio communication . . .

A GENERALIZATION OF WOODWARD'S THEOREM AND THE SPECTRUM OF A HIGH HARMONIC OF A SINUSOID PLUS NARROW-BAND GAUSSIAN NOISE
N.M. Blachman, Electronic Defense Labs., Mountain View, Calif., 28 March 1961, 12p. (Technical memo, EDL-M367) AD 263 056.

. . . the power spectrum of a slowly frequency-modulated signal is given by the first-order probability density of the modulation. It can be extended to cover the case where there is slow amplitude modulation as well (correlated or uncorrelated and deterministic or random)

THE OUTPUT SPECTRAL DENSITY OF A DETECTOR OPERATING ON A F.M.C.W RADAR SIGNAL IN THE PRESENCE OF BAND-LIMITED WHITE NOISE
J. Lait, Proc. Instn. Elect. Engrs. Part C, London, vol. 108, no. 13, March 1961, p. 197/207.

A method of analysis suggested by Lawson and Uhlenbeck is used to examine the interaction between reference signal, echo and noise in the detector stage of a frequency-modulated c.w. radar receiver. . . .

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1961, p. 1613/1629.

. . . for multiplexed binary telegraph signals that are used to frequency-modulate an RF

carrier that is subsequently corrupted by fading and noise. Frequency-shift keying, amplitude keying, and phase-shift keying are considered. It is shown that most telegraph errors occur when the carrier fades below threshold . . . The analysis pertains most directly to tropo-scatter systems, but the general conclusions regarding the effect of FM threshold should be relevant also for fading transmission paths such as those met in line-of-sight and telemetry . . .

POWER-BANDWIDTH TRADE-OFFS FOR FEEDBACK FM SYSTEMS: A COMPARISON WITH PULSE-CODE MODULATION
E. Bedrosian, RAND Corp., Santa Monica, Calif., Oct. 1961, 59 p., (Rept. RM-2787) AD 264 781.

. . . For a given quality of service, power can be traded against bandwidth depending on the amount of feedback used. Large amounts of feedback in a typical system can reduce the amount of transmitter power required by as much as 8 db while roughly doubling the radio channel occupied, compared with a conventional FM system designed to minimize transmitter power. Assuming an optimum detection process, a comparable PCM system requires about 3 db less power than a conventional toll-quality FM system but about 5 db more power than a feedback FM system using 35 to 40 db of feedback.

A GENERALIZATION OF WOODWARD'S THEOREM ON FM SPECTRA
N.M. Blachman, Information Control, vol. 5, no. 1, March 1962, p. 55/63.

VARIABLE BANDWIDTH FM TRANSMISSION SYSTEM
J. Bordogna, et al., Commun. Bridge or Barrier, 7th Natl. Commun, Symp., vol. 7, Oct. 1961, p. 310/317.

. . . application . . . in general and in FM tropospheric scatter . . . will significantly reduce interference and fuel consumption by allowing the reduction of required transmitter power while maintaining reliability . . .

THE VISUALIZATION OF FREQUENCY-MODULATION TRANSIENTS BY MEANS OF MECHANICAL MODELS
M.J.E. Golay, IRE Trans. Circuit Theory, vol. CT-9, no. 1 March 1962, p. 78/82.

THE THEORY AND DESIGN OF F.M. RECEIVERS
D. Hess, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., 11 May 1962, 84p., AD282 110.

The spectrum of an F.M. wave modulated by gaussian noise is studied . . . response of linear band-pass networks to an F.M. signal . . . Several new and several existing F.M. demodulators are studied to establish design criteria for the demodulators. Finally the ability of a phase-lock loop to demodulate an F.M. signal is studied . . .

SYNCHRONIZED SELECTIVITY RECEIVER
F.H. Hilbert, Motorola, Inc., Chicago, Ill., Final rept., 1 Apr. 1959 - 31 May 1961, 31 May 1961, 1v. incl. illus., 18 refs., AD 282 446.

Synchronized selectivity was investigated as a method of improving receiver range through threshold improved performance of voice communications (index of modulation 5) FM receivers. Results were negative. Techniques of frequency compression and phase tracking were also evaluated for improved range. Results were negative. A re-examination of threshold phenomena showed this to necessarily be the case for the index of modulation used. However, if wide band FM were abandoned and narrow band PM utilized, threshold does not occur and the superior weak signal performance and range of an AM system results.

DIE ZEIGERMETHODE
EIN ANSCHAULICHES VERFAHREN ZUR BEHANDLUNG VON VERZERRUNGEN DER KLEINHUB-FM MIT ANWENDUNG AUF FM-RICHTFUNK (The Vector (Phasor) Method. An Indicative Method for the Analysis of FM Distortion in Cases of Low FM Index.) (In German)
M. Muller, Arch Elekt. Übertrangung, vol. 16, no. 2, Feb. 1962, p. 93/96.

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO FM SIGNALS AND NOISE
D.L. Schilling, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y. June 1962, 136p. incl. illus. tables, refs. (Research rept. no. PIBMRI-1040-1962) AD 295 555.

. . . Emphasis is placed on the system's response to frequency ramp modulated signals . . . The response of the System to an FM signal is obtained using a perturbation technique and perturbing about the solution to the nonlinear pendulum problem. A piecewise-linear solution is also presented. . .

FM RECEPTION UNDER CONDITIONS OF STRONG INTERFERENCE
J. van Slooten, Philips Tech. Rev., vol. 22, no. 11, July 1961, p. 352/360.

APPROXIMATE DETERMINATION OF THE EXTREME THRESHOLD POSITION IN FREQUENCY MODULATION

G. Battail, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 136.

. . . to approximately determine the reception threshold position in large index frequency modulation, as reached by the use of a hypothetical (yet unknown) optimum demodulator. . . . an interpretation of threshold phenomenon . . . in the case of a continuous modulation system with modulation gain (i.e., which trades minimum necessary power against bandwidth). After Shannon, demodulation is then represented as a non-topological mapping in high-dimensional signal spaces. . . . One may . . . share the noise after demodulation into "neighborhood" and "error" noise, . . . The former is predominant above threshold, the latter below; threshold is defined by the equality of their powers. In the FM case, neighborhood noise is already known, according to the conventional large signal theory. Error noise may be approximately computed after replacing the actual continuous modulating signal by a discontinuous one, . . .

SWEPT FREQUENCY MODULATION. A MEANS OF REDUCING THE EFFECTS OF IMPULSE NOISE.

J. C. Dute, et al., Michigan U., Ann Arbor, Report on Telemetry and Command Destruct, Dec. 1962, 19 p., ASD TDR 62-836, AD 297 798.

THE DESIGN AND CAPABILITIES OF FEEDBACK FM RECEIVERS

R. M. Gagliardi, (Western Electronic Show and Convention, Los Angeles, Calif., Aug. 21-24, 1962), 1962 WESCON Convention Record, Part 7 - Communications, vol. 6, 1962, 9 p.

. . . will maximize power savings over standard FM for a given output SNR. System parameters such as transmitter modulation index, loop gain, IF bandwidth, and baseband-filter bandwidth are specified, corresponding to this optimum design. Particular attention is given to output SNR in the range from 15-50 db, the practical operating range of most analog systems . . .

ON THE PERFORMANCE OF FM COMMUNICATIONS IN THE PRESENCE OF RF NOISE

G. A. Hellwarth, IRE Trans. Mil. Electronics, vol. MIL-6, no. 4, Oct. 1962, p. 346/349.

A critical view is taken of some common notions of input signal-to-noise ratio "thresholds" below which frequency-modulation radio links become inoperative but above which highly satisfactory communications results.

Experimentally derived curves are shown giving output vs input S/N's for three FM receiver bandwidths and a signal employing sine-wave modulation. When the experimental FM curves are compared with theoretical curves for AM, DSB, and SSB, it becomes clear that the "threshold" concept is extremely misleading. . . .

SIGNAL-TO-NOISE-EFFECTS AND THRESHOLD EFFECTS IN FM

M. Schwartz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 59/71.

. . . a tutorial discussion of threshold effects in wideband FM receivers. Comparison is made between the analytical approaches used independently by Rice, Middleton, Wang and Stumpers. Their analyses show the existence of two thresholds: (1) The noise at the output of the detector increases rapidly when the carrier-to-noise ratio drops below about 10 db. (2) A signal suppression effect takes place when the carrier-to-noise ratio drops below 0 db. Some recent experimental verification of the theoretical results is presented. The application of the threshold phenomena to FM frequency feedback receivers, and to the study of digital error rates in fading FM systems is noted.

THE POWER SPECTRUM PRODUCED BY THE LINEAR MIXING OF SIGNALS FREQUENCY MODULATED BY GAUSSIAN NOISE

L. M. Tozzi, Harry Diamond Labs., Washington D. C., 15 Nov. 1962, 26p. (Rept. no. TR-1093), AD 298 088.

THEORETICAL STUDIES ON SIGNAL-TO-NOISE CHARACTERISTICS OF AN FM SYSTEM

H. Akima, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 4, Dec. 1963, p. 101/108, 28 refs.

. . . assuming that the transmitted wave is frequency-modulated by a discontinuous signal, which is made by sampling from the original information signal at every sampling point equally spaced by a Nyquist interval . . . Studies are made with a simple model of an FM demodulator of a new type, which may be called the band-dividing FM demodulator. As a result of these studies a limit to the degree of improvement in the threshold of an FM system is obtained. The result obtained here again suggests that it is possible to improve the threshold of the system beyond that of a so-called conventional FM demodulator. . . . Brief discussions on the threshold effects in the so-called phase-lock and frequency-lock FM demodulators are also given. . . .

BANDWIDTH AND SPECTRA OF PHASE-AND-FREQUENCY-MODULATED WAVES
N. Abramson, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 407/414, 14 refs.

The spectrum of a sinusoid, angle-modulated by a stationary Gaussian random process (GRP) of almost arbitrary spectrum, is investigated. Such a GRP provides a convenient model for voice signals, TV signals, and complex communication signals of other types. It is shown that the rms bandwidth of the modulated wave is the product of the rms bandwidth of the modulating wave and the rms angle modulation. In the frequency modulation case, this results says the rms bandwidth of the modulated wave is $1/2\ \pi$ times the rms frequency deviation. A general expansion for the shape of the spectrum of the modulated sinusoid is derived. . . .

FM IMPROVEMENT TECHNIQUES
E. J. Baghdady, et al., Adcom, Inc., Cambridge, Mass., Final Rept., 1 Feb. 1963, 291 p., AD 417 637 and N63-22119.

. . . discussion of the noise threshold of exponential modulation systems . . . The fundamental theory of threshold reduction by means of the oscillating limiter, the phase-locked loop and demodulators with frequency - compressive feedback is then presented . . . experimental results . . . dealing principally with the oscillating limiter.

CORRECTIONS TO "APPROXIMATE DETERMINATION OF THE EXTREME RECEPTION THRESHOLD POSITION IN FREQUENCY MODULATION" (Correspondence)
G. Battail, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 286.

. . . to correct some points in a previous paper (originally published in France). . . .
G. Battail, IRE Trans. on Inform. Th., vol. IT-8, pp. S108-S121; September, 1962. . . .

BINARY DATA TRANSMISSION BY FM OVER A REAL CHANNEL
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2387/2426.

Formulas are derived for probability of error in the detection of binary FM signals received from a channel characterized by arbitrary amplitude- and phase-vs-frequency distortion as well as additive Gaussian noise. The results depend on the signal sequence and can be presented in terms of averages over all signal sequences or as bounds for the most and least vulnerable ones. Illustrative examples evaluated include Sunde's method of suppressing intersymbol interference in band-limited FM . . . It is found that a performance from 3 to 4 db poorer than that theoretically attainable from binary PM is realizable over a variety of filtering situations.

ASYMPTOTIC BEHAVIOR OF THE SPECTRA OF RF PULSES WITH LINEAR FREQUENCY MODULATION
S. L. Borison, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 9 Oct. 1963, 29 p., refs., Rept. 41G-5; AD 421 872, N64-17663.

. . . It is specifically shown that at frequencies (measured from the carrier frequency) much larger than the maximum FM deviation the effect of the FM is small. . . .

NOTES ON THE THEORY OF MODULATION
J. R. Carson, Proc. IEEE, vol. 51, no. 6, June 1963, p. 893/896.

. . . It had been proposed that frequency modulation could be used to provide a radio signal narrower in band than the modulation. In the following paper from the Proceedings of 1922, John R. Carson proved mathematically, in classically simple style, that a frequency-modulated signal could not occupy less space than the modulation band. . . . The reasoning that followed seems to have gone somewhat like this: Carson had proved that . . . frequency modulation had nothing to offer for the purpose under study-frequency modulation had little to offer. The summary, if lightly read, says so. Thus we waited fifteen years for Armstrong! . . .

FM CHANNEL CAPACITY DOUBLING BY POWER DIVISION
E. A. Conover, Army Electronics Research & Development Agency, Fort Monmouth, N.J., March 1963, 23 p., AD 419 623 and AD 407 691.

A specialized receiving system which enables the extraction of the weaker of two co-channel frequency-modulated signals . . . modifications made to a standard military receiver R-110/GRC (38 to 55 MC range) . . . An innovation is introduced which considerably decreases the amount of distortion and increases the intelligibility when speech is used as the modulation of both weaker and stronger signals. This innovation consists of the superimposition of a constant-level sinusoidal audio tone to the voice-modulated stronger signal. . . . Charts illustrating spectra of detected audio components before and after circuit modification to effect this innovation are included. A theory is advanced in explanation of the improved intelligibility obtained by the innovation.

MINIMUM POWER ANALOGUE COMMUNICATION
J. A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., 15 May 1963, 38 p., Rept. no. TDR 169 3250 43 TN2, AD 437 203.

. . . theory of minimum power wide-band frequency modulation communications . . . considered: . . . sources of noise, frequency modulation theory, frequency-following reception, phase-lock and FM feedback, thresholding, the effects of system nonlinearities, and the use of pre-emphasis.

TABLES OF ORDINARY BESSEL FUNCTIONS OF THE SECOND KIND OF ORDERS 0 THROUGH 9 VOLUMES I-V

G. C. Francis, et al., Ballistic Research Labs., Aberdeen Proving Ground, Md., March 1963, approx. 400 p., AD 405 467 (Vol. I), AD 405 468 (Vol. II), AD 405 469 (Vol. III), AD 405 470 (Vol. IV), AD 405 471 (Vol. V).

THE EFFECT OF A POWER-LAW DEVICE ON THE CORRELATION FUNCTION OF A FREQUENCY-MODULATED SIGNAL

H. Kaufman, et al., Journal of Electronics and Control, 1st Series, vol. 16, March 1964, p. 307/324, A64-16669.

Presentation of a derivation of the cross-correlation function at the output of a power law device when the input consists of frequency-modulated signals plus both correlated and uncorrelated additive noise. Detailed results are presented for the case of an ideal limiter, a linear amplifier, a square-law device, and a cube-law device. . . .

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS (PHASE 3 REPORT)

J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Final rept., Feb. 1962-Feb. 1963, May 1963, 175 p., RADC TDR63 147, N63-17933, AD 407 343.

The maximum likelihood estimation of FM-modulated signals is investigated. . . . threshold phenomenon in FM reception with an ideal discriminator and a postdetection Wiener filter for the case of a random modulation function. . . . bounds on the performance of PCM systems for transmitting analog information . . . compared with theoretical bounds for systems of prescribed complexity. The analysis of the optimization of N-ary digital systems operating over a dispersive channel, which was begun during a previous phase of the contract, is further advanced.

INTEGRATION AND DIFFERENTIATION IN THE GENERATION AND DEMODULATION OF F.M. WAVES

G. May, Electronic Engng., (GB), vol. 35, Feb. 1963, p. 96/99.

Integration and differentiation are shown to be basic processes in the generation and demodulation of frequency-modulated waves. In considering these processes the term modulation coefficient and an associated symbol m_c is introduced. The relationships between modulation index, modulation coefficient and modulation factor are discussed and a comparison is made of the effects of frequency-multiplication and frequency translation on the quantities.

FREQUENCY-MODULATED SIGNALS AND THEIR POWER SPECTRA

G. H. Nitta, Naval Ordnance Lab., Corona, Calif., Feb. 1964, 139 p., NOLC TM74 208, AD 436 407.

. . . a condensation and interpretation of mathematical analyses that relate to frequency-modulated signals, their spectra, and the effect of passing such signals through linear filters. . . . involve almost-periodic and aperiodic signals. Formulas are also given which show the effects of processing frequency-modulated signals through rectangular, RC, and Gaussian-shaped low-pass filter, and Gaussian passband and linear narrowband filters.

THE HISTORY OF LAND-MOBILE RADIO COMMUNICATIONS (Correspondence)

J. S. Smith, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 253.

Dr. Noble's article in the Fiftieth Anniversary Issue . . . one area which this author thinks needs clarification . . . concerned with that critical period after Major Armstrong first conceived FM . . . steps that lead to the acceptance of FM as the best medium for mobile radio. . . .

BAND LIMITATION AND ERROR RATE IN DIGITAL UHF-FM TRANSMISSION

H. J. von Baeyer, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 110/117.

The literature on systems design for the transmission of high speed digital data in the "megabits per second" range over UHF links is scarce and somewhat contradictory. . . . problem of finding the best compromise between radiated bandwidth, power balance, and output SNR, the latter being directly related to the error rate. Confining the analysis to frequency modulation . . . optimization is analyzed. The effects of intersymbol interference, FM transient characteristics, and F, improvement threshold are discussed . . .

A FORTRAN PROGRAM TO CALCULATE BESSEL FUNCTIONS OF INTEGRAL INDEX AND COMPLEX ARGUMENT

J. E. White, Jr., Brown Engineering Co., Inc., Huntsville, Ala., Scientific Research Labs., July 1963, 35 p., 5 refs., N63-22562.

. . . Calculation of the radar cross section of a cylindrical shell plasma requires very accurate computations of the Bessel functions of the 1st, 2nd and 3rd kinds with complex arguments and integral order. FORTRAN II subroutine for the IBM-1410 computer have been written to calculate these functions . . .

AN ANALYSIS AND SYNTHESIS PROCEDURE FOR FEEDBACK FM SYSTEMS. PART A: CONVENTIONAL FM SYSTEMS. PART B: FEEDBACK FM SYSTEMS
A. Wonjnar, Massachusetts Inst. of Tech., Cambridge Research Lab. of Electronics, Sept. 30, 1963, 53 p., 31 refs., N63-23575.

. . . frequency-compressive feedback FM systems . . . threshold behavior . . . survey of the existing noise analysis of FM systems . . . shown that the excess-noise component predominates in the threshold region of most conventional FM systems. A new analytical expression (which agrees with experimental evidence) has been found for the location of the noise threshold. Two possible mechanisms causing noise threshold in a feedback FM system are examined . . . Experimental results with certain feedback FM configuration . . .

Related Publications:

FLIGHT TEST DATA SYSTEM VICTOR SYSTEM 272
G. Luecke, (Presented by G. E. Sandgren), IRE Trans. Telem. Remote Contr., vol. TRC-3, no. 1, April 1957, p. 1/16.

. . . FM information is recorded on a 30 track, 3,000 ft. 1 1/2" magnetic tape for a maximum of 40 minutes per reel.

THEORETICAL ERROR PROBABILITIES FOR FREQUENCY-SHIFTKEYED TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague (Netherlands), Sept. 1959, 65 p., AD 226 924.

A NEW PRACTICAL APPROACH TO SUBCARRIER PRE-EMPHASIS
W. E. Hane, 1959 Nat. Telemetering Conf., May 1959, p. 151/160.

New designs for fm/fm telemetry often lack a method of obtaining optimum subcarrier preemphasis. . . . The use of an optimum preemphasis curve rather than a "standard" curve significantly increases the effective range of a given telemetry system. However, when the system has more than six to eight subcarrier oscillators, the data distortion often becomes intolerable. . . .

IDEAL BINARY PULSE TRANSMISSION BY AM AND FM
E. D. Sunde, Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1357/1426.

. . . It is shown that intersymbol interference can be avoided in binary pulse transmission by FM without the need for a wider channel band than in double-sideband AM, for equal pulse transmission rates . . . partial pulse shaping by premodulation and postdetection low-pass filters is also considered.

EXPLICIT FORM OF F.M. DISTORTION PRODUCTS WITH WHITE-NOISE MODULATION (Extension and Correction)
R. G. Medhurst, et al., Proc. Instn. Elect. Engrs. Part C, London, vol. 107, no. 12, Sept. 1960, p. 367/369.

THE CASE OF FM-AM VS FM-FM TELEMETRY
L. L. Rauch, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 2, June 1960, p. 81/84.

VARIABLE BANDWIDTH FM TRANSMISSION SYSTEM
J. E. Palmer, et al., RCA Defense Electronic Products, Camden, N.J., 30 April 1961, 143 p., 43 refs., RADC TR61-124, AD 259 090.

. . . A system is proposed in which data rate would be varied by adjusting the transmitted bandwidth in accordance with the prevailing conditions. . . . Efficient use of the communications channel, especially in systems such as forward propagation tropospheric scatter where the received signal power varies over a wide range. . . .

BANDWIDTH LIMITING EFFECTS OF FREQUENCY SELECTIVE FADING OVER TROPOSPHERIC SCATTER PATHS
P. D. Shaft, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., Master's thesis, 12 Dec. 1961, 105 p. incl. illus., tables, 25 refs., Research rept. no. PIBMRI-976-61, AD 281 967.

. . . applicable to systems frequency modulated with frequency division multiplexed telephone and telegraph channels. . . .

FM-SIGNAL DEMODULATION IN MICROWAVE FREQUENCY-COMPRESSION RECEIVERS
W. L. Sweet, Electronic Defense Labs., Mountain View, Calif., 3 Feb. 1961, Technical memo. no. EDL-M334, AD 252 712.

Reception of broad-band FM signals may be improved by employing the technique of frequency compression in the receiver. Frequency compression is briefly compared with other FM reception techniques, and its application in microwave receivers is discussed. . . . the possibility of combining several FM reception techniques is considered.

APPROXIMATE BAND-PASS LIMITER ENVELOPE DISTRIBUTIONS
W. Doyle, et al., Rand Corp., Santa Monica, Calif., Feb. 1962, 21 p. incl. illus., 20 refs., Memo. no. RM-2987-PR, AD 274 684.

. . . An approximate distribution is computed for the envelope of sine wave plus noise after passage through a wide-band filter, limiter and narrow-band filter. . . .

FREQUENCY MODULATION TECHNIQUES AS APPLIED TO PULSE DOPPLER RADAR
G. R. Hetrich, IRE Intern. Conv. Rec., Pt. 5, vol. 5, March 1962, p. 76/86.

. . . Two methods of frequency modulating the transmitted carrier for ranging purposes are considered for a typical Pulse Doppler radar. . . . linear FM and sinusoidal FM. . . .

TRANSMISSION OF F.M. SIGNALS THROUGH LINEAR FILTERS
D. T. Hess, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 469/476.

. . . the response of a linear filter to an F.M. signal is derived. . . . expressed as a closed form function of the instantaneous frequency of the input wave plus an error term on which a tight bound is kept. . . .

THE PIONEER IV LUNAR PROBE: A MINIMUM-POWER FM/PM SYSTEM DESIGN
B. D. Martin, JPL, Calif. Inst. of Tech., Pasasena, Calif., 15 March 1962, 76 p. incl. illus., tables, refs., Tech. rept. no. 32-215, AD 274 664.

. . . 2 typical FM/PM system design calculations are presented to illustrate the application of the previously derived techniques.

FM STAR-LOCK SYSTEM USING MASK WITH LINEAR SECTORS
E. K. Sandeman, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 1, March 1962, p. 24/34.

. . . With misalignment . . . the output of the photocell is frequency modulated. The resulting FM wave is suitably processed to provide misalignment signals along two axes. . . .

FM STAR-LOCK SYSTEM USING MASK WITH SPIRAL SECTORS
E. K. Sandeman, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 1, March 1962, p. 35/47.

LA DISTORSION EN MODULATION DE FREQUENCE (FM Distortions, Last Part) (In French)
J. Schwob, Ann. Telecommn., vol. 17, March-April 1962, p. 46/66, 27 refs.

RADAR ALTIMETRY
S. H. Black, Sperry Engineering Review, vol. 16, Spring 1963, p. 38/43, A63-17585.

. . . FM-CW technique . . . the low-noise FM-CW system will result in freedom from step error, by providing continuous nonquantized data output.

AN FM-CW ORBITAL RENDEZVOUS AND LANDING RADAR SYSTEM
J. Hooper, et al., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 53/56.

. . . (1) . . . typical sensor data requirements for performing rendezvous in orbit and landing from orbit, (2) describe an FM-CW radar designed . . . for both of these functions . . . (3) review the results of a research program that has been directed toward solving the major problems associated with building this radar. . . .

SPECTRUM OF PERIOD-MODULATED SINUSOIDAL OSCILLATIONS
L. Y. Il'nitskiy, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 1/5.

. . . A comparison is made with the spectrum of a frequency-modulated signal. For RC oscillators there exists a linear relationship between the oscillation period T and the values of the circuit elements the magnitude of which determines the period . . . The linear relationship between the period and the parameters, the magnitude of which can be varied by means of the modulating voltage implies that for period-modulation it is possible to have a large depth of modulation without any nonlinear distortions. . . .

SPECTRAL DENSITY DISTRIBUTION OF SIGNALS FOR BINARY DATA TRANSMISSION
H. J. Pushman, J. Brit. Instn. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

. . . It can be argued in the case of f.m. that to avoid discontinuities in the waveform, the signal can be generated by switching between locked oscillators, and for a smooth transition . . . a digit of the higher frequency must contain an integral number of cycles more than a digit of the lower frequency. . . .

PARAMETER OPTIMIZATION OF AN FM/FM MULTICHANNEL TELEMETRY SYSTEM
D. H. Sapp, RCA Rev., vol. 24, no. 3, Sept. 1963, p. 381/390.

. . . The various sources of distortion in FM systems are discussed and graphs are given to show typical saddle points by means of which parameters can be selected to maximize the signal-to-noise ratios. . . .

1.233: Phase Modulation

Included: Analog polyphase modulation.

Not Included: Phase demodulators; Phase lock loops; Phase modulators.

Cross References: Digital phase modulation systems (Sect. 1.34); Phase distortions in transmission systems (1.626); Multiple modulation systems with phase modulation (Div. 1.9); Pulse phase modulation = PPM (1.442).

Principal Publications:

A NEW HORIZON IN COMMUNICATION THEORY-THE POLYPHASE CONCEPT
A. A. Kunze, et al., Rome Air Development Center, Griffiss AFB, New York, Tech. Note 58-6, Jan. 1958, AD 148 538.

THE GENERATION OF SINGLE SIDEBAND CARRIER TELEPHONE CHANNELS BY POLYPHASE MODULATION
J. R. Mensch, Rome Air Development Center, Griffiss Air Force Base, N.Y., June 1958, 13 p., AD 148 773.

PHASE INTERCEPT DISTORTION
P. F. Ordung, Dunham Lab., Yale U., New Haven, Conn., Oct. 1958, Quarterly progress rept. no. 6, 8 Oct. 1958, AD 207 085.

. . . attenuation shall be constant and the phase characteristic shall be a linear function of frequency throughout the passband of the message. . . . these conditions . . . are not sufficient to guarantee that the transmission . . . will be distortion free. An additional requirement should be that the linear phase characteristic in the passband when extended to zero frequency shall have a phase angle intercept (or phase intercept) that is a multiple of π radians. When the phase intercept angle is other than a multiple of π radians, a form of distortion, which is known as phase intercept distortion, is obtained. (Author) (See also AD 154 561).

DIE BEDEUTUNG DER 90° PHASENDREHUNG BEI SPEZIELLEN MODULATIONSVERFAHREN (The Meaning of the 90° Phase Shift in Special Modulation Methods) (In German)
H. Schleisier, Hochfrequenztech. Elekt. Akust, vol. 67, Sept. 1958, p. 42/48.

ANALYSIS OF A PHASE MODULATION COMMUNICATIONS SYSTEM
R. L. Choate, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Oct. 1959, 9 p., Progress rept. no. 30-21, AD 234 529.

A communication system is analyzed which utilizes phase modulation (PM) and phase detection. The analysis shows that when the total radio frequency (RF) power level is significantly above the receiver threshold, a margin of safety exists which may be traded for additional signal-to-noise ratio (SNR) at the demodulated output of the receiver. In this respect the PM system is similar to FM Communication systems which utilize an "FM improvement factor." Several examples are presented to indicate the magnitude of the PM improvement factor when the signal is a sine wave variable throughout the audio band. A novel type of closed-loop phase detector is suggested which is linear over a very wide range of phase angles.

ANALYSIS OF A PHASE MODULATION COMMUNICATIONS SYSTEMS
R. L. Choate, IRE Trans. Commun. Syst., Vol. CS-8, no. 4, Dec. 1960, p. 221/227.

NOTATIONS FOR BALANCED POLYPHOSE (POLYPHASE) SYSTEM AND THEIR OPERATIONAL METHODS. I. PROPOSITION ON NOTATIONS FOR BALANCED POLYPHOSE (POLYPHASE) SYSTEM
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. 11, no. 1, 1959, p. 45/54.

Considers the relation between spatial and electrical phase angle in a balanced polyphase system. . . . a general notation is developed for dealing with these systems. . . . Operational methods . . .

NOTATIONS FOR BALANCED POLYPHASE SYSTEM AND THEIR OPERATIONAL METHODS. II. OPERATIONAL METHODS BY NOTATIONS FOR BALANCED POLYPHASE SYSTEM
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. 11, no. 3-4, 1960, p. 155/177.

Multiplication, addition and subtraction of the systems . . . are derived by consideration of the general term for the q^{th} phase. The authors conclude that the derived results constitute the basic modulation and demodulation theory of polyphase systems, and will be of use in considering polyphase communication systems. . . .

GENERAL PRINCIPLES OF POLYPHASE VACUUM TUBE OSCILLATOR
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. 11, no. 3-4, 1960, p. 179/201.

The theory . . . is extended to a general consideration of the polyphase vacuum tube oscillator. . . . it is shown that there is a multiplicity of possible modes and corresponding frequencies. Attention is then given to the phenomenon of "frequency jumping" in polyphase oscillators . . . Finally the circuit diagram of an RC-coupled five-phase oscillator is given, and the conditions for oscillation, the modes and the corresponding frequencies are calculated. . . .

BANDWIDTH AND SPECTRA OF PHASE-AND-FREQUENCY-MODULATED WAVES
N. Abramson, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 407/414, 14 refs.

MINIMUM SIGNAL TO NOISE-DENSITY RATIOS FOR TRANSMISSION OF TELETYPE AND SPEECH
F. F. Yates, Aerospace Corp., El Segundo, Calif., Engineering Div., Jan. 1964, 12 p., refs., AD 429 202, N64-15825.

. . . requirements of a phase-modulation communication channel . . .

Related Publications:

POLYPHASE OSCILLATORS
A. S. Gladwin, Electronic Radio Engr., vol. 35, Jan. 1958, p. 16/24.

PHASE-SHIFT KEYING IN FADING CHANNELS
H. B. Voelcker, Proc. Instn. Elect. Engrs., London, Part B., vol. 107, no. 31, Jan. 1960, p. 31/38.

THE PIONEER IV LUNAR PROBE: A MINIMUM-POWER FM/PM SYSTEM DESIGN
B. D. Martin, JPL, Calif. Inst. of Tech., Pasadena, Calif., 15 March 1962, 76 p. incl. illus., tables, refs., Tech. rept. no. 32-215, AD 274 664.

. . . Use of phase-coherent techniques in both the carrier and subcarrier channels produced a system capable of threshold performance at two Moon distances . . .

THE USE OF PHASE MODULATIONS IN RADIO NAVIGATION AIDS
C. R. N. Barnard, Electronics Research and Development for Civil Aviation Conference, London, Oct. 2-4, 1963, p. 197/200, A64-12856.

Discussion of the use of phase modulated transmissions in radio navigation systems. A method is proposed which calls for simultaneous transmission by Master and Slave stations on the same frequency. . . .

THE STRUCTURE OF EFFICIENT DEMODULATORS FOR MULTIDIMENSIONAL PHASE MODULATED SIGNALS
H. L. Van Trees, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 261/271.

Section 1.28

1.280: Various Other Analog Modulation Methods

Included: Velocity modulation of propagating waves; Hybrid modulation methods; Polarization modulation; Modulation by nonlinearities in the propagation medium; Passive modulation techniques.

Not Included: Multiplexing of different channels with simultaneous AM and PM (2); Physics of ionospheric interaction; Optical polarization modulators (3B).

Cross References: PACM-FM modulation method (1.934); Combined phase and amplitude modulation in data transmission (1.383).

Principal Publications:

COMBINED AM AND PM FOR A ONE-SIDED SPECTRUM
N. Chakrabarti, Proc. IRE, vol. 47, Sept. 1959, p. 1663.

PERFORMANCE OF COMBINED AMPLITUDE AND PHASE-MODULATED COMMUNICATION SYSTEMS
J. C. Hancock, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 232/237.

SPECTRUM ANALYSIS IN AMPLITUDE-PHASE MODULATION
L. E. Kliagin, Radio Engng: Transl of Radiotekhnika, vol. 15, no. 8, 1960, p. 96/106. p. 96/106.

DISCUSSION OF "COMBINED AM AND PM FOR A ONE-SIDED SPECTRUM"
Proc. IRE, vol. 49, no. 6, June 1961, p. 1094/1095.

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS
E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

A COHERENT DIGITAL AMPLITUDE AND PHASE MODULATION SCHEME
C. N. Campopiano, et al., IRE Trans. Commun., Syst., vol. CS-10, no. 1, March 1962, p. 90/95.

VELOCITY MODULATION OF PROPAGATING WAVES
R. Landauer, Journal of Applied Physics, vol. 34, July 1963, p. 1893/1896, A63-18623.

DIVISION 1.3
DIGITAL MODULATION METHODS

This division is concerned with references to digital or discrete information transmission systems, generally known as data transmission systems. They are characterized by the availability of a finite number of clearly distinguishable transmission states (waveforms) at the transmitter. Some are selected during each transmission interval to express the desired information. If there are only two states and one is selected during each interval, one speaks of a binary system. If there are more than two states and only one of them is selected during each interval, the system is called a higher order data system, or an m-ary system. If more than one state is selected during some or all of the intervals, one arrives at a multi-signal system, also called a multi-digital system.

Section 1.31 deals with the analysis of such binary, higher order and multi-signal systems, offering also special subdivisions for the various classes of waveforms, which may be used in data transmission.

The other sections of this division deal with the different classes of modulation methods which are available for carrying the selected signals or waveforms over band-pass transmission systems. These digital modulation methods follow the same pattern as analog modulation methods, and are organized into amplitude, frequency and phase modulation systems.

A section on special receiving problems and another one on particular hybrid transmission systems conclude the division.

It is important to be aware of the fact that some data transmission systems combine the functions of waveform generation and modulation, while others provide one subsystem for the generation of base-band signals and another subsystem for the modulation of these signals on a subcarrier or a final transmission carrier. The corresponding receiving functions may be likewise either combined or separated. Hybrid designs with separated functions at the sending terminal and combined functions at the receiving terminal or vice versa are also in use.

This situation leads to an endless variety of possible designs and any attempt at a logical classification is of dubious value. This is why the common analytical background of data transmission systems is presented in section 1.31, while the individual, best documented operational systems are reported in other sections where they are identified by the names of their promoters or by artificial names and classified according to their principle modulation method.

One controversial point is the discrimination between, or the identity of, data transmission systems in the above sense and of pulse code modulation systems. In this bibliography, the latter are arranged in a separate division (1.5), the reason is their fundamentally different range of applications. Data transmission systems are designed to accept any sequence of discrete, usually binary, input symbols. Pulse code modulation systems are designed to accept analog input waveforms, to convert them to groups of digital symbols, to transmit these discrete symbols with a minimum of errors and to re-assemble finally the analog waveform at the receiver output. While this difference appears to be a rather significant one, it has to be recognized that the actual discrete transmission system of a pulse code modulation (PCM) system is functionally identical with a data transmission system. This is the reason why we concentrate in this bibliography in division 1.33, on the transmission aspect of discrete signals and in division 1.5 on the quantization and coding problems of converting analog information to discrete symbols.

Between these two divisions falls the area of sampled modulation systems, also called pulse modulation systems or semi-analog transmission systems. They are discrete in the time domain, by transmitting information only at specified sampling instants, but they offer at each of these instants a continuous (analog) range for the modulation of one or more transmission parameters. We deal logically with these systems in division 1.4, following the data transmission systems but preceding PCM.

To complicate the situation further, it is necessary to realize that most operational data transmission systems, primarily telemetering systems, use simultaneously a large number of parallel channels, i.e., they are multiplex systems. The modulation frequently takes place in several subordinate levels, leading to multiple modulation methods. Indeed, one can find today on a single space craft, for example on the Saturn booster and the Apollo space craft, AM, FM, PhM in all possible combinations of time division and frequency division multiplexing with a large variety of codes, data formats, subchannel bandwidths and other transmission parameters.

To guide the reader through this complex multitude of system combinations, we have placed all references to multiplexing, coding and detection systems in volume 2 of this series. We concentrate all multiple modulation methods in division 1.9 and we quote a large number of comparisons of single modulation methods in division 1.8.

Section 1.30

1.300: Data Transmission Systems in General

Included: Digital data systems; Digital communications; High speed data transmission; Integrated data systems; Discrete communication systems.

Not Included: Telemetering systems; Digital control systems; Time division systems (2); Detection theory for discrete systems (2).

Cross References: Sampled data systems (Div. 1.4); Pulse code modulation systems (Div. 1.5); Comparison of modulation systems (Div. 1.8); Multiple modulation systems (Div. 1.9).

Principal Publications:

THE CHALLENGE OF DIGITAL COMMUNICATIONS
R. M. Fano, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 63/64.

DIGITAL COMMUNICATION SYSTEMS
R. L. Plouffe, IRE Nat. Conv. Rec., vol. 6, no. 8, March 1958, p. 186/189.

The concept of an all-digital communication system for the universal handling of all communication services is presented.

A NEW HIGH-SPEED DIGITAL TECHNIQUE FOR COMPUTER USE
D. Eldridge, Proc. Instn. Elect. Engrs., London, vol 106, March 1959, p. 229/240.

RECENT PROGRESS IN APPLYING INFORMATION THEORY TO DIGITAL TRANSMISSION SYSTEMS
R. F. Filipowsky, Commun. Electronics, Jan. 1959, p. 848/855.

INTEGRATED DATA SYSTEMS
R. F. Filipowskiy, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 95/101.

. . . Binary or quaternary sets of transmission signals cannot achieve the ideal channel capacity as long as decision systems have to operate at 8-to-10-db "energy contrast" (E/N_0) for a sufficiently low error rate . . . Operating with higher-order signaling systems and applying error-correcting codes are the two principles which promise the largest increase in transmission efficiency. All the rest of these ten "Cardinal Principles" are discussed briefly.

DIGITAL TECHNIQUES APPLIED TO WORLD-WIDE COMMUNICATIONS
W. Firestone, et al., Motorola Inc., Applied Research Engrs Dept., Comm. & Indus. Elec. Div., May 1959, p. 1/15.

TEKHNIKA SVYAZI ZA RUBEZHOM (Foreign Communications Technique) (In Russian)
Sviaz'izdat, M., Orgasviaz'., 1960, 98 p.

. . . Orgasviaz' is a new kind of communication, realizing the transmission of information over a distance, differing substantially from telegrams, speech and images. . . . The collection contains information about systems and channel instrumentation of orgasviaz' as used in USA, where the use of orgasviaz' is widespread.

THE PUSH FOR FASTER DATA TRANSMISSION
Lenkurt Demodulator, vol. 9, no. 2, Feb. 1960, p. 1/8.

MODULATION AND SIGNAL SELECTION FOR DIGITAL DATA SYSTEMS
R. M. Lerner, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 2/14, 28 refs.

The statistical decision model of a communication channel is used to discuss a variety of signal modulation techniques intended to overcome the problems met in the use of voice-bandwidth channels for high performance digital data transmission. The importance of proper transmission of timing and word-start information is emphasized. . . . It is pointed out that in the presence of additive white Gaussian noise, the performance of such simple-waveform systems as AM, Phase Reversal, and FSK is the same to within a few db. the implications of the fact that the channel noise is not Gaussian, but impulsive in character are briefly explored.

DATA TRANSMISSION AND COMMUNICATIONS
E. Rechtin, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, 30 April 1960, 12 p. incl. illus., tables, Technical release no. 34-55, AD 236 103.

. . . designs of several radio systems for space communications exist. Within the next several years, however, development of low temperature receivers and attitude-stabilized spacecraft will considerably change the picture. . . . concerned with the design parameters of the spacecraft-to-Earth link which are most affected by these recent events.

THE NEW MASS COMMUNICATIONS
H. Sherman, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 1.

High speed data transmission as a new communications service is growing under our eyes into a mass information exchange, second only to voice communications as a major communications service. . . .

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . The book is essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." . . .

SURVEY OF DIGITAL COMMUNICATIONS
C. A. Deutschle, Hughes Aircraft Co., Culver City, Calif., Rept. on 480L System, 15 April 1961, 386 p. incl. illus, tables, 7 refs., Rept. no. TR-1, ESD TDR 62-158, AD 276 176.

Discrete message types . . . Transmission requirements and techniques . . . cryptography . . . Transmission media . . . Error control . . . Comparative evaluations . . .

TRUNK TERMINAL TELEGRAPH AND DATA TRANSMISSION SYSTEM
H. Place, ITT Federal Labs., Nutley, N.J., July 1961, 135 p., AD 430 081.

A number of high speed data transmission equipments (data modems), which were in the development and early test stages eighteen months ago, are now available in the industry. . . . Characteristics of telephone transmission line parameters and certain vagaries of the telephone network itself are still restricting low-error, high reliability performance at signaling rates over 3000 bits per second. . . . detailed equipment descriptions covering ten leading data modems; data modem error performance test results . . . updated data transmission bibliography.

USAF 480L AIRCOM PROGRAM SYSTEM DESIGN. VOLUME III. TRANSMISSION SUBSYSTEM DESIGN
ITT Communication Systems, Inc., Paramus, N.J., 3 June 1961, Rept. no. ICS-61-TN-2, AD 258 527.

. . . presents transmission subsystems as design modules. In categorizing and describing these modules, these transmission subsystems have been included that are now available or potentially available within the 1961-1964 AIRCOM time period. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATIONS SYSTEMS (PHASE 2 REPORT)
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Rept. for Jan. 1961-Jan. 1962, 20 Feb. 1962, 311 p. incl. illus., refs., Rept. no. UA-1420-S-2, RADC TDR 62-134, AD 276 847.

. . . analysis of the degradation of the performance of noncoherent binary FSK and carrier keyed systems due to a frequency offset of the received signal. The optimization of systems operating over dispersive channels in the presence of nonwhite, gaussian noise is treated and the effects of medium phase perturbations on the performance of digital systems are analyzed. Partial orderings of digital channels specified by their transition probabilities are also investigated.

WEAK SIGNAL COMMUNICATION TECHNIQUES
P. M. Dollard, et al., Bell Telephone Labs., Inc., Whippany, N.J., Interim rept., 1 May 1961-30 April 1962, AD 299 219.

DESCRIPTORS: . . . Communication theory . . . Frequency-shift keyers, Frequency modulation, Phase-locked communication systems . . .

INTRODUCTION TO AEROSPACE VEHICULAR DIGITAL COMMUNICATIONS
L. B. Hallman, Jr., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, 57 p.

. . . a review of the papers contained in the issue of the IRE Transactions on Aerospace and Navigational Electronics . . .

A STUDY OF WRITTEN COMMUNICATION (APPENDIX V - TEST MATERIALS)
F. H. Knower, Ohio State U., Research Foundation, Final rept., Nov. 1962, 1 vol., Rept. no. 4, vol. 3, RADC TDR 62-611, vol. 3, AD 299 387.

Descriptors: Communication systems . . . Air traffic control systems, Data transmission systems . . . Teletype systems . . .

MODULATION AND SIGNAL SELECTION FOR DIGITAL DATA SYSTEMS
R. M. Lerner, Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 661/669, 33 refs.

. . . signal modulation techniques intended to overcome the problems met in the use of voice-bandwidth channels for high-performance digital data transmission. The importance of proper transmission of timing and word-start information is emphasized. . . . Implications of the fact that the channel noise is not Gaussian, but impulsive in character, are briefly explored. . . .

DIGITAL COMMUNICATIONS BETWEEN AEROSPACE VEHICLES AND STATIONS ON THE GROUND
K. W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 58/66, 23 refs.

. . . tutorial paper presents an introduction to the problems of communications between aerospace vehicles and stations on the ground. The possible types of aerospace-to-ground communication links are described and classified according to the mode of signal propagation and according to obtainable range. The suitability of carrier frequencies throughout the electromagnetic radiation spectrum from very-low radio frequencies to light frequencies is discussed for the various types of links. . . . selection of modulation and demodulation techniques . . . practical value of digital coding . . . transmitter power requirement . . .

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., AD 272 958.

A study of digital data transmission over existing military voice communications systems is being made. Error measuring and recording techniques are discussed. The amplitude and delay characteristics of the AN/TCC-7 communications systems are included.

A SURVEY OF HIGH SPEED DATA COMMUNICATIONS
United Aircraft Corp., East Hartford, Conn., Report on Weather observing and Forecasting System 433L., 22 June 1962, 20 p. incl. tables, rept. no. WSC M-33, ESD TDR 62-217, AD 283 924.

. . . techniques available . . . Developmental techniques . . . developed to the firm planning stage are also considered. . . . a specific example of a typical data transmission problem is considered. The example assumed a message of 277,220 computer words to be transmitted a distance of 1300 miles twice daily, with 20 minutes allowed for each transmission. The factors of cost, transmission time, and error control are considered for several techniques to provide sufficient clarification of what may be achieved, and at what cost.

TRANSMISSION OF NUMERICAL INFORMATION (In French)
M. Poliet, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 106/116.

. . . flexibility and many applications of transmission systems using numerically coded data. . . development of these systems . . . because of the development of transistors which by their size and their characteristics make it possible to construct small devices.

COMMUNICATION AND RADAR—SECTION A. GENERAL
R. Price, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 240/246, 146 refs.

. . . digital communication and radar, particularly from the point of view of detection and parameter-estimation theory. . . .

SAMPLED DATA MODULATION SYSTEMS
R. Sanders, (IN: Space Communications, Edited by A. V. Balakrishnan, New York, McGraw-Hill Book Co., Inc.), 1963, p. 104/122, A64-11236.

Survey of three classes of modulation techniques: (1) that which transforms a signal waveform into some continuously variable modulation parameter where no sampling or time quantization of the signal source is performed prior to modulation; (2) that involving continuously variable modulation parameters; and (3) that commonly referred to as any general method of digital transmission . . . Included . . . synchronization requirements in class (2) modulation systems; PCM systems; bandwidth requirements for PCM systems; error correction and detection methods in PCM systems; and orthogonal systems.

Related Publications:

SECURE COMMUNICATIONS, A BIBLIOGRAPHY
North American Aviation, Inc., Downey, Calif., Rept. for 1956-1962, 19 April 1962, 35 p., Rept. no. SID 62-518, AD 282 471.

STUDY OF A/G COMMUNICATION SUBSYSTEM FOR W-47 METEOROLOGICAL SYSTEM
ITT Communication Systems, Inc., Paramus, N.J., 15 Feb. 1963, 69 p., Rept. no. ICS-63-TR-139, AD 298 567.

Descriptors: Data transmission systems, Air-to-surface, Frequency-shift keyers, Coding, High frequency.

Section 1.31
Analysis of Digital Modulation Methods

Definitions for binary, higher order and multi-signal data systems have been offered in the comment to this division. These fundamental classes of systems are covered in the second, third and last subdivision of this section. The first subdivision contains many references to the special signal theory of discrete waveforms.

This subdivision includes discussions of the so-called signal base or the bandwidth- time product of digital waveforms. The characteristics of special elementary waveforms of pulsive nature, such as Gaussian, raised cosine, or exponential signals are the subject of several papers in this first subdivision.

Signals of more complex waveforms are covered in the references of the fifth and sixth subdivisions.

The subject of the fourth subdivision is the use of binary sequences, primarily the so called PN (pseudo noise) or m (maximum length) sequences, in advanced digital communications systems. The practical application of these methods leads to the coded phase coherent data systems of subdivision 1.345. These systems are gaining importance in communications links of deep space probes. The associated mathematical coding theory will be discussed in volume 2.

1.311: Signal Theory of Digital Waveforms

Included: WT product of digital waveforms; Bandwidth time product; Band-limited functions; Time-limited functions; Prolate sphersidal wave functions; Dipulse; Harmonic exponentials; Orthogonal function expansions of waveforms Gaussian signals; Orthonormal exponentials; Impulsing of linear networks; Elementary signals; Spectra of digital waveforms.

Not Included: Waveform generators; Pulse generators.

Cross References: Signal theory in general (Sect. 1.14); Orthogonal sets of signals (1.315); Spread spectrum waveforms (1.316).

Principal Publications:

THEORETICAL FUNDAMENTALS OF PULSE TRANSMISSION
E. D. Sunde, Bell Syst. Tech. J., May 1954, p. 729.

MAXIMUM NUMBER OF SIGNALS OF FIXED TOTAL ENERGY AMONG WHICH A DISCRIMINATION TO WITHIN ϵ CAN BE MADE IN THE PRESENCE OF WHITE GAUSSIAN NOISE
P. Bethoux, Compt. Rend. Acad. Sci., Paris, vol. 247, Aug. 1958, p. 573/575.

A CODER FOR HALVING THE BANDWIDTH OF SIGNALS
A. R. Billings, Proc. Instn. Elect. Engrs., London, Part B, vol. 105, March 1958, p. 182/184.

. . . the scale of numbers must be increased to n^2. Two adjacent samples are specified uniquely by a one-digit number in the scale of n^2.

USE OF LAGUERRE FILTERS FOR REALIZATION OF TIME FUNCTIONS AND DELAY
A. K. Choudhury, et al., Indian J. Phys., vol. 32, May 1958, p. 205/211.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART I. THE USE OF ORTHOGONALIZED EXPONENTIALS
W. H. Huggins, Johns Hopkins U. School of Engineering, Baltimore, Md., Nov. 1958, 76 p., (Rev. of Rept. no. AFCRC TR-57-357, AD 133 741), AD 208 133.

. . . construction of an orthonormal-filter for measuring the signal coordinates relative to an orthonormal basis constructed from any prescribed set of expotentials by Kautz' method, is described. . . . a small alphabet of damped exponentials are capable of approximating a variety of waveforms with surprisingly good fidelity.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART II. AN ORTHONORMAL FILTER FOR EXPONENTIAL WAVEFORMS
D. C. Lai, Johns Hopkins U., School of Engrg., Baltimore, Md., June 1958, 49 p., AD 152 443.

A newly designed device is described which will generate sets of orthonormalized exponential functions.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART III: SIGNAL REPRESENTATION USING DIRAC'S NOTATION
D. C. Lai, Johns Hopkins U., School of Engineering, Baltimore, Md., Oct. 1958, 71 p., AD 160 869.

. . . New compact symbols and operators are applied to the 4 usual operations to represent their mathematical counterparts (sifting, tilding,

convolution and multiplication). . . . various experimental processes used in analyzing signals. . . . Familiar time-domained frequency-domain representations of a signal are discussed in detail, and it is shown that a discrete basis may be used for representing signals and systems. . . . An example of a complete basis, 2-sided ortho-normal exponentials are used to represent an arbitrary 2-sided and a general operator.

MOMENTS OF ANALYTIC SIGNALS
R. A. Silverman, IRE Trans. Circuit Theory, vol. CT-5, March 1958, p. 84/85.

"SIGNAUX TYPES" ET REGIMES TRANSITORIES EN TELEVISION (Typical Signals and Transients for Television) (In French)
L. Bourassin, L'Onde Electr., vol. 39, Jan. 1959, p. 7/31.

GAUSSIAN-RESPONSE FILTER DESIGN
M. Dishal, Elect. Commun. vol. 36, no. 1, 1959, p. 3/26.

Filters having a gaussian response shape are useful in pulse systems because of the small under- and overshoots or ringing they produce following rapid signal changes. This paper gives a resume of the magnitude, phase, impulse response, step response, and effective thermal noise bandwidth of perfect gaussian filters. A physically realizable approximation to the magnitude characteristic is then given. The complex frequency roots of this approximation (up to the 9th order) are supplied. . . . design stagger-tuned systems, lossless and uniformly lossy filters resistively loaded on one end only, and . . . resistively loaded on both ends . . . 7 tables . . . example . . .

UBER GEWISSE ASYMPTOTISCHE BEZIEHUNGEN ZWISCHEN FREQUENZ UND ZEITFUNKTIONEN (On Certain Asymptotical Relations Between Frequency Response and Time Functions) (In German)
H. Dobesch, Nachrichtentech., vol. 9, Jan. 1959, p. 13/18.

REPRESENTATION OF COMPLEX SIGNALS BY MEANS OF DAMPED OSCILLATORY BASE FUNCTIONS
L. Dolansky, Gordon McKay Lab. of Applied Sciences, Harvard U., Cambridge, Mass., Aug. 1959, 42 p., Scientific Rept. No. 59-1, AFCRC TN-59-648, AD 232 538.

Traditionally, the more complicated communication signals have been most often expressed in terms of Fourier series components or as time functions specified at a large number of points. Such approaches are usually mathematically complete and may be useful in many respects; however, for good insight and simplicity of the associated equipment, they are often inferior to approaches using components functions more directly related to the process which generates the particular class of signals studied. An orthonormal set of decaying oscillatory base functions was obtained and the problem of expressing voiced speech sounds by means of a small number of such functions, and of obtaining their coefficients by measurements, was studied. The experimental results indicated that an analysis of the speech waveform into damped oscillatory base functions and subsequent synthesis within a good approximation is indeed possible.

SIGNALS WITH MAXIMUM AND MINIMUM PROBABILITY OF DETECTION
V. A. Kotel'nikov, Radio Engrg. & Electronics, vol. 4, no. 3, 1959, p. 5/11.

. . . the derivation of the extreme values enables us to establish the limits within which the signal form can affect the probability of its detection. . . . represents all signal forms by . . . mutually orthogonal functions in the interval -T2, +T/2 . . .

UBER GRUDLAGEN DER THEORIE ELEKTRISCHER SIGNALE (Fundamentals of the Theory of Electrical Signals) (In German)
F. H. Lange, Hochfrequenz . Elekt. Akust., vol. 68, May 1959, p. 25/35.

MEANS FOR COUNTING "EFFECTIVE" NUMBERS OF OBJECTS OR DURATION OF SIGNALS (Correspondence)
R. Lerner, Proc. IRE, vol. 47, Sept. 1959, p. 1653.

. . . if a signal has approximate duration T and approximate bandwidth W, it can be specified by approximately 2 TW numbers or coefficients. In dealing with signals of large time-bandwidth product, it is customary to speak of the "effective" number of degrees of freedom as the number of these coefficients that are "sufficiently" large. Except in the case of band limited signals, however, no means of computing the "effective" number of degrees of freedom has been suggested.

THE REPRESENTATION OF SIGNALS
R. M. Lerner, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 197/216.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART IV. ON THE USE OF GROWING HARMONIC EXPONENTIALS TO IDENTIFY STATIC NONLINEAR OPERATORS
H. J. Lory, et al., Johns Hopkins U. School of Engineering, Baltimore, Md., May 1959, 7 p. (Rept. no. AFCRC TN 58-559), AD 160 868.

IMPULSING OF LINEAR NETWORKS IN INTEGRATED DATA SYSTEMS
G. K. McAuliffe, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 189/194.

Waveforms useful in data transmission may be obtained by impulsing suitable linear networks, and these same networks may be used, in certain cases, as receiving matched filters. A filter design for certain low-pass waveforms is described, together with a procedure for realizing band-pass analogs of these low-pass waveforms. The latter avoid the use of modulators. . . .

THE AUTO AND CROSS CORRELATION FUNCTIONS OF ELEMENTARY WAVEFORMS
E. I. Muehldorf, et al., 1959 Nat'l Conf. Proc. Aeron Electronics Conf., May 1959, p. 232/239.

METHOD OF OBTAINING AMPLITUDE AND PHASE SPECTRA OF A TRANSIENT FUNCTION USING GRAPHICAL INPUT DATA
W. J. Remillard, J. Acoust. Soc. Am., vol. 31, April 1959, p. 531/534.

Both amplitude and phase spectra are needed to characterize transient functions completely. Analysis shows how these spectra can be obtained from the envelopes of the line spectra of the even and odd parts of a transient function made to recur in time. Instrumentation is described for the convenient determination of these line spectra.

ON THE ACCURACY OF RESTORING A FUNCTION WITH A FINITE NUMBER OF TERMS OF A KOTEL'NIKOV SERIES
B. S. Tsybakov, et al., Radio Engrg. Electronics, vol. 4, no. 3, 1959, p. 274/275.

In various problems of radio communications and telemetering the following question arises. There is an unknown function f(t) with a bounded spectrum (frequency spectrum ϕ (w) of the function f(t) which does not include, for example, frequencies higher than W. An approximate value for f (t) is required in some finite time interval (-T, T), knowing only the consecutive sample values of the function through the time intervals $\Delta t < 1/W$.

THE ANALYTICAL REPRESENTATION OF A TIME FUNCTION WITH AN UNLIMITED SPECTRUM
I. T. Turbovich, Radio Engrg., vol. 14, no. 3, 1959, p. 30/36.

. . . in the form of the sum of time functions with a limited spectrum . . . In the series of functions obtained, the mean square value of each consecutive term proves to be considerably less than the preceding one, which permits the use of approximate methods when using this series (for example the small parameter method).

COMPUTATION OF AN EXPRESSION FOR THE FREQUENCY SPECTRUM OF A TWO-SIDED SIGNAL
T. A. Bickart, IRE Trans. Electronic Computers, vol. EC-9, no. 2, June 1960, p. 263/264.

CONCERNING THE IMPORTANCE OF MOMENTUMS FOR TIME AND FREQUENCY FUNCTIONS (In German)
H. Dobesch, et al., Nachrichtentechnik, vol. 10, June 1960, p. 240/246.

COSINE-CUBE PULSES
M. S. Gurevich, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 91/96.

. . . pulses formed by the law of the third power of the cosine, termed "cosine-cube pulses" . . . experience more rapid diminution in out-of-band radiation when the frequency increases and they have "less time to rise". . . .

SINE-SQUARED PULSES IN TELEVISION SYSTEM ANALYSIS
R. Kennedy, RCA Rev., vol. 21, no. 2, June 1960, p. 253/265.

The development of sine-squared pulse testing as it has occurred in Europe is traced, followed by a comparison of Heaviside step versus sine-squared pulse spectra and their effect on a system. The methods of pulse generation are next presented. The methods of testing various portions of system bandwidths by use of shaped bars, T, and 2T pulses are discussed. Rating factors, time-series computations, envelope delay, and linearity testing are also considered. . . .

BRIEF COMMUNICATIONS RECOGNITION OF CONTINUOUS SIGNALS
A. A. Kharkevich, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 12/15.

. . . representation of a signal (in the form of a continuous function over a finite interval) as one or several numbers, and the optimum (from the point of view of distinguishing the signals from the set) selection of these numbers. . . .

ON A NEW THEORY OF THE LIMITATION OF THE SIGNAL SPECTRUM (In French.)
J. Oswald, Cables et Transm., vol. 14, no. 4, Oct. 1960, p. 249/261.

. . . The basic idea of the present work is the substitution of a distributed function for the continuous functions (linear network operators) generally

used for representing signals. This results naturally from the theory of sampling. . . .

DESIGN PROBLEMS IN PULSE TRANSMISSION
D. W. Tufts, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Doctoral thesis, 28 July 1960, 48 p., 24 refs., Technical rept. no. 368 , AD 259 772.

Criteria for determining optimum pulse shapes for use in a synchronous pulse transmission link are proposed and compared. Formulas for the optimum pulses are presented, and calculations are carried through in examples. In a secondary problem, we present methods for calculating optimum interpolatory pulses for use in reconstructing a random waveform from uniformly spaced samples. The results provide a generalization of the sampling principle.

BEMERKUNGEN UND ERGANZUNGEN ZUR KUPFMULLERSCHEN EINSCHWING-FORMEL (Remarks and Additional Notes to the Transient Formula of Kuptmuller) (In German)
G. Wunsch, Hochfrequenztech. Elekt. Akust., vol. 69, no. 1, Feb. 1960, p. 35/39.

A GENERAL METHOD FOR CONTROLLING THE TIME AND FREQUENCY ENVELOPES OF FM SIGNALS
E. N. Fowle, Lincoln Lab., MIT Lexington, 5 June 1961, 13 p. Rept. 41G-0008, AD 258 055.

. . . The method applies when the product of the function's time duration and its frequency extent is large. . . . extending the previous technique which required that one envelope or the other be rectangular.

ANALOGRECHENSCHALTUNGEN FUR DIE ENTWICKLUNGSKOEFFIZIENTEN NACH ORTHOGONALFUNKTIONEN (Determination of the Coefficients of Expansions into Orthogonal Functions by Analog Computers) (In German)
R. Herschel, Elektron. Rechenanlagen, vol. 3, no. 5, May 1961, p. 212/217.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

. . . It is shown that efficient codes perform better than equidistant codes if the noise is nonwhite; i.e., properly chosen waveforms are more efficient than binary coding. . . . The detection scheme used does not require estimation of the signal or the noise levels at the receiver and is thus independent of fading.

PROLATE SPHEROIDAL WAVE FUNCTIONS, FOURIER ANALYSIS AND UNCERTAINTY - II
H. J. Landau, et al., Bell Syst. Tech. J., vol. 40, no. 1, Jan. 1961, p. 65/84.

The theory developed in the preceding paper is applied to a number of questions about time-limited and bandlimited signals. In particular, if a finite-energy signal is given, the possible proportions of its energy in a finite time interval and a finite frequency band are found, as well as the signals which do the best job of simultaneous time and frequency concentration.

ON THE DISCRETE REPRESENTATION OF A SIGNAL LIMITED IN TIME
V. V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 1, 1961, p. 69/74, 13 refs.

The author discusses an interpolation function differing from that used by V. A. Kotel'nikov for the representation of a signal limited in time by a series of discrete values. He considers the relationship of the obtained series with the Kotel'nikov's series, the errors associated with expansion, and the characteristics of spectral representation. . . .

COMPRESSION, FILTERING, AND SIGNAL-TO-NOISE RATIO IN A PULSE-MODULATED SYSTEM
E. A. Marcatili, Bell Syst. Tech. J., vol. 40, no. 5, Sept. 1961, p. 1421/1453.

. . . Some aspects of the transmission of Gaussian pulses in a frequency-division multiplex system have been calculated.

PROLATE SPHEROIDAL WAVE FUNCTIONS, FOURIER ANALYSIS AND UNCERTAINTY - I
D. Slepian, et al., Bell Syst. Tech. J., vol. 40, no. 1, Jan. 1961, p. 43/63.

A complete set of bandlimited functions is described which possesses the curious property of being orthogonal over a given finite interval as well as over $(-\infty, \infty)$. Properties of the functions are derived and several applications to the representation of signals are made.

ASYMPTOTIC METHODS IN LINEAR RADIO ENGINEERING (In Russian)
D. Ye. Bakman, Moscow, Soviet Radio Press, 1962, 246 p.

. . . for calculating the action of complex signals upon linear and quasilinear elements in radio equipment. . . . a powerful and quite rigorous mathematical apparatus that is physically intuitive. The application . . . to concrete problems of modern radio engineering permits the . . . calculation of the spectrum of 40 oscillatory signals . . . analyzing transients in FM . . .

RADIATION INCORPORATED SIGNALING SYSTEM STUDY
D. D. Baxter, Radiation Inc., Orlando, Fla., Special rept., 1 June 1961-31 May 1962, 31 May 1962, 98 p. incl. illus., 48 refs., AD 283 320.

. . . almost exclusive attention is given to the dipulse (a single cycle of a sine wave) and tripulse (the matched filter response to a dipulse). The spectra of the signals are displayed and the concept of the matched filter is discussed and applied as the optimum detector for the signals in question.

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS
E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

. . . a rather general and mathematically convenient formulation of analog-modulated signals which makes use of the analytic signal concept. Known types of modulation are readily identified as special cases. . . .

THE GENERATION OF PULSE-LIKE FUNCTIONS BY MEANS OF LUMPED EQUIVALENTS OF DELAY LINES
N. B. Chakraborti, Proc. Instn. Elect. Engrs., London., (Part C), vol. 109, no. 15, March 1962, p. 117/125, 12 refs.

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS
C. E. Cook, IRE Intern. Conv. Rec. Pt. 4, vol. 10, no. 4, March 1962, p. 174/184.

. . . Paired-echo theory has been used to describe the effects of network and time-function distortions (both amplitude, and phase) of pulsed signals. The advent of coded-waveform techniques (e.g., pulse compression) that generate waveforms having sidelobes extending in time has led to the application of paired echo theory in the establishment of design criteria for modern radar techniques. This paper introduces somewhat more general conditions into the paired echo analysis as a basis for conducting experimental work on the effects of phase-error modulation of the time signal in a pulse compression system. . . .

BESSEL FUNCTIONS AND ORTHOGONAL POLYNOMIALS AS TRANSFER AGENTS IN COMMUNICATIONS SYSTEMS
Ya. A. Dubrov, Referativnyy zhurnal. Matematika, no. 10, 1962, p. 56 abstract 10V280, (In collection: Avtomat. kontrol'i izmerit. tekhn. no. 5, Kiyev, AN USSR, 1961, p. 46/54), AD 400 791.

REPRESENTATION AND ANALYSIS OF SIGNALS PART XII. THE DESIGN OF PURE SYSTEMS
W. H. Huggins, Johns Hopking U., Baltimore, Md., Oct. 1962, 159 p., AD 411 401.

In this final report, the accomplishments of a research program on representation of signals are surveyed and briefly summarized.

SPECTRA AND ANALYSIS (In Russian) (Fourth Edition)
A. A. Kharkevich, Moscow, Fizmatgiz, 1962, 236 p.

The monograph deals with a selection of spectral representations used in the theory of oscillations, acoustics, and radio engineering . . . aims to widen the theoretical horizons of engineers working in the fields of radio and acoustics. . . .

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J. M. Kirshner, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

The concept of signal space allows one to apply geometric principles to waveforms used in communication. Its use enables a number of interesting conclusions to be drawn. . . . 2. Orthogonality of Functions . . . 3. Modulation, Demodulation, and the Sampling Theorem . . . 4. The Sampling Theorem and Separation of Channels . . . 5. Noise and Channel Capacity . . . 7. Rotation of Coordinates and the Number of Independent Channels . . . 8. Orthogonality of Gaussian Noise Signals. . . .

PROLATE SPHEROIDAL WAVE FUNCTIONS, FOURIER ANALYSIS AND UNCERTAINTY - III: THE DIMENSION OF THE SPACE OF ESSENTIALLY TIME- AND BAND-LIMITED SIGNALS
H. J. Landau, et al., Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1295/1336.

The purpose of this paper is to examine the mathematical truth in the engineering intuition that there are approximately 2WT independent signals φ_i of bandwidth W concentrated in an interval of length T. Roughly speaking, the result is true for the best choice of the φ_i (prolate spheroidal wave functions), but not for sampling functions (of the form sin t/t). . . .

KORRELATIONSELEKTRONIK. GRUNDLAGEN UND ANWENDUNG DER KORRELATIONS-ANALYSE IN DER MODERNEN NACHRICHTEN-, MeB- UND REGELUNGSTECHNIK; (2 Aufl.) (Correlation Electronics. Fundamentals and Application of the Correlation Analysis in Modern Communications and Control Technique (2nd Edition)) (In German)
F. H. Lange, Berlin, Verlag Technik, 1962, 381 p.

SUR LA LIMITATION SPECTRALE ET LA FREQUENCE INSTANTANEE DES SIGNAUX (On the Spectral Limitation and the Instantaneous Frequency of Signals) (In French)
J. Oswald, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 275/282.

THE SPACE OF ESSENTIALLY TIME- AND BAND-LIMITED SIGNALS
H. O. Pollak, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 774.

ORTHONORMAL EXPONENTIALS
D. C. Ross, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 838/849.

A generalization of the Kautz method of orthonormalizing a given set of exponentials is described. The generalized orthonormal exponentials provide flexibility which may be used to design bases of lower dimensionality in some signal representation applications than would be required by the earlier method .

SOME PROPERTIES OF THE FINITE CONVOLUTION
J.A. Sheehan, Mitre Corp., Bedford, Mass. 17 July 1962, 26 p., 9 refs. (Technical memo. no. TM-3346) (ESD TDR 62-315), AD 291 868.

. . . In this paper, we shall impose upon r(tau) and f(t) the restriction that they are members of the class of functions on compact support, that is, functions which vanish outside finite intervals of the tau- or t-axis. Our main results are a set of existence and uniqueness (or non-uniqueness) theorems on the solution of r(tau) in short functions. A short function is, of course, simply the Fourier transform of a band-limited signal, and a short auto-correlation function is simply the Fourier transform of the square of the envelope of a band-limited signal.

(No Title)
T. Y. Young, et al., Johns Hopkins U., Baltimore, Md., 6 Nov. 1962, 9 p., AD 411 370.

Digitizing the orthonormal exponentials with complex exponents are discussed.

DISCRETE ORTHONORMAL EXPONENTIALS
T. Y. Young, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 10/18.

. . . deals with digitizing the orthonormal exponentials with complex exponents. The z-transforms of continuous orthonormal exponentials are not themselves orthogonal in z-domain . . . For this reason, we introduce the Kautz process in the z-domain to define a set of discrete orthonormal exponentials. These discrete orthonormal exponentials approach the ordinary continuous orthonormal exponentials in the limit as the sampling interval T approaches zero.

'COMPLEMENTARY' SIGNALS AND ORTHOGONALIZED EXPONENTIALS
T. Y. Young, et al., IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 362/370, 14 refs.

. . . When a signal is approximated by a finite set of component signals which span a subspace . . . the least-square approximation may be interpreted geometrically in signal space as the projection of the true signal vector upon this finite dimensional subspace. In case the component signals are one-sided exponentials, the projection operators may be realized by simple physical filters following Kautz' procedure for constructing orthogonalized exponentials.

The purpose of this paper is to describe the 'present-instant' error, the 'complementary' signal and the 'complementary' filter which are sueful concepts in approximating a signal by one-sided exponential components.

SIGNAL SELECTION IN COMMUNICATION AND RADAR SYSTEMS
T. L. Grettenberg, IEEE Trans. Inform. Th., IT-9, no. 4, Oct. 1963, p. 265/275.

A criterion for selecting a finite set of transmitter signals for a continuous communication channel is proposed. The "optimum" signal sets using this criterion are selected to maximize the minimum divergence between hypothesis pairs being tested at the reveiver. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS. PART XVII. REPRINTS ON SIGNAL THEORY
Johns Hopkins U., School of Engineering, Baltimore, Md., Final rept. 30 Nov. 1963, 1v., AD 431 162

. . . reprints of a group of published papers reporting some of the main accomplishments under the program. . . . four appendices . . . (I) . . . names of those who have contributed to this program: (II) abstracts of all technical reports . . . (III) list all relevant papers . . . (IV) summarize lectures and talks.

SEISMOLOGICAL APPLICATIONS OF ORTHOGONAL FUNCTIONS EXPANSIONS
United Electrodynamics, Pasadena, Calif., Semi-annual technical summary report, 28 Feb. 1963, 10 p., 5 refs., AD 401 029.

Rayleigh waves form shots and earthquakes received at distant seismic stations are often short enough so that a Laguerre series of a few dozen terms can adequately represent them. This report shows such an example, describes how an analog computer can form the orthogonal expansion and digitize the coefficients automatically

. . . example of the frequency spectra computed from such an orthogonal expansion. A set of complex pole orthogonal functions with Q's of 4 covering the short period seismic band are used for a time varying power spectrum analysis of seismic noise and signals. In addition, relations between Legendre polynomials for which zeros and integrating coefficients are known and generalized orthogonal functions are described.

SELECTION OF SIGNALS FOR SPACE-VEHICLE COMMAND
E. J. Baghdady, ADCOM, Inc., Cambridge, Mass. 1 June 1963, 68 p., (NASA CR-55086), N64-12157.

. . . A survey of the types, requirements, and techniques of command signal design . . . provides a basis for conceiving and evaluating specific signals for special command purposes and provides a guide for the classification of command signals.

A NOTE ON DIFFERENTIAL APPROXIMATION AND ORTHOGONAL POLYNOMIALS
R. Bellman, RAND Corp., Santa Monica, Calif., March 1963, 5 p., (Memo. no. RM-3482-PR), AD 299 487.

DISCRETE, FINITE REPRESENTATION OF A LINEAR, STATIONARY SYSTEM
P. J. Butterly, Johns Hopkins U. Carlyle Barton Lab., Baltimore, Md., May 1963, 50 p., 6 refs., RADC-TDR-62-124 , AD 405 826, N63-16919.

This report describes a linear system representation suitable for use with signals of finite dimensionality. This representation takes the form of a matrix with elements which depend both on the choice of signal basis and on the transmission properties of the system . . . transformation formulas are established for a number of cases . . .

CONSTRUCTION OF TIME-LIMITED FUNCTIONS WITH SPECIFIED AUTO-CORRELATION FUNCTIONS
E. M. Hofstetter, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 119/126.

AN ORTHOGONAL MULTIPLEXED COMMUNICATION SYSTEM USING MODIFIED HERMITE POLYNOMIALS
S. Karp, et al., Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 341/353.

. . . A pulsed multiplex system is outlined which transmits orthogonal signals and features excellent time bandwidth compression properties. For nominal time-limiting and band-limiting, the signals preserve orthogonality better than comparable systems utilizing orthogonal sine or Legendre polynomial waveforms. This system generates as its basic signals modified Hermite polynomials which form an orthonormal basis. . . .

OPTIMUM USE OF SPACE-TIME SIGNALS
A. A. Kuriksha, (Radiotekhnika i Electronika, vol. 8, April, 1963, p. 552/563.) Radio Engineering and Electronic Physics, vol. 8, April 1963, p. 595/605, 8 refs., Translation.

OPTIMIZATION OF SIGNAL WAVEFORMS
G. Lachs, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 95/97.

TWO-DIMENSIONAL SIGNAL REPRESENTATION USING PROLATE SPHEROIDAL FUNCTIONS
D. A. Landgrebe, et al., IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 30/40, 13 refs.

. . . Two similar 2-dimensional signal representations are defined for use in signal analysis problems. The proposed procedure divides the time-frequency plane into rectangles of arbitrary length and width and assigns a certain portion of the represented signal to each such rectangle. Representations are based upon time-limited and band-limited forms of the angular prolate spheroidal functions for conceptual and mathematical reasons. Applications and numerical examples are provided. . . . (Abstract in Proc. Nat. Electronics Conf. 62 (18)-PNEC-10, 774).

GROWING EXPONENTIALS AS A PROBING SIGNAL FOR SYSTEM IDENTIFICATION
S. Litman, Proc. IEEE, vol. 51, no. 6, June, 1963, p. 917/923.

REPRESENTATION AND ANALYSIS OF SIGNALS PART XV MATCHED EXPONENTS FOR THE REPRESENTATION OF SIGNALS
R. N. McDonough, John Hopkins U., Baltimore, Md., 30 April 1963, 174 p., AD 411 431.

Approximation by sums of exponentials is considered from various points of view, such as the time-domain approximation problem of network synthesis . . . Prony's method for approximate determination of the exponents is exhaustively reviewed in all its forms . . . The procedure is illustrated for the continuous case, and extensions to the discrete case are discussed.

NON-UNIFORMLY-WEIGHTED ORTHONORMAL OVER-DAMPED EXPONENTAIL APPROXIMATIONS
J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif., Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., SM-45777, N64-17757.

THE IDENTIFICATION OF OVERDAMPED PROCESSES IN THE TIME-DOMAIN
J. M. Mendel, Polytechnic Inst. of Brooklyn, Microwave Research Inst., N. Y., April 19, 1963, 151 p., 34 refs. (PIBMRI-1131-63).

. . . by means of exponential functions . . . Particular attention is given to: (1) the choice of a suitable error criterion . . . (2) the choice of weighting functions . . . (3) the extention of the orthonormal exponential approximations of Kautz and Huggins to approximations of any asymptotic-order in the s-domain.

OPTIMIZATION OF SIGNALS
F. C. Schweppe, Lincoln Lab., Mass. Inst. of Tech., Lexington, 16 Jan. 1964, 49 p. Group rept. no. 64 4, ESD TDR 64 18, AD 430 345.

A general theory is presented for the design of optimum signal waveforms. Explicity constraints on the signal's energy, amplitude and bandwidth are possible. The development is based on optimum control theory and employs the state variable concept with differential equations as basic models. Pontryagin's Maximum Principle provides a two-point boundary value problem whose solution gives the optimum signal. A communication problem of deciding which of M signals was transmitted and a radar problem of deciding the range rate of a target are used as examples.

THE STRUCTURE OF FUNCTIONS WITH A LIMITED SPECTRUM AND RELATED PROBLEMS IN COMMUNICATIONS THEORY
B. S. Tsybakov, et al., Joint Publications Research Service, Washington, D. C., 3 April 1963, 19 p, AD 404 929.

A NOTE ON BANDLIMITED FUNCTIONS (Correspondence)
F. Tung, IEEE Trans. Circuit Theory, vol. CT-10, no. 2, June 1963, p. 275/276.

. . . a bandlimited function. . . . can be constructed from its sample values. . . . it is sometimes desirable to find expansions of f(t). . . . One may inquire into the possibility of finding functions $\Psi_n(t)$ . . . We shall restrict ourselves to exploring functions that can be generated from second-order ordinary linear differential equations . . .

IMPROVEMENT IN GAUSSIAN SIGNAL PERCEPTION BY DETERMINISTIC SIGNAL INJECTION AND HARMONIC-ZONE DETECTION
A. Weiner, et al., Electronic Defense Lab., Mountain View, Calif., 8 Feb. 1963, 28 p., AD 404 476.

. . . perception of narrowband, Gaussian signals . . . using a reference sine wave, a stiff limiter, and a harmonic-zone filter . . . The comparison of this new technique with energy detection showed equal signal perception at 3-db lower S/N ratios for perception probabilities greater than 0.5 at fixed false-alarm probabilities of 1/1000, 1/10,000, 1/100,000 and 10 to the minus 6th power.

ABBREVIATED REPRESENTATION OF SIGNALS BY MEANS OF SYSTEMS OF ORTHOGONAL FUNCTIONS
A. M. Zayezdynyy, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 3/11.

. . . Abbreviated description means the representation of assigned signals in the form of expansions in a new system of orthogonal functions with a smaller number of terms. A method of obtaining a new system of orthogonal functions that provides an abbreviated representation of assigned signals with least root-mean-square error is given. . . .

Related Publications:

INFORMATION THEORY WITH AN ABSTRACT ALPHABET
A. Perez, Theor. Prob. Appl., vol. 4, no. 1, 1959, p. 99/102.

Generalized Forms of McMillian's Limit Theorem for the Case of Discrete & Continuous Times.

PROBLEMS ENCOUNTERED IN WIDE-BAND FREQUENCY MODULATION
D. D. Wilcox, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 173/181.

. . . recording of very wide-band signals in which the modulating frequency closely approaches the carrier frequency. . . .

SIGNAL DETECTION IN A NOISY WORLD
W. H. Huggins, Rand Corp., Santa Monica, Calif., 3 May 1960, 82 p., AD 241 288.

. . . designing an efficient signal analyzer which will measure the principal components of a signal ensemble so that each signal may be adequately characterized by specifying the fewest number of coordinates, thus simplifying the data-processing problem. . . .

THE INTERPOLATION OF FUNCTIONS BY EXPONENTIAL POLYNOMIALS AND ITS APPLICATION TO THE SYNTHESIS OF ELECTRICAL CIRCUITS WITH RESPECT TO TIME CHARACTERISTICS
N. S. Kochanov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 87/95.

AN EXPERIMENTAL CONSTANT RESISTANCE LINK AMPLIFIER FOR PULSE AMPLIFICATION
H. S. McGaughan, et al., Cornell U. School of Electrical Engineering, Ithaca, N. Y., (Tech. rept. 57, Research Rept. EE 479), 1 Sept. 1960, 24 p., AD 250 154.

. . . provides a frequency characteristic, which is approximately Gaussian in shape and which has an impulse response of similar shape. Such characteristics should be most useful in low-distortion pulse amplification.

THEORY OF A FREQUENCY-SYNTHESIZING NETWORK
B. M. Wojciechowski, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 649/673.

. . . By the introduction of "sideband algebra" and of a frequency symbolic network, the new method offers formal design procedures in place of intuitive ones.

DATA LINE TECHNIQUES

Armour Research Foundation, Chicago, Ill., 1 April 1961, 458 p., 62 refs., AD 263 144.

. . . a review of pertinent theoretical material and a survey of wire line digital communication techniques to support suggestions for improving channel utilization. . . . anti-impulse noise techniques. . . .

AN INTERPRETATION OF "PAIRED ECHO THEORY" FOR TIME-DOMAIN DISTORTION IN PULSED SYSTEMS AND AN EXTENSION TO THE RADAR "UNCERTAINTY FUNCTION" (Correspondence)

J. V. DiFranco, et al., Proc. IRE, vol. 49, Sept 1961, p. 1432/1433.

THE PERFORMANCE OF AN INERT DETECTOR FOR PULSES OF COMPLEX SHAPE
I. A. Fastovskii, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 5, 1961, p. 72/85.

A METHOD OF DESIGNING SIGNALS OF LARGE TIME-BANDWIDTH PRODUCT
E. L. Key, et al., IRE Intern. Conv. Rec., vol. 4, March 1961, p. 146/154.

. . . wherein the envelope shape and autocorrelation function may both be separately specified . . . The design problem hinges on an integral equation, for which an approximate solution, valid for large time-bandwidth products, is found by the method of stationary phase . . .

THE GENERATION OF IMPULSE-EQUIVALENT PULSE TRAINS
D. A. Huffman, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. S10-16.

. . . An "impulse-equivalent" pulse train is defined as one that yields, as closely as is theoretically possible, the same autocorrelation function that a single pulse gives. . . .

INSTANTANEOUS SPECTRA AND AMBIGUITY FUNCTIONS
M. J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, AD 723 239.

The definition of the instantaneous spectrum of a waveform introduced by C. H. Page (J. Applied Physics 23:103-106, 1952) is modified to take into account past and future values of the waveform symmetrically and is extended to complex signals. The resulting function is the double Fourier transform of the ambiguity functions and has other interesting properties.

APPROXIMATION TO A SPECIFIED TIME RESPONSE
W. C. Yengst, IRE Trans. Circuit Theory, vol. CT-9, no. 2, June 1962, p. 152/162.

. . . Synthesis procedures have been developed to solve the realization provided the transfer function of the network can be expressed as a rational fraction, i.e., the ratio of polynomials in terms of the complex frequency variables having real coefficients. . . .

SPEKTRAL'NYE I FAZOCHASTONYE KHARAKTERISTIKI IMPUL'SNYKH NULEVYKH BIENII DLIA ODNOGO CHASTNOGO SLUSHAIA (Spectral and Phase-Frequency Characteristics of Pulsed Zero Beat for a Special Case) (In Russian)
A. A. Abramian, Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 219/233. A64-17126.

DESIGN OF INPUT WAVEFORMS TO YIELD TIME-LIMITED ORTHOGONAL OUTPUTS
J. B. Campbell, et al., Northeastern U., Boston, Mass., March 1963, 59 p., 7 refs., N63-19808.

The following problem is posed. Given a time-invariant, linear system, with impulse response h(t), system function H(s), is there a set of input signals which results in a set of output signals that are orthogonal on a given interval of time? . . .

A SURVEY OF LITERATURE ON TECHNIQUES AND INSTRUMENTATION FOR MEASURING ELECTRICAL PULSE INTERVALS
B. A. Cryce, et al., Autonetics, Downey, Calif., 28 Feb. 1963, 1v., AD 403 137.

. . . bibliography . . . on rise time and width range of very short electrical pulses. Emphasis has been placed on how to measure time and peak amplitude by accurate nanosecond measurements . . . covers approximately a 12-year period with most of the literature encompassing the last four years.

A PULSE COMPRESSION SYSTEM EMPLOYING A LINEAR FM GAUSSIAN SIGNAL
E. N. Fowle, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 304/312.

. . . includes . . . the detailed characteristics of the signal, the sidelobe level of the receiver output waveform (signal autocorrelation function), the sensitivity of the sidelobe level to Doppler frequency shift in the signal, and the relative complexity of the equipment required to generate and receive the signal.

SIMPLE FILTERS FOR PULSE TRANSMISSION OVER RADIO LINKS
P. Gibbons, Signals Research and Development Establishment (Gt. Brit.), March 1963, 20 p. SRDE UDC 621 372 54, AD 409 497.

Five filters are studied to determine how their properties affect the bandwidth and waveform of a transmitted binary pulse train. These are the sine squared, two gaussian types, a modified gaussian, and a very narrow filter with nearly rectangular amplitude response. Computed and experimental results are produced to show that the modified or truncated gaussian filter provide the best compromise between bandwidth reduction and simplicity of construction.

GENERATION OF ERROR VECTORS
A. Kobos, Rome Air Development Center, Griffiss AFB, N.Y., Sept. 1963, 10 p., (RADC-RAU-TM-6306), N63-23001.

. . . In experiments with digital data sources, it is often required to generate a repeating digital waveform whose period is a binary sequence. A method is presented by which any arbitrary waveform can be generated, using a minimum number of shift register stages and standard circuitry consisting of modulo-two adders, multipliers, and inverters. The particular case where the period consists of all possible binary n-tupules is examined. This is of interest because it contains all the error vectors which may be added in transmission . . . The connections of this study with other mathematical disciplines (such as topology, directed graphs, and state diagrams) are discussed.

COMMUNICATION AND RADAR—SECTION B. (Radar Waveform Selection)
R. M. Lerner, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 246/248.

THE PERFORMANCE EVALUATION OF TELEVISION LINE AND MICROWAVE LINKS USING SINE-SQUARED TEST TECHNIQUES
K. H. Potts, J. Brit. Instn. Ragio Engrs., vol. 25, no. 4, April 1963, p. 357/376, 14 refs.

The principles involved in the use of sine-squared pulse test techniques and the application of this type of test to the assessment of the linear transmission performance of television line and microwave radio links are surveyed in detail. . . .

SCATTER COMMUNICATION MODELS FOR SPACE VEHICLES
R. A. Scholtz, University of Southern Calif., Engineering Center, Los Angeles, Jan. 1964, 38 p., SSD TDR64 59, AD 433 717.

. . . Multipath communications are characterized by imperfect knowledge of signal waveforms when they arrive at a receiver. Under the assumption that this signal waveform is a sample function of a Gaussian random process, a pulse-amplitude-modulation communication system is designed. . . .

OPTIMUM PULSE SHAPES FOR TRANSMITTERS WHICH ARE BOTH PEAK POWER LIMITED AND AVERAGE POWER LIMITED
D. W. Tufts, et al., Cruft Lab., Harvard U., Cambridge, Mass., 12 Nov. 1963, 16 p., TR 428, AD 434 875.

. . . an explicity formula is derived for the input waveform p(t) which maximizes the output waveform amplitude at a prescribed time instant. The problem and the results are closely related to the matched filter problem of radar theory and the bang-bang problem of optimal control theory. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS. PART XIV. TIME VARYING SYSTEMS WITH SEPARABLE SYSTEM FUNCTIONS
L. Weiss, Johns Hopkins U., School of Engineering, Baltimore, Md., 30 Jan. 1963, 94 p., AD 411 274.

The relationship of the differential equation of a system to the system's weighting pattern (impulse response) is discussed. The realization of linear differential systems is discussed, and some "tricks" regarding manipulation of the position of function generators in an analog computer type realization (without changing the input-out relation) are presented . . .

1.312: Analysis of Binary Transmission Systems

Included: Randomly variable binary channels; Binary erasure channel; Asymmetric binary channels.

Not Included: Error correcting codes for binary channels (2).

Cross References: Mathematical models of communications channels (1.130); Statistical description of time variable transmission media (1.611); Comparison of modulation methods for binary channels (1.830); Special binary data transmission systems (1.3).

Principal Publications:

IDEAL BINARY PULSE TRANSMISSIONS BY AM AND FM
E. D. Sunde, Bell Syst. Techn. J., Nov. 1949, p. 1357.

ERROR PROBABILITIES OF BINARY DATA TRANSMISSION IN THE PRESENCE OF RANDOM NOISE
S. Reiger, IRE Conv. Record, pt. 8, 1953.

COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
J. G. Lawton, Conf. Proc. Nat. Conf. on Aeronautical Electronics, June 1957, p. 128/132.

SOME ASPECTS OF DIGITAL DATA TRANSMISSION
S. Reiger, Nat. Conf. Proc. Aeronautical Electronics, 1957.

CAPACITY OF A CERTAIN ASYMMETRICAL BINARY CHANNEL WITH FINITE MEMORY
Sze-Hou Chang, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 152/159.

. . . 1) Blocks of equal numbers of binary digits are used as the transmitting symbols. 2) The channel resumes its quiescent state at the beginning of each block. 3) The memory of the channel is characterized by the dependence of the noise probabilities for each digit upon the preceding digit or digits in the same block.

COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
J. G. Lawton, Proc. Conf. Mil. Electronics, 1958, p. 54.

FEHLERWAHRSCHEINLICHKEIT BINAR KODIERTER MELDUNGEN BEI STORUNG DURCH WEISSES RAUSCHEN (Error Probability of Binary Encoded Messages Under White Noise Interference) (In German)
H. J. Held, Nachrichtentech. Zeitsch., vol. 11, May 1958, p. 244/249.

A PARTIAL ORDERING FOR BINARY CHANNELS
N. M. Abramson, Stanford Electronics Labs., Stanford U., Calif., 15 April 1960, 38 p., AD 237 640.

. . . This ordering is applied to: (a) the general binary channel, (b) the iterated binary symmetric channel and (c) the unreliable binary symmetric channel when used with many iterations. Curves allowing one to use the ordering are given and an example using these curves is worked out.

A PARTIAL ORDERING FOR BINARY CHANNELS
N. Abramson, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 529/539.

THE RATE OF INFORMATION TRANSMISSION THROUGH SYMMETRIC CHANNELS
L. F. Borodin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. 10 Sept. 1962, 27 p. incl. illus. 9 refs. (Trans. no. FTD-TT-62-878 from Sto Let so Dnya Rozhdeniya A. S. Popova, Yubileynaya Sessiya, Izdatel'stvo Akademii Nauk SSSR, p. 57-73, 1960). AD 286 603.

. . . A graphical method is given for determining the optimum value of the probability of symbol erasure (in the sense of the maximum traffic capacity of a channel). . . . It is shown that the optimum code of an erase channel in the presence of a sufficiently large number of symbols in a code combination allows information to be transmitted through an erase channel with a previously assigned uncertainty and rate, close to the traffic capacity of the channel. A method is indicated for setting up codes which have properties close to those of the optimum code of an erase channel, and also codes in which all combinations differ from one another exactly by d = a to the m-1 positions.

STUDIES OF COMMUNICATION CHANNELS
Sze-Hou Chang, Electronics Research Lab., Northeastern U. (Boston, Mass.), 17 May 1960, 46 p. incl. illus. (Scientific rept. no. 3, pt. 2), (AFCRC TN 60-574, vol. 2), AD 242 674.

. . . The following topics are discussed: (1) The capacity of a symmetrical binary channel with uniform digit spacing, exponentially decaying memory, and additive Gaussian noise is approximated by a numerical method. (2) Discrete channels are combined to form cascaded, sum, product, or other networks in order to achieve such objectives as increasing range, capacity, or reliability. (3) Feedback systems for the reduction of multipath distortion have been evaluated. (4) A study has been carried out of mathematical techniques applicable to the combination of fallible formal neurons as proposed by McCulloch.

CONSTRUCTION AND DECISION DETECTION OF BINARY INFORMATION
B. W. Russell, Proc. Nat. Aerosp. Electron, Conf., vol. 9, May 1961, p. 302/306.

. . . definition of "information" . . . description of a simple Pulse Code Modulation communication system . . . derives basic signal power, bandwidth, information rate and error loss factor relationships . . .

A NOTE ON RANDOMLY VARIABLE BINARY CHANNELS
J. Loeb, IN: RADIO WAVES AND CIRCUITS; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 195/199.

. . . Statistical properties of random binary channels are represented by 2 x 2 matrices built with error probabilities. Cascading elements of a complex matrix amount to multiplication of elementary matrices. Resulting "equivocation" can be approximately computed by means of the determinant of the matrix product. The results found can be considered as a particular case of Siforov's theory.

SPECTRAL DENSITY DISTRIBUTIONS OF SIGNALS FOR BINARY DATA TRANSMISSION
H. J. Pushman, J. Brit. Inst. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 43/51.

Related Publications:

SINGLE ERROR-CORRECTING CODES FOR ASYMMETRIC BINARY CHANNELS
W. H. Kim, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 62/66.

TRANSMISSION OF SIGNALS BY PULSE-PARAMETER COMPARISON METHOD
N. T. Petrovich, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 1, 1961, p. 1/9, 12 refs. (Russian only).

. . . a method . . . based on comparison of parameters of individual pulses, which permits the use of new techniques on communications. Also discussed is one of its specific applications in pulse carrier-wave phase comparison (relative phase telegraphy RPT). . . .

ASYMPTOTIC ESTIMATES OF THE ERROR PROBABILITY FOR THE TRANSMISSION OF MESSAGES THROUGH A DISCRETE MEMORYLESS COMMUNICATION CHANNEL WITH A SYMMETRIC MATRIX OF TRANSACTION PROBABILITIES
R. L. Dobrushin, Foreign Techn. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 3 July 1963, 50 p. FTD TT 63 543, AD 413 329.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A. B. Glenn, et al., (Western Electronic Show and Convention, Los Angeles, Calif., Aug. 21-24, 1962), 1962 WESCON Convention Record. Part 5 - Aeronautical and Navigational Electronics, Military Electronics, Space Electronics and Telemetry, vol. 6, 1962, 7 p., A63-12452.

STOCHASTIC SAMPLING OF A BINARY RANDOM PROCESS
S. J. Redman, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 1, March 1963, p. 3/24.

. . . When a binary random process is sampled by an independent random pulse process a new binary process is generated. Statistical properties of this new binary process are investigated in this paper. Two methods of sampling are considered, according as an even or odd number of zeros of the binary process being sampled occur between successive sampling pulses. . . . a brief description at an experimental sampling device and some results obtained with it, is given.

This paper is envisaged as the first of a series of three papers dealing with binary random processes and their application in the analysis of simple filters containing a randomly switched parameter.

1.313: Higher Order Data Systems in General

Included: M-ary digital transmission systems; Bi-ternary transmission; Non-binary data transmission systems; Ternary data systems; Quaternary digital systems in general.

Not Included: Detection theory for higher order systems (2); Multiple hypothesis testing (2); Multivariate decision theory (2); Null-zone reception systems (2); Sequential decoding procedures (2); Error correcting codes with higher order symbols (2).

Cross References: Sequences of binary elements as higher order signals (1.314); Bi-orthogonal transmission systems (1.315); Multi-level AM data systems (1.325); Multi-phase digital systems (1.344); Multiple frequency shift data systems (1.333); Non-binary pulse code modulation systems (1.518); Quaternary phase shift systems (1.343).

Principal Publications:

A COMPARISON OF TRANSMISSION METHODS FOR PULSE CODE MODULATION COMMUNICATION SYSTEMS
A. P. Brogle, Army Signal Research and Development Lab., Oct. 1958, 47 p., (USASRDL Technical rept. no. 1954), AD 227 104

. . . . A new method of transmission, called biternary, is described and is compared with quaternary transmission as a means of doubling the channel capacity of PCM systems without requiring increased bandwidth or transmission facilities. . . .

ERROR RATES IN DATA TRANSMISSION
S. Reiger, Proc. IRE, vol. 46, May 1958, p. 919/920.

. . . error rate reduction by use of error correcting codes, gain obtainable by choosing signaling alphabets other than binary.

INTEGRATED DATA SYSTEMS
R. F. Filipowsky, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 95/101.

. . . Operating with higher-order signaling systems and applying error-correcting codes are the two principles which promise the largest increase in transmission efficiency.

PULSE TRANSMISSION STUDY
H. Fiege-Kollmann, Westinghouse Electric Corp. Dec. 1959, 144p., Quarterly Tech. Note # 4 - RADC TN 60-11, AD 232 838, AD 211 434.

. . . Error probability of higher order alphabet. . .

A NON-SYNCHRONOUS APPROACH FOR IMPROVED COMMUNICATIONS RELIABILITY
C. H. Stewart, II, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 141/150.

. . . expanding requirement for mobile teleprinter communications. . . use of conventional techniques will not yield the required circuit reliability.

One approach to the provision of increased performance reliability is. . . to minimize detector bandwidth. By using sequential combinations of two audio frequency tones to define the combinatorial possibilities of the standard five-bit teleprinter code, the per-tone sampling period is increased by a factor in excess of three times that of the start-stop system. The nonsynchronous characteristic of this coding scheme allows optimum use of a variable band-width, so that the system can be operated at the maximum circuit capacity for all conditions.

COHERENT DETECTION BY SEMI-ORTHOGONAL SQUARE-WAVE PULSE FUNCTIONS
R. C. Titsworth, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Sept. 1960, 20 p. AD 232 038.

THE ASYMPTOTIC BEHAVIOR OF IDEAL M-ARY SYSTEMS
G. L. Turin, Proc. IRE, vol. 47, Jan. 1959, p. 93/94.

THE THEORY OF SIGNAL TRANSMISSION WITH MULTIPLE DISCRETE VALUES
B. A. Varshaver, Radio Engrg., vol. 14, no. 1, 1959, p. 1/13.

A NEW TRANSMISSION METHOD FOR PULSE-CODE MODULATION COMMUNICATION SYSTEMS
A. P. Brogle, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 155/160.

. . . study of the basic factors underlying the selection of a preferable method of transmission for pulse-code modulation communication systems. A new method of transmission, called biternary, is described and is compared with quaternary transmission, as a means of doubling the channel capacity of PCM systems without requiring increased bandwidth or transmission facilities. . . . The use of biternary transmission is planned in present and future military pulse-code modulation communication systems.

COMBINED DIGITAL PHASE AND AMPLITUDE MODULATION COMMUNICATION SYSTEMS
C. R. Cahn, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 150/155.

. . . When the number of bits per sample of the signal is large, . . . combination of digital amplitude and phase modulation is found to make more efficient use of transmitter power than phase modulation alone.

THE COMPARISON OF DIGITAL COMMUNICATION SYSTEMS
C. W. Helstrom, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 141/150.

. . Two methods are proposed for comparing the performances of digital communication systems

differing in the number of available signals, in bandwidth, in rate of transmission and in complexity. . . . The concept of 'strictly comparable systems' is introduced; for these the two methods lead to the same ranking. . . . The advantage over binary systems of systems of higher order, in which more than one kind of signal can be transmitted, is illustrated.

BRIEF COMMUNICATIONS RECOGNITION OF CONTINUOUS SIGNALS
A. A. Kharkevich, Radio Engng: Transl. of Radiotekhnika vol. 15, no. 10, 1960, p. 12/15.

. . . representation of a signal (in the form of a continuous function over a finite interval) as one of several numbers, and the optimum (from the point of view of distinguishing the signals from the set) selection of these numbers. . . .

MATCHED FILTERS FOR MULTIPLE PROCESSES (Correspondence)
A. V. Balakrishnan, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 52.

By a multiple process is meant a q-dimensional (real-valued) vector stochastic process. As is well-known, a matched filter is defined for one-dimensional processes as one that minimizes the noise-to-signal ratio. Now, in the multiple process case we can define noise-to-signal ratio in several ways and it is the purpose of this note to examine the corresponding matched filters.

CAPACITY OF A CHANNEL WITH QUANTIZED MODULATION
V. M. Baykovskiy, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 7, 1961, p. 9/18.

. . . defines the capacity of a channel with quantized modulation in the absence of noise. It is shown that potentially this method of transmission possesses higher capacity than delta modulation and PCM (pulse-code modulation). . . . Asynchronous QM is characterized by the fact that the pulses reach the channel precisely at the moments of transition of the quantity f(t) through a quantization level. In synchronous QM the pulses are transmitted only at regular moments in time. . . .

ERROR PROBABILITIES FOR NON-ORTHOGONAL M-ARY SIGNALS UNDER PHASE-INCOHERENT RECEPTION
A. H. Nuttall, Litton Systems, Inc., Waltham, Mass., 15 June 61, 153p. (Technical rept. no. TR-61-1-BF) AD 261 182.

. . . derived in the form of previously untabulated single and double integrals. Two modes of reception are considered. In the first. . . no fading and only one path is available for communication (no multipath). In the second. . . a threshold is incorporated in the receiver. If the largest correlation value is less than the threshold, a decision is made that no signal was transmitted; if the largest correlation value exceeds the threshold, the signal corresponding to that particular correction value is decided to have been transmitted. . . .

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE—A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS
E. Arthurs, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 336/372.

. . . a geometric interpretation of the detection problem is presented on a tutorial level. . . . this technique is used to derive the optimum detector for each of three basic data transmission systems: m-level Phase Shift Keyed, m-level Amplitude Shift Keyed and m-level Frequency Shift Keyed. Corresponding probability of error curves are derived, compared and discussed with reasonable detail. . . .

RADIATION INCORPORATED SIGNALING SYSTEM STUDY
D. D. Baxter, Radiation Inc., Orlando, Fla., Special rept., 1 June 61-31 May 62, 98 p. incl. illus., 48 refs., AD 283 320

. . . almost exclusive attention is given to the dipulse (a single cycle of a sine wave) and tripulse (the matched filter response to a dipulse). The spectra of the signals are displayed and the concept of the matched filter is discussed and applied as the optimum detector for the signals in question.

PARTIAL ORDERING OF DISCRETE CHANNELS
T. T. Chang, et al., IRE Intern. Conv. Rec. Pt. 4, vol. 10, Mar. 1962, p. 190/199.

. . . A discrete, finite, memoryless channel K_1 is said to include another such channel K_2 if it is possible to duplicate all of the transition probabilities of K_2 by interposing K_1 between pairs of suitably chosen pre- and post-channels. In general, it is not known what the necessary and sufficient conditions for inclusion are. . . .

ON THE OPTIMUM PERFORMANCE OF N-ARY SYSTEMS HAVING TWO DEGREES OF FREEDOM
R. W. Lucky, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 185/192.

. . . the n possible symbols correspond to n vectors in a 2 WT_0 dimensional signal space. This paper considers the theoretical properties of a class of digital systems where the signal space is two-dimensional. Such systems are both amplitude- and phase-modulated. Approximate expressions are derived for the average probability of error for these systems as a function of the placement of the n symbol vectors in the two-dimensional signal space. . . .

ERROR PROBABILITIES FOR EQUICORRELATED M-ARY SIGNALS UNDER PHASE-COHERENT AND PHASE-INCOHERENT RECEPTION

A. H. Nuttall, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 305/314, 72 refs.

. . . derived in the form of previously untabulated single and double integrals. These integrals are amenable to computer evaluation for arbitrary M. Two modes of reception are considered. In the first, one of M equal energy equiprobable signals is known to be transmitted during a symbol interval of T seconds through a nonfading channel with additive white Gaussian noise. . . . the cross-correlation coefficients between all the signals are equal. The probability of correct decision in both phase-coherent and phase-incoherent reception is derived exactly, as a function of the signal-to-noise ratio, the common cross-correlation coefficient, and the size of the signal set M. In the second mode of reception, the only difference is that a threshold is incorporated in the receiver. The probability of false detection and the probability of detection and correct decision are derived exactly for both phase-coherent and phase-incoherent as a function of the threshold level, the signal-to-noise ratio, the common cross-correlation efficient and the size of the signal set M.

M-ARY TRANSMISSIONS WITH LINEAR FILTERING ON RAYLEIGH FADING CIRCUITS

J. N. Pierce, Air Force Cambridge Research Labs., Bedford, Mass. March 1962, 13 p. incl. table, 7 refs. (AFCRL 62-160) AD 275 436.

On a nonfading circuit, arbitrarily small error rates can be achieved by using uncoded M-ary transmission with linear receiver filtering. . . . on a Rayleigh fading circuit. . . . improvement obtained in communicating binary data with M-ary transmissions is equivalent to a saving in transmitter power of less than 4.6 db. . . .

DIGITAL COMMUNICATION STUDIES: PART I. COMPARATIVE PROBABILITY OF ERROR AND CHANNEL CAPACITY. PART II. ASYNCHRONOUS TIME-MULTIPLEXING OF MULTICHANNEL SPEECH SOURCES

M. P. Ristenbatt, et al., Office of Research Administration, U. of Michigan, Ann Arbor, March 1962, 128 p. incl. illus., tables, 41 refs. (Tech. rept. no 133; Rept. no. 4251-2-T), AD 275 480.

. . . M-ary bi-orthogonal signals are deemed best for low S/N if probability of error is stringent. Binary and M-phase signals appear best for medium and large S/N. This treatment should help structure the selection of modulation and coding methods for proposed communication systems. Also, since many signalling methods are considered, some fundamental principles, terminology, and methods of comparing are suggested. An analytical multiplexing for multichannel speech signals. . . . it is proposed that the source-to-channel sample assignment be asynchronous.

ON COMPARING N-ARY SYSTEMS (Correspondence)

J. K. Wolf, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 216/217.

. . . when comparing transmission systems with alphabets of various sizes, a comparison of the probabilities of error per character is not. . . easily interpreted. . . . The purpose of this note is to illustrate one surprising result. . . it will be shown that the relative performance of the systems may depend upon the size of the information alphabet for which the error probabilities are computed and then compared. . . .

BINARY TO TERNARY CONVERSION BY LINEAR FILTERING

J. K. Wolf, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., May 1962, 8 p. incl. illus., 3 refs. (RADC TDR 62-230) AD 278 264

A simple linear filter consisting of a delay element and an adder is described for converting a random stream of binary pulses into a stream of ternary pulses. . . Another simple linear filter is described for reconverting the stream of ternary pulses into the stream of binary pulses. Results of an experimental implementation of such a system are presented. Also, a generalization of this scheme for binary to N-ary to binary conversion is discussed.

ADAPTIVE RECEPTION OF SIGNALS WITH UNKNOWN GAIN AND DELAY

J. C. Hancock, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 54/65.

Assuming unknown channel gain and unknown channel delay we derive a set of delay estimators . . . The estimating filter output is the true path delay plus a noise term that is Gaussian when the additive channel noise is Gaussian. . . . Any of these delay estimators can be incorporated into an adaptive M-ary receiver which uses the noisy estimates in a manner that would be optimum if the measurements were precise. . . .

KODIEREN MIT ORTHOGONALEN FUNKTIONEN. I. GRUNDLAGEN (Encoding With Orthogonal Functions. I. Fundamentals.) (In German.)
H. Harmuth, Arch. Elekt. Uebertragung, vol. 17, Sept. 1963, p. 429/437.

The characters of code alphabets can be represented by the superposition of orthogonal time functions. This representation permits the detection of telegraph signals by cross-correlation with a few sample functions rather than by cross-correlation with many sample characters that can be assembled from these functions. . . . Furthermore, the fundamentals for the computation of the relative error rates due to thermal noise are derived. They will be used in a forthcoming paper to devise alphabets that permit an error-free transmission. Unlike the error-free alphabets devised by Elias they allow to approach arbitrarily well Shannon's limit of the transmission capacity of a communication channel. . . .

SOME ASPECTS OF BITERNARY TRANSMISSION
M. Hooten, et al., Army Electronics Research & Development Agency, Ft. Monmouth, N.J., April 1963, 6 p., AELRDL 2357, AD 420 286.

The transmission of a PCM signal using biternary signaling is reviewed. Two different biternary signals are compared with respect to their ease of generation and detection. . . .

THE ASYMPTOTIC BEHAVIOR OF INCOHERENT M-ARY COMMUNICATION SYSTEMS (Correspondence)
I. Jacobs, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 251/252.

RELIABILITY IMPROVEMENT OF DIGITAL COMMUNICATION USING REDUNDANCY IN UNCERTAINTY REGION RECEPTION
L. Kurz, New York U., N.Y., College of Engineering, June 1963, 88 p., 10 refs., (Thirteenth Scientific Report; Tech. Rept. 400-77; AFCRL-63-187), N63-20836.

. . . considers an efficient method for utilizing the redundancy of transmittable language to improve the reliability of a digital communication system disturbed by additive non-white-gaussian noise. The reliability of digital systems using orthogonal and binary digit codes is improved by introducing an uncertainty region at the receiver. This method is an extension and generalization of null-zone reception previously applied to the improvement of binary transmission in the presence of white-gaussian or peak-limited noise. . . .communication links using orthogonal digit coding afford greater reliability than corresponding links using binary digit coding. . .A geometric interpretation of the results is given in terms of n-dimensional Euclidean space. . .

OPTIMIZATION OF SIGNAL WAVEFORMS
G. Lachs, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 95/97.

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS (Phase 3 Report)
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Final rept., Feb. 1962-Feb. 1963, May 1963, 175 p., RADC TDR 63 147, AD 407 343.

. . . The analysis of the optimization of N-ary digital systems operating over a dispersive channel, which was begun during a previous phase of the contract, is further advanced.

ERROR PROBABILITIES FOR SOME GENERAL CLASSES OF NON-ORTHOGONAL M-ARY SIGNALS UNDER PHASE-COHERENT RECEPTION
A. H. Nuttall, Litton Systems Inc., Waltham, Mass. 1 Sept. 1963, 16 p., Rept. no. TR63 7 BF, AD 419 991.

. . . derived under conditions of synchronized phase-coherent reception in a non-fading single path channel subject to additive white gaussian noise. The results are in the form of untabulated low-order multiple integrals which are amenable to computer evaluation.

OPTIMUM PULSE TRANSMISSIONS FOR MULTIPATH CHANNELS
J. G. Proakis, Lincoln Lab. Mass. Inst. of Tech., Lexington, 16 Aug. 1963, 40 p., refs., (Rept. 64 G-3; AD 416 639), N64-17454.

. . . performance of an incoherent M-ary communication system. . .computed under very restrictive conditions on the channel behavior, namely, that the received signal consists of resolvable, independent Rayleigh fading paths, each of which has been corrupted additively by independent gaussian noise. . . generalizations of results obtained earlier. From these expressions the optimum time duration for pulse transmissions is computed for two channels-the orbital dipole channel and the moon.

OPTIMIZATION OF SIGNALS
F. C. Schweppe, Lincoln Lab., Mass. Inst. of Tech., Lexington. 16 Jan. 1964, 49 p., Group rept. no. 644, ESD TDR 64 18, AD 430 345.

. . . A communication problem of deciding which of M signals was transmitted and a radar problem of deciding the range rate of a target are used as examples.

TABULATION OF THE PROBABILITY OF DETECTION AND CORRECT DECISION AMONG M ALTERNATIVES FOR PHASE-INCOHERENT RECEPTION
D. Shnidman, Air Force Cambridge Research Labs., Bedford, Mass., Sept. 1963, 31 p., AFCRL 63 374, AD 424 731.

OB ODNOM METODE KODIROVANIIA DLIA PEREDACHI DVOICHNYKA CHISEL PO KANULA SVIAZI S SHUMAMI (In Russian)
(A Coding Method for the Transmission of Binary Numbers Over a Communications Channel in the Presence of Noise)
E. V. Voronov, Radiotekhnika i Elektronika, vol. 8, Aug. 1963, p. 1312/1318.
Radio Engineering and Electronic Physics, Aug. 1963, p. 1273/1279, 6 references. Translation. A63-25287 and A64-17668.

Presentation of a solution to two extremum problems for the case in which the more significant symbols—i.e., symbols corresponding to the larger powers of 2—are transmitted by longer pulses, with the subsequent optimum processing.

Related Publications:

ERROR-CORRECTING CODES FOR AN ASYMMETRIC NONBINARY CHANNEL (Correspondence)
W. H. Kim, IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 189/190.

MULTIVALUED SWITCHING ALGEBRAS AND THEIR APPLICATION IN DIGITAL SYSTEMS
E. I. Muehldorf, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 467/480.

. . . a brief survey of ternary switching algebras is given. . . . In applying a nonbinary switching algebra to switching circuitry one can realize two cases. The one is to apply it to binary devices, the other is to apply it to multivalued devices. . . .

AN IDEAL IDENTIFICATION DEVICE FOR COMPLEX SIGNALS
L. F. Borodin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 60/74.

. . . an identification device which for a given receiver will ensure the maximum probability of correct reception of the combinations in a correcting code. It is shown that the use of this ideal device and "equidistant" codes makes it possible to transmit messages along channels with the desired degree of authenticity. The possibility of correcting errors by arithmetic operations is indicated. The results are given of an experiment carried out on a high-speed electronic computer to compare a number of other methods of reception with the ideal method. The results of the experiment confirm that the "symbol" method of reception is imperfect. . . .

OPTIMUM THRESHOLD FSK COMMUNICATION WITH DECISION REJECTION
D. Middleton, Air Force Command & Control Develop. Div., Air Research & Develop. Command, Bedford, Mass., April 1960, Rept. no. AFCRC TR 60-137, AD 245 725.

. . . Besides a detailed examination of the binary rejection cases, the theory of the multiple alternative detection process with decision rejection is also outlined.

QUATERNARY CODES FOR PULSED RADAR
G. R. Welti, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 400/408.

. . . coded waveforms can be generated in a simple network. . . the same network can be readily converted to a matched filter for the coded waveform.

SINGLE ERROR-CORRECTING CODES FOR NONBINARY BALANCED CHANNELS
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 2/7.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

. . . A theory of so-called efficient codes (minimax, equal separation, and nearly equal separation) is developed. . . . if the noise is nonwhite; . . . properly chosen waveforms are more efficient than binary coding. . . .

ON THE DETECTION AND ESTIMATION PROBLEM FOR MULTIDIMENSIONAL GAUSSIAN RANDOM CHANNELS
J. K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N.Y., Nov. 1961, 26 p. (RADC-TR-61-214), AD 268 492.

TERNARY LOGIC AND RELATED STUDIES: AN ANNOTATED BIBLIOGRAPHY
E. E. Graziano, Lockheed Aircraft Corp., Sunnyvale, Calif., (Special bibliography rept. no. SB-62-65; Rept. no. 8-44-62-3), AD 299 464.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Intern. Conv. Rec. Pt. 4, vol. 4, March 1962, p. 161/173.

. . . Basically, it is shown that subdividing the decision interval (O, T) and coding each subinterval using optimum waveforms is a more efficient method of combatting the impulse noise than using optimum waveforms in the full decision interval. . . .

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 274/280.

. . . each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. . . .

A NOTE ON SEQUENTIAL DECODING APPLIED TO LARGE ALPHABET INCOHERENT CHANNELS - R COMP DETERMINATION
M. H. Check, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 31 May 1963, 11 p. Rept. no. 65G6, AFESD TDR63 77, AD 410 883.

. . . investigation of the computation cutoff rate for such channels. . .the meaning of 'incoherent' will be made precise presently. Suppose one of 1 orthogonal and equal energy bandpass signals is sent over a channel perturbed by additive white Gaussian noise. The prior probability of all signals is assumed equal. The received signal is detected by a bank of 1 filters matched to the 1 waveforms. The envelopes of the filter outputs are formed and are sampled at the appropriate time. This detection procedure is optimum if the receiver does not have knowledge of the RF phase of the signal, and if the RF phase, whatever it is, is constant over the signalling interval. A decoder has available to it the 1 analog outputs. A decision on the largest of these destroys information. Accordingly, if coding is to be used, it is appropriate to view the 1 analog outputs as a vector which may be operated on by a decoder.

LARGEST OF N SELECTION SYSTEMS AFFECTED BY MULTIPATH TIME SPREADING (Correspondence)
J. Dumanian, Proc. IEEE, vol 51, no. 2, Feb. 1963, p. 390.

Several authors have considered the error probabilities in detecting a signal when the transmitted signal is one of N orthogonal waveforms. . . . In this note. . .the received signal is Gaussian noise in Gaussian noise. Moreover, in this description it is assumed that the time duration of the received signal is greater than the reciprocal of the signal bandwidth. . . .

RELIABILITY IMPROVEMENT OF DIGITAL COMMUNICATION USING REDUNDANCY IN UNCERTAINTY REGION RECEPTION
L. Kurz, New York U. Coll. of Engineering, N. Y., Scientific rept. no. 13., June 1963, 78 p., TR no. 400 77, AFCRL Rept. no. 63 187, AD 414 370.

. . . utilizing the redundancy of the transmittible language to improve the reliability of a digital communication system disturbed by additive non-white gaussian noise. . . . systems using orthogonal and binary digit codes

. . .uncertainty region at the receiver. . . . an extension and generalization of null-zone reception previously applied to the improvement of binary transmission in the presence of white gaussian or peak-limited noise. . . . it is shown that communication links using orthogonal digit coding afford greater reliability than corresponding links using binary digit coding. . . .

RESEARCH ON AUTOMATIC COMPUTER ELECTRONICS. VOL. I. COMPUTER DEVICE AND CIRCUIT RESEARCH
R. 1. Tanaka, Lockheed Missiles and Space Co., Palo Alto, Calif. Final rept. for 1 Sept. 1962-1 Oct. 1963. Feb. 1964, 345 p., AD 435 760

. . . design of a ternary threshold element, a cryogenic ternary storage element, the design of a memory array using ternary storage elements, and the design of a variable gain threshold element. . . .

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE (Translation)
I. A. Tsikin, Telecommunications and Radio Engineering. Part 2 - Radio Engineering, July 1963, p. 1/11, 5 refs., A64-15462.

. . . demonstrating that orthogonality in the wide sense is also necessary in the case of codes with a base greater than two. . . .

1.314: Digital Sequences as Data Transmission Waveforms

Included: Polynomial-like signals; Binary sequences as transmission waveforms; Random binary waves; Pseudo random binary sequences; PN sequences in data systems; Maximum length sequences in data systems; Bi-orthogonal binary sequences; Orthogonal binary sequences; D-ary sequences.

Not Included: RADACS = random access discrete address communications systems (2); Coding theory of PN sequences (2); Shift register codes in general (2); Binary sequences for ranging codes (2); Random sequence generators.

Cross References: Multi-orthogonal discrete sequences (1.317); Higher order data transmission systems (1.313); Special orthogonal sets of waveforms (1.315); Spread spectrum waveforms (1.316); Noise communication systems (1.316); Matched filter extractors (1.372); Correlation receivers for data transmission (1.373).

Principal Publications:

THE CORRELATION FUNCTIONS OF RANDOM SEQUENCES OF RECTANGULAR PULSES
I.N. Amiantov, et al., Radio Engrg., vol. 14, no. 4, 1959, p. 9/25

TWO PROPERTIES OF PSEUDO-RANDOM SEQUENCES
L. L. Campbell, IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 32.

. . . which may make them useful in certain communication systems. . . .

A BOUND ON THE CROSSCORRELATION FUNCTIONS OF A SET OF BINARY SEQUENCES OF FINITE LENGTH
G.E. Mongold, Jr., MIT, Res. Lab. Quarterly Progress Rept. #52, Jan. 1959, p. 112/128.

. . . form a class of signals that might be used as modulating functions in a communication system employing correlation detection. . . .

MODULATION BY RANDOM AND PSEUDO-RANDOM SEQUENCES
R.C. Titsworth, et al., Jet Propulsion Laboratory, June 1959, (Prog. Rept. 20-387).

SERIAL CORRELATION IN THE GENERATION OF PSEUDO-RANDOM NUMBERS
R.R. Coveyou, J. Assn. for Computing Machinery, vol. 7, no. 1, Jan. 1960, p. 72/74.

A METHOD OF OBTAINING ARBITRARY PHASES OF AN M-SEQUENCE
R.C. Curry, Rochester U., N.Y., Nov. 1960, 44 p., AD 248 455.

. . . If an m-sequence is generated by an N-stage shift register which has been modified by the addition of logical feedback, a sequence delayed by up to a maximum of ((2 to the power N)-1) digits can be obtained by adding modulo 2 the outputs of various stages of the shift-register generator. A method is given for determining from which stages the outputs should be added to obtain any specified delay . . . Also described is the network of modulo 2 adders which are used to obtain the delayed sequence. A program is given in the appendix for generating the phase-table with a digital computer (IBM 650).

EXPERIMENTAL AUTOCORRELATION OF BINARY CODES
D.F. DeLong, MIT Lincoln Laboratory, Oct. 1960.

M equally probable symbols may be encoded as continuous waveforms whose sample values are the coordinates of the vertices of a regular simplex in N Dimensions. These vertices or code points, therefore, are equally spaced, and the resulting waveforms are adapted particularly to low signal-to-noise communication systems.

QUATERNARY CODES FOR PULSED RADAR
G.R. Welti, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 400/408.

. . . A class of quaternary codes is described, and an algorithm for generating the codes is given. The codes have properties that make them useful for radar applications: (1) their auto-correlation consists of a single pulse, 2) their length can be any power of two, 3) each code can be paired with another code (its mate) of the same class in such a way that the cross-correlation of mates is identically zero, 4) coded waveforms can be generated in a simple network . . . 5) the same network can be readily converted to a matched filter for the coded waveform.

CODING THEORY AND ITS APPLICATIONS TO COMMUNICATIONS SYSTEMS
L. Baumert, et al., Jet Propulsion Lab., CIT, Pasandena, Calif., 31 Mar. 1961, 84 p., (Tech. rept. 32-67), AD 257 752.

A general theory of binary sequences with desirable correlation properties is developed for application to the design of digital communication systems.

WIDE-BAND CARRIER COMMUNICATIONS, VOLUME III. BINARY COMMUNICATION BY MEANS OF NOISE SAMPLES
R.L. Luedtke, et al., Lockheed Aircraft Corp., Sunnyvale, Calif., Nov. 1961, 1 v. (Rept. no. LMSD-704048, vol. 3), AD 253 283.

A novel and easily instrumented technique of binary communications is described . . .

A short elaboration is given on the low detectability of the signal by an unfriendly observer while operating at low signal-to-noise ratios . . .

ON CODED PHASE-COHERENT COMMUNICATIONS
A.J. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-7, no. 1, March 1961, p. 3/14.

. . . this paper considers the result of encoding independent equiprobable binary words or sequences of indpendent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white Gaussian noise and detected by correlating them with their stored or locally generated replicas at the receiver . . . It is shown that the limit as the code word length and the bandwidth approach infinity, the received information rate approaches the channel capacity for only one value of the above ratio.

AN OPTIMUM SELF-SYNCHRONIZED COMMUNICATION SYSTEM
S.S. Chang, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 110/116.

One set of optimum signal waveforms for undirectional transmission with minimum error probability, when the interference is additive gaussian noise, consists of sequences of binary waveforms resembling a modified Reed Code. The binary waveforms considered here are phase-shifted sinusoids. The theoretical design of the receiver is given such that the reference signal required for correlation detection is directly generated from the message signal itself.

A NOTE ON ORTHOGONAL DIGIT CODING
L. Kurz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 775/782.

. . . considers some general ideas pertaining to multisignal coding for digital communication systems perturbed by additive Gaussian noise which may be non-white with a known demodulated noise power density spectrum. The signals are formed from weighted sums of the orthogonal set of eigenfunctions generated by an integral equation with its kernel corresponding to the inverse Fourier transform of the Gaussian noise power density spectrum. The orthogonal digit codes thus generated afford greater reliability for fixed data rate and average power limited communication links then do binary digit codes . . . A new interpretation of the results in terms of the matched-filter-theory is given.

POWER SPECTRA OF SIGNALS MODULATED BY RANDOM AND PSEUDORANDOM SEQUENCES
R.C. Titsworth, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Oct. 1961, 45 p.,(Rept. 32-140), AD 268 119.

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 199/205.

. . . The application of sequential decoding to the continuous asymmetric channel, and a new decoding scheme for convolutional codes, successive decoding, are considered. . . .

MUTUALLY DISTINGUISHABLE QUASI PN SEQUENCES
D.R. Anderson, IEEE Intern. Conv. Rec. Pt. 4, vol. 11, no. 4, March 1963, p. 124/132.

. . . shows how to construct periodic p-ary digital signals which have small out-of-phase autocorrelation and which have small in-and out-of-phase crosscorrelation. For each prime p, finite field theory is used to construct families of p-ary signals of a period p^m-1 corresponding to each positive interger m. . . .

DECODING RULES FOR CERTAIN PRODUCT CODES
L. Calabi, et al., Parke Mathematical labs., Inc., Carlisle, Mass. March 1963, 25 p. AFCRL 63 137, AD 409 453, N63-18357.

Decoding procedures are formulated, and their performance established, for products of binary group codes of even minimal weight and for Hobbs's codes of any dimension. . . .

CORRELATION FUNCTIONS FOR THE RANDOM BINARY WAVE (Correspondence)
P.W. Cooper, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 496/497.

This note presents expressions for the autocorrelation function, its Hilbert Transform, and the associated "envelope" and "phase" functions for the band-limited random binary wave. Interest in these functions could arise, for example, in analysis of the "envelope" of a signal and in correlation detection of a single side-band waveform, . . .

ELECTRON TUBE RESEARCH
N. DeClaris, Cornell U. School of Electrical Engineering, Ithaca, N.Y., Quarterly progress rept., no. 11, 1 June-31 Aug. 1962. 31 Aug. 1962, lv. incl. illus., tables, refs.,(Research rept. no. EE-537; Rept. no. 15), AD 291 073.

This report included: AN EXPERIMENTAL STUDY OF THE CONSTRUCTION OF BINARY SIGNALING ALPHABETS FROM RANDOM BINARY SEQUENCES, by H.S. McGaughan and George S. Downs. 1 Sept. 1962, lv. incl. illus. tables. (Research rept. no. EE 534; Technical rept. no. 72)

THE THEORETICAL COMPARISON OF THREE DIGITAL SYSTEMS FOR SPACE TELEMETRY (In French)
J. Dupraz, Onde Electr., vol. 43, no. 432, March 1963, p. 298/310.

. . . theoretical comparison of three digital systems . . . relate the orthogonal binary codes of which the possibilities have recently been discovered . . . to the PCM non-redundant code . . . results of the theory of statistical detection . . . techniques of demodulation . . . criterion used for comparison is the efficiency coefficient β as defined by Sanders . . . derive the advantages and disadvantages of orthognal codes. This allows a considerable increase in the range of the circuit for a given radiated power but at the cost of a considerable increase in the bandwidth.

POLYPHASE CODES WITH GOOD NON-PERIODIC CORRELATION PROPERTIES
R.L. Frank, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 43/45.

N-phase codes are described which have an autocorrelation function with one main peak and very small side peaks. With N phases an N long pulse sequence is generated. Properties have been verified for N up to 8 and a rule for main peak-to-side-peak ratio is conjectured for larger N. For N greater than 5, the ratio is substantially better than the best ratios which have been shown for binary bipolar codes. Doppler shift effects appear to be similar to those of linear FM radar pulse compression . . . A comparison of the performance of higher-order polyphase codes with similar length binary codes indicates a superiority in the polyphase codes.

AN INTERESTING DECOMPOSITON PROPERTY FOR THE SELF-PRODUCTS OF RANDOM OR PSEUDORANDOM BINARY SEQUENCES (Correspondence)
W.J. Gill, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 246/247.

ON THE SELECTION OF AN ORTHOGONAL SIGNAL ENSEMBLE FOR THE TRANSMISSION OF BINARY DATA
L.R. Halsted, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 66/74.

. . . considers binary data transmission systems in which signal interference may be caused by a combination of signal blanking and fading, additive impulse noise, and additive nonwhite gaussian noise. For each disturbance the paper shows how the error rate can be improved by the suitable choice of a signal ensemble, and it discusses the choice of a good signal ensemble for a given combination of these disturbances. The systems are assumed to use ideal linear correlators for signal detection and to have minimum bandwidth for transmitting the data in binary form. The paper also illustrates the role of n-by-n orthogonal matrices in the choice of a signal ensemble to transmit a block of n information bits. . . .

A TRACTABLE BERNOULLI-SEQUENCE GENERATOR
C.C. Hoopes, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, 282/294.

. . . implementation and evaluation of a random-pulse-train generator. The technique is of special interest and advantage for those testing or working with digital equipment. The generator is a reliable, reproducible, and stable source of Bernoulli sequences with p in the range 10^{-3} to 10^{-1}. The Bernoulli sequence is generated by means of a noise source in conjunction with a shift-register generator. . .

The error probabilities for uncoded multiple alternative transmission of the output of a discrete data source are derived quite generally and numerically evaluated for a sample case. Specifically, the source emits D-ary equiprobable messages (information digits) which are represented by (associated with) an M-ary alphabet (transmission digits) so as to minimize the average symbol length in the M-ary representation. One of the M signals is transmitted and a M-ary decision made in the receiver. A sequence of these received digits is then reassociated into the information alphabet. . . . phase-coherent reception in a non-fading additive Gaussian noise channel . . . No bandwidth constraints are imposed. One of the major conclusions is that . . . the optimum transmission alphabet size to minimize the average D-ary error probability has M equal to D . . .

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATIONS
J.K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N.Y., Final rept., Aug. 1963, 15 p., Proj 4519, Task 451903; RADC TDR63 314, AD 417 232.

. . . filtering a random binary sequence with certain finite memory, linear and non-linear filters. The statistical properties of the filtered sequence are considered . . . standard methods of analysis are used to obtain some new results which have potential application in communications systems.

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATION
J.K. Wolf, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 422/427.

WEAK SIGNAL COMMUNICATION TECHNIQUES
Bell Telephone Labs., Inc., Whippany, N.J., Final rept., May 1961 - Apr. 1963. July 1963, 96 p., AD TDR63 525.

. . . analysis of FSK systems with noise-like signals, and determination of group code performance. . . . An octary system, a breadboard version implemented under this program, is described in detail.

Related Publications:

AN ELECTRONIC GENERATOR OF RANDOM SEQUENCES (In Czech.)
J. Havel, Slaboproudy Obzor, vol. 20, no. 12, 1959, p. 735/740.

RANDOM SIGNAL CODING FOR FINITE MESSAGE SETS
T. L. Grettenberg, Stanford Electronics Labs., Stanford U., California, 30 June 1961, 65 p., (Tech. rept. 2004-3), AD 262 357

The divergence between statistical hypotheses is used as a criterion for selection of a finite transmitter alphabet in a communications system. The members of the transmitter alphabet are sample functions from one of a finite set of normally distributed random processes. The receiver uses a maximum-likelihood decoding procedure, and the probability of error is evaluated for this receiver for a class of codes having orthogonal covariance functions.

SHIFT REGISTERS GENERATING MAXIMUM-LENGTH SEQUENCES
P. H. R. Scholefield, Electronic Technol., vol. 37, no. 10, Oct. 1960, p. 389/394.

AN ELECTRONIC GENERATOR OF RANDOM NUMBERS
G. M. Dillard, et al., Navy Electronics Lab., San Diego, Calif., 21 Dec. 1962, 24 p. incl. illus., tables, 6 refs., (NEL rept. no. 1152), AD 296 752.

A NEW DIGITAL MATCHED FILTER COMMUNICATION TECHNIQUE
G. E. Goode, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 371.

Abstract Only.

RECOVERY OF RANDOMLY SAMPLED TIME SEQUENCES (Correspondence)
C. S. Lorens, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 214/216.

. . . In coded communication systems the times of channel availability are random. . . . This paper considers the noise and recovery problem associated with a random sampling of a continuous time sequence. . . .

DELAY-LOCK TRACKING OF BINARY SIGNALS
J. J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., Technical rept. on Communications, Sept. 1962, 30 p. incl. illus., refs., (Rept. no. 6-90-62-85), AD 285 566.

. . . The dealy-lock discriminator is a nonlinear feedback system which employs a form of cross-correlation in the feedback loop. Its function is to estimate continuously the relative delay between a reference signal and a delayed version of that signal which is perturbed with additive noise. Binary maximal-length shift-register sequences are used as the signal because they can easily be regenerated with any desired delay and because they possess desirable autocorrelation functions. Problems of target search and acquisiton are stuided. The system performance in the presence of additive Gaussian noise is discussed. Computations are made of the effect of amplitude-limiting the received data on the system noise performance.

SEVERAL CLASSES OF CODES GENERATED FROM ORTHOGONAL FUNCTIONS
P. Hsieh, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 88/91.

. . . utilizing the existing knowledge of discrete error-correcting binary codes . . . The method consists in constructing the transformation matrix . . . that performs the linear transformation by taking the finite set of orthogonal functions into the set of continuous code words . . . . In constructing signals for continuous channels, it is possible to use waveform redundancy to reduce the probability of transmission error. . . . In particular, discrete ternary codes using symbols -1, 0, 1 are constructed to form some classes of continuous codes .

M-ARY SIGNALLING AND BALANCED INCOMPLETE BLOCK DESIGNS
A. S. Kobos, Rome Air Development Center, Griffiss Air Force Base, N. Y., Final rept., June 1963, 11 p., Proj. 4519, Task 451903, RADC TDR 63 256, AD 413 835, N63-19779.

A set of code words obtained by the cyclic permutation of binary sequences having autocorrelation functions with only two values is discussed. The relationships of this type of code to solutions of balanced incomplete block design problems and other mathematical constructs are presented. These codes consist of m words of m binary digits each. A simple m-ary system transmitting through white Gaussian noise is used to discuss error probabilities. . . . The advantages of signalling with this type of code, as compared to orthogonal code words, are discussed.

STATISTICAL PROPERTIES OF THE INTEGRAL OF A BINARY RANDOM PROCESS
D. G. Lampard, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 413/427, 26 refs.

. . . Statistical properties of the output $z(t)$ of a finite time integrator are discussed. The input process considered is a binary random process $y(t)$ having successive axis-crossing intervals which are statistically independent. Transform expressions are derived for the first- and second-order transition probability densities of the integrated process, and it is shown how these results may be extended to three or more dimensions. Four processes are considered as examples.

BINARFOLGEN LINEAR RUCKGEKOPPLTER SCHIEBEREGISTER, ERZEUGUNG, EIGENSCHAFTEN UND ANWENDUNG-SBEISPIELE (Binary Effects of Coupled

Linear Feedback Shift - Register, Generation, Characteristics and Examples of Application)

H.H. Leibelt, Deutsche Versuchsanstait fur Luft- und Raumfahrt, Oberpfaffenhofen, (W. Germany), Inst. fur Flugfunk und Mikrowellen, Nov. 1963, 89 p., refs., in GERMAN, Available from Vereinigte Universitats-u, Fachbuchhandlungen, R. Wagner Str. 1, Cologne, W. Germany, (DVL-307), N64-15032.

The characteristics of the binary effects generated by a coupled-feedback linear shift register are discussed. Emphasis is placed on investigations of period length, the correlation function, and the number of effects with maximum-period length.

POWER AND SIGNAL-TO-NOISE CALCULATIONS OF A CERTAIN PSEUDO-RANDOM SIGNAL

E.J. McManus, Jr., Army Missile Command, Redstone Arsenal, Huntsville, Ala., 25 Jan. 1963, 16 p. incl. illus. 3 refs. (Rept. no. RE-TR-63-1, AD 297 096.

. . . shown that the amplifier bandwidth which maximized the output signal-to-noise ratio is given by 2/tau, when tau is the bit length in the pseudo-random sequence

TRANSMISSION OF TELEMETRY DATA BY MEANS OF GROUP CODES

E.V. Mitriaev, (Radiotekhnika i Elektronika, vol. 8, June 1963, p. 923-929, In Russian), Radio Engineering and Electronic Physics, vol. 8, June 1963, p. 923/940. Translation. A64-17556.

Discussion of a method of optimum representation of digital data by group code combinations. The method is stated to minimize the mean risk with the power of the loss function s > 1 and with uniform probability distribution. Statement of the problem, properties of the group code combination-transformation matrix, the best permutation and its properties, and an example of optimum correlation are considered . . . .

ERROR PROBABILITIES FOR UNCODED M-ARY TRANSMISSION OF D-ARY DATA

A.H. Nuttall, Litton Industries, Waltham, Mass., 1 Aug. 1963, 26 p., Rept. no. TR63 6BF, AD 420 125.

DETECTION OF A SIGNAL MODULATING A RANDOM NOISE CARRIER (In French)

C. Ducot, Onde Electr., vol. 43, no. 433, Apr. 1963, p. 452/455.

IMPROVING THE QUANTITIZATION OF RANDOM SIGNALS BY DITHERING

G.G. Furman, RAND Corp., Santa Monica, Calif., May 1963, 35 p., RAND RM3504 PR, AD 405 473.

. . . practical problems of determining the effects of independent quantizer activators called dithers upon the statistical processing properties of the quantizer . . . For the highly important sinusoidal and sawtooth dithers exact analysis yields for the first time answers. . . . to the question of what upper bounds does the dither impose.

A RANDOM ACCELERATION MODEL FOR FILTERING POLYNOMIAL-LIKE SIGNALS

L. Jones, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington. 25 Oct. 1963, 15 p., Rept. no. 28G3, AFESD TDR63 567, AD 423 431.

Random type models for filtering discrete time, polynomial-like signals from noise are discussed. The particular model analyzed is a second-degree polynominal with the acceleration (second derivative) considered to be a random process. The optimum filter corresponding to this model is derived . . .

THE SYNTHESIS OF NONLINEAR FEEDBACK SHIFT REGISTERS

K.B. Magleby, Stanford Electronics Labs., Stanford U., Calif., Oct. 1963, 89 p., Rept. no. 63 118, TR 6207 1, AD 428 081.

Two domains that describe the behavior of a feedback shift register were developed. These are the sequence and polynomial domains, which are analogous to the frequency and time domains in the description of continuous systems. The domains are related by an expansion of orthogonal functions. . . . In the procedure, the output sequences are mapped to the roots of irreducible polynomials, thereby providing an algebraic description of the register's behavior. To synthesize the shift register in the sequence domain, several properties of the output sequences are needed. . . . The cycles and output sequences of a simple, circulating shift register are used to synthesize an arbitrary feedback shift register.

SYNCHRONIZATION OF COHERENT DETECTORS

I. Selin, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 100/109.

The estimation of carrier frequency and subcarrier epoch in a coded- "noise" communication system is discussed. . . .

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE

I.A. Tsikin, Radio Engng: Transl. of Radiotekhnika vol. 18, no. 7, July 1963, p. 1/11.

. . . The hypothesis that orthogonal systems, in the wide sense, ensure maximum noise immunity in a channel with indeterminate signal phase in the presence of additive fluctuation noise was first advanced by L.M. Fink . . . A rigorous proof of this statement is given below for the special case of binary systems with Rayleigh fading of the signal. Considerations are also developed for optimum choice of signals with non-Rayleigh fading and for the noise immunity of multiposition systems. . . .

1.315: Special Sets of Orthogonal Waveforms

Included: Time limited orthogonal outputs of networks; Orthogonal polynomials products of trigonometric functions; Orthogonal network problems; Laguerre polynomials.

Not Included: Orthogonal multiplexing techniques (2); Orthomux systems (2).

Cross References: Orthogonal digital sequences (1.314); Impulsing of linear networks in general (1.311); Orthogonal multi-signal systems (1.317); Ortho-normal exponentials (1.311); High order data transmission systems (1.313); Signal theory of digital waveforms (1.311); Matched filter extractors (1.372).

Principal Publications:

ON THE APPLICATION OF FOURIER ORTHOGONAL FILTERS
H. Blasbalg, East Coast Conf. Aeronautical Navig. Electronics, vol. 5, Oct. 1958, p. 165/172.

. . . filters have been synthesized for generating the Laguerre Functions and a tranversal filter has been suggested for generating the Hermite Orthogonal Functions (Gram Chalier Series) . . . In this paper, we propose to show that a set of simple physically realizable filters can be synthesized which sample the frequency spectrum of the input signal. It is well known that corresponding to the sampling theorem in the time domain there exists and equivalent theorem for the frequency domain . . .

without increase of distortions due to additive white normal noise. A method for the elimination of the phase information is based on the decomposition of the audio signal by correlation with a set of orthogonal functions. These correlations yield for each orthogonal process these coefficients in analogue or digital computers to reduce further the bandwidth required for the transmission of audio signals with certain spectral distribution, e.g. voice signals. . . .

ANALOGRECHENSCHALTUNGEN FUR DIE ENTWICKLUNGSKOEFFIZIENTEN NACH ORTHOGONALFUNKTIONEN (Determination of the Coefficients of Expansions into Orthogonal Functions by Analog Computers.) (In German)
R. Herschel, Elektron. Rechenanlagen, vol. 3, no. 5, May 1961, p. 212/217.

A METHOD OF DESIGNING SIGNALS OF LARGE TIME-BANDWIDTH PRODUCT
E. L. Key, et al., IRE Intern. Conv. Rec., vol. 4, March 1961, p. 146/154.

. . . wherein the envelope shape and autocorrelation function may both be separately specified. . . The design problem hinges on an integral equation, for which an approximate solution, valid for large time-bandwidth products, is found by the method of stationary phase. . .

QUANTIZATION IN COHERENT AND QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Rev., vol. 22, no. 3, Sept. 1961, p. 461/486.

. . . The analysis is given for both coherent and quadrature detection with ideal analog signal processing and for digital processing using time and amplitude quantization.

A NEW MULTIPLEX TECHNIQUE FOR TELEMETRY
A. H. Ballard, Nat. Telem. Conf., June 1962, 6-2, p. 1/16.

. . . The name ORTHOMUX (meaning Orthogonal Waveform Multiplexing) has been adopted to describe the new concept. . . . The polynomial waveforms which exhibit this property may be generated in a very simple way by cascading miniature circuit modules fully transistorized in design. . . .

RADIATION INCORPORATED SIGNALING SYSTEM STUDY
D. D. Baxter, Radiation Inc., Orlando, Fla., Spectial rept., 1 June 1961-31 May 1962, 31 May 1962, 98 p. incl. illus., 48 refs., AD 283 320.

. . . almost exclusive attention is given to the dipulse (a single cycle of a sine wave) and tripulse (the matched filter response to a dipulse). The spectra of the signals are displayed and the concept of the matched filter is discussed and applied as the optimum detector for the signals in question.

THE ANALYTIC SIGNAL REPRESENTATION OF MODULATED WAVEFORMS
E. Bedrosian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2071/2076.

. . . a rather general and mathematically convenient formulation of analog-modulated signals which makes use of the analytic signal concept. Known types of modulation are readily identified as special cases. . . . a new type of modulation has been discovered—single sideband frequency modulation (SSB FM)—which can be derived from a conventional phase-modulated signal by an additional amplitude modulation, using the exponential function of the modulating signal's Hilbert transform. The resulting modulated signal will have a one-sided spectrum about the carrier frequency, will be compatible with existing FM receivers, and will cause a decrease in signal bandwidth.

A REVIEW OF ORTHOGONAL SQUARE-WAVE FUNCTIONS AND THEIR APPLICATION TO LINEAR NETWORKS
J. L. Hammond, Jr., et al., J. Franklin Inst., vol. 273, March 1962, p. 211/225.

A NOTE ON ORTHOGONAL DIGIT CODING
L. Kurz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 775/782.

. . . considers some general ideas pertaining to multisignal coding for digital communication systems perturbed by additive Gaussian noise which may be non-white with a known demodulated noise power density spectrum. The signals are formed from weighted sums of the orthogonal set of eigenfunctions generated by an integral equation with its kernel corresponding to the inverse Fourier transform of the Gaussian noise power density spectrum. The orthogonal digit codes thus generated afford greater reliability for fixed data rate and average power limited communication links then do binary digit codes . . . A new interpretation of the results in terms of the matched-filter-theory is given.

TWO DIMENSIONAL SIGNAL REPRESENTATION USING PROLATE SPHEROIDAL FUNCTIONS
D. A. Landgrebe, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 774.

Two separate methods for defining two dimensional signal representations are presented, using time- and bandlimited forms of the prolate spheroidal functions in order to maintain the desired two dimensional conceptual qualities as well as mathematical convenience . . . Due to the peculiar properties of the prolate spheroidal functions, as the number of orthogonal function terms is increased, the representation of a time limited function tends to converge first in a specified bandwidth and the representation of a bandlimited function tends to converge first in a certain time interval.

. . . The spectrum of the product of two time functions may be determined in a similar manner at discrete values of frequency . . . Simple numerical examples are presented for some of these properties.

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Rev., vol. 23, no. 3, Sept. 1963, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given . . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantiles of error probability as well as the mean probability of error.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART IX. "COMPLEMENTARY" SIGNALS AND ORTHOGONALIZED EXPONENTIALS
T. Y. Young, et al., Johns Hopkins U., School of Engineering, Baltimore, Md., 1 Jan. 1962, 32 p., AD 271 107.

SEISMOLOGICAL APPLICATIONS OF ORTHOGONAL FUNCTION EXPANSIONS
United Electrodynamics, Inc., Pasadena, Calif., Quarterly progress rept. no. 2, 1 May-31 July 1962, 13 Aug. 1962, 11 p., ARPA Order 180 62, AD 419 789.

. . . complete sets of orthogonal functions can be defined by specifying their pole patterns. Circuits with these same frequency responses, modeled on an analog computer, have impulse responses which are the orthogonal functions themselves. Examples of several such sets presented in this report show what resonant and decay characteristics of the time functions result from different pole patterns.

SEISMOLOGICAL APPLICATIONS OF ORTHOGONAL FUNCTIONS EXPANSIONS
United Electrodynamics, Pasadena, Calif., Semi-annual technical summary report, 28 Feb. 1963, 10 p., 5 refs., AD 401 029.

. . . describes how an analog computer can form the orthogonal expansion and digitize the coefficients automatically . . . A set of complex pole orthogonal functions with Q's of 4 covering the short period seismic band are used for a time varying power spectrum analysis of seismic noise and signals. . . .

A NOTE ON DIFFERENTIAL APPROXIMATION AND ORTHOGONAL POLYNOMIALS
R. Bellman, Rand Corp., Santa Monica, Calif., March 1963, 5 p., Memo. no. RM-3482-PR, AD 299 487.

SOME FORMULAS INVOLVING PRODUCTS OF TRIGONOMETRIC FUNCTIONS SPACED AT REGULAR INTERVALS
M. Blumberg, Lockheed Aircraft Corp., Sunnyvale, Calif., Dec. 1962, 106 p., Rept. no. 6-90-62-125, AD 401 223.

Functions of the complex variable $z = x + jy$ involving products of trigonometric functions spaced at regular intervals . . . A compilation of the important formulas derived in the text together with examples is given in the appendix.

DESIGN OF INPUT WAVEFORMS TO YIELD TIME LIMITED ORTHOGONAL OUTPUTS
J. B. Campbell, et al., Northeastern U., Boston, Mass., Scientific rept. no. 3 March 1963, 61 p., N63-19808, AD 411 224.

Given a time-invariant, linear system, with impulse response h(t), system function H(s), is there a set of input signals which results in a set of output signals that are orthogonal on a given interval of time . . . It is shown that the proposed solution involves finding a set of real-valued, finite-energy $p_k(t)$ which are 'sufficiently differentiable' for the rational system function and which have the property that the set $N(D)\,p_k(t)$ is orthogonal, $N(\ )$ being the polynomial of differentiation equivalent to the polynomial N(s) . . . It

is demonstrated that many such sets can be found for a given rational H(s).

CURVE FITTING BY MEANS OF ORTHOGONAL POLYNOMIALS

D. J. Crouse, Philco Corp., Palo Alto, Calif., 15 March 1963, 1 vol., Rept. no. WDL-TR1998, AD 298 715.

A RECURSION PROCESS FOR THE GENERATION OF ORTHOGONAL POLYNOMIALS IN SEVERAL VARIABLES

D. E. Dupree, In NASA, Marshall Space Flight Center Progress Rept. no. 3 on Studies in the Fields of Space Flight and Guidance Theory, June 15-Dec. 20, 1962, Feb. 6, 1963, p. 181/188, 2 refs., N63-16809.

KODIEREN MIT ORTHOGONALEN FUNKTIONEN. I. GRUNDLAGEN (Encoding with Orthogonal Functions. I. Fundamentals) (In German)

H. F. Harmuth, Arch. Elekt. Uebertragung, vol. 17, Sept. 1963, p. 429/437.

The characters of code alphabets can be represented by the superposition of orthogonal time functions. This representation permits the detection of telegraph signals by cross-correlation with a few sample functions rather than by cross-correlation with many sample characters that can be assembled from these functions . . . Furthermore, the fundamentals for the computation of the relative error rates due to thermal noise are derived. They will be used in a forthcoming paper to devise alphabets that permit an error-free transmission. Unlike the error-free alphabets devised by Elias they allow to approach arbitrarily well Shannon's limit of the transmission capacity of a communication channel. . . .

KODIEREN MIT ORTHOGONALEN FUNKTIONEN II. KOMBINATIONS-ALPHABETE UND MINIMUM-ENERGIE-ALPHABETE (Encoding with Orthogonal Functions: II. Combination Alphabets and Minimum-Energy Alphabets) (In German)

H. F. Harmuth, Arch. Elekt. Uebertragung, vol. 17, Nov. 1963, p. 508/518.

SEVERAL CLASSES OF CODES GENERATED FROM ORTHOGONAL FUNCTIONS

P. Hsieh, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 88/91.

. . . utilizing the existing knowledge of discrete error-correcting binary codes . . . The method consists in constructing the transformation matrix . . . that performs the linear transformation by taking the finite set of orthogonal functions into the set of continuous code words. . . . In constructing signals for continuous channels, it is possible to use waveform redundancy to reduce the probability of transmission error. . . . In particular, discrete ternary codes using symbols -1, 0, 1 are constructed to form some classes of continuous codes. . . .

NON-UNIFORMLY-WEIGHTED ORTHONORMAL OVER-DAMPED EXPONENTIAL APPROXIMATIONS

J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif., Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., SM-45777, N64-17757.

Weighting functions that emphasize small values of time, large values of time, or a range of time (t_1, t_2), $t_1 > 0$, are considered. Exponential approximants are developed in terms of the classical Jacobi Polynomials. Its is shown that these approximants (1) are orthonormal with respect to a nonuniform weighting function . . . (2) are of any asymptotic order (in the s-domain) . . . (3) have their poles equally spaced along the negative-real axis of the plane . . .

TRANSMISSION OF INFORMATION BY MEANS OF ORTHOGONAL SIGNALS

I. M. Teplyakov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 4, April 1963, p. 1/5.

. . . We shall consider the transmission of quantized functions, the spectrum of which is contained within the band from zero to a frequency W_0. The interval T_0 between two adjacent samples of a function will then be determined by W_0, i.e., $T_0 = 1/2\ W_0$. All quantization levels will be assumed equiprobable, their number being denoted by L. . . . if no delay is introduced either in transmission or reception, the L possible quantization levels must be transmitted by means of a system of L/2 equiprobable orthogonal signals and their opposite signals. . . . Such a system of signals will be termed optimum. . . . A reduction of the required signal power can be obtained by introducing delays in the transmission and reception of information in the following manner. Two function samples will be combined into one sample having L^2 quantization levels. At the same time an additional delay of value T_0 will be required in transmission. . . .

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE

I. A. Tsikin, Telecommunications and Radio Engineering. Part 2 - Radio Engineering, July 1963, p. 1-11, 5 refs., Translation, A64-15462.

Proof of the statement that orthogonal signals in the wide sense ensure maximum noise immunity in a channel with indeterminate signal phase. The special case of binary systems with Rayleigh fading of the signal is considered, with development for optimum signal choice with non-Rayleigh fading, and for noise immunity of multiposition signals. It is pointed out that the operating principle of an optimum receiver is the same in the presence of Rayleigh fading as in its absence. . . . demonstrating that orthogonality in the wide sense is also necessary in the case of codes with a base greater than two. . . .

ABBREVIATED REPRESENTATION OF SIGNALS BY MEANS OF SYSTEMS OF ORTHOGONAL FUNCTIONS

A. M. Zayezdynyy, et al., Radio Engng: Transl. of Radiotekhnika vol. 18, no. 11, Nov. 1963, p. 3/11.

. . . Abbreviated description means the representation of assigned signals in the form of expansions in a new system of orthogonal functions with a smaller number of terms. A method of obtaining a new system of orthogonal functions that provides an abbreviated representation of assigned signals with least root-mean-square error is given. . . .

Related Publications:

A NOTE ON CHAR'S ORTHOGONAL NETWORK SOLUTION
P. M. Honnell, Tensor Club, Gt. Brit., vol. 9, March 1959, p. 72/77

CAUER COORDINATES AND ORTHOGONAL NETWORKS
P. M. Honnell, Tensor Club, Gt. Brit., vol. 9, June 1959, p. 102/106.

A CRITERION FOR THE DIAGONAL EXPANSION OF A SECOND-ORDER PROBABILITY DISTRIBUTION IN ORTHOGONAL POLYNOMIALS
J. L. Brown, Jr., IRE Trans. Inform. Th., vol. IT-4, Dec. 1958, p. 172.

ON SIGNAL PARAMETER ESTIMATION
E. M. Glaser, et al., IRE Trans. Inform. Th., vol. IT-4, Dec. 1958, p. 173/174.

. . . ideas of Statistical Decision Theory are applied to estimate the parameters of signals represented by a linear expansion of orthogonal functions.

PULSE TRANSMISSION STUDY
H. Fiege-Kollmann, Westinghouse Electric Corp., Dec. 1959, 144 p., Quarterly tech. note No. 4, RADC TN60-11, AD 232 838.

. . . Swinging waveforms. . . Experimental investigation of frequency-amplitude-modulated signals. . . (See also AD 312 170).

G. K. McAuliffe, et al., Westinghouse Electric Corp, Baltimore, Md., June 1959, 118 p., Final report, AFCRC TR-59-166, AD 230 966.

. . . the use of higher order alphabets for digital transmission is investigated. It is found that, for a practical system, higher order alphabets permit a more efficient approach than binary alphabets towards the maximum transmission rate. . . . A set of four harmonic orthogonal waveforms is given. . . .

IMPULSING OF LINEAR NETWORKS IN INTEGRATED DATA SYSTEMS
G. K. McAuliffe, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 189/194.

Waveforms useful in data transmission may be obtained by impulsing suitable linear networks, and these same networks may be used, in certain cases, as receiving matched filters. A filter design for certain low-pass waveforms is described, together with a procedure for realizing band-pass analogs of these low-pass waveforms. The latter avoid the use of modulators. . . .

DERIVATIVES AND INTEGRALS OF THE LAGUERRE POLYNOMIALS (Correspondence)
E. Mishkin, Proc. IRE, vol. 47, Sept. 1959, p. 1652/1653.

THE AUTO AND CROSS CORRELATION FUNCTIONS OF ELEMENTARY WAVEFORMS
E. I. Muehldorf, et al., Proc. Nat. Aeronautical Electronics Conf., vol. 7, May 1959, p. 232/239.

STATISTICAL MEASUREMENTS OF DETECTION OF M ORTHOGONAL SIGNALS KNOWN EXCEPT FOR PHASE

D. W. Fife, Research Inst., U. of Michigan, Ann Arbor, Dec. 1960, 9 p. (Technical memo 81; Rept. 2899-40-T), AD 250 288.

. . . SIMulated Receiver and Recorder (SIMBAR) equipment was used to make statistical measurements of detection of M orthogonal signals known except for phase and starting time. The possible starting times of the signals are overlapping. The results are compared to the theoretical detection performance for nonoverlapping signals.

PRODUCTS OF LAGUERRE POLYNOMIALS
J. Gillis, et al., Math Computation, vol. 14, no. 69, Jan. 1960, p. 60/63.

ORTHOGONAL CODES
H. F. Harmuth, Proc. Instn. Elect. Engrs. Part C., (London), vol. 107, no. 12, Sept. 1960, p. 242/248.

Code alphabets whose characters can be represented by a finite sequence of digits of value +1 have been extensively investigated. The characters of these binary codes may be considered to be superpositions of orthogonal functions, one for each digit, which are multiplied by +1 or -1. A character of an orthogonal code consists of one function of a set of orthogonal functions multiplied by +1 or -1. . . .

ON THE TRANSMISSION OF INFORMATION BY ORTHOGONAL TIME FUNCTIONS
H. F. Harmuth, Commun. Electronics, no. 49, July 1960, p. 248/255.

RADIO COMMUNICATION WITH ORTHOGONAL TIME FUNCTIONS
H. F. Harmuth, Commun. & Electronics, no. 49, July 1960, p. 221/228.

AN ORTHOGONAL CODING TECHNIQUE FOR COMMUNICATIONS
G. A. Franco, et al., IRE Intern. Conv. Rec., vol. 8, March 1961, p. 126/133.

. . . orthogonal time functions are utilized to generate large alphabets.

AUDIO COMMUNICATION WITH ORTHOGONAL TIME FUNCTIONS
H. F. Harmuth, Proc. Instn. Elect. Engrs. Part C (London), vol. 108, no. 13, March 1961, p. 139/144.

An audio signal may be decomposed into components having certain frequency and phase. Half the information of the signal is contained in the phase of the frequency components. Since the human ear is almost insensitive to phase, one may eliminate the phase information without causing a noticeable reduction in the signal quality. The elimination of the phase information implies a permissible reduction of the bandwidth required for the transmission of the signal to one-half and a reduction of the signal power by 3 dB

MAXIMUM-WEIGHT GROUP CODES FOR THE BALANCED M-ARY CHANNEL
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 550/555.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A. B. Glenn, et al., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 168/173.

OPTIMIZATION OF SIGNAL WAVEFORMS
G. Lachs, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 95/97.

A NEW METHOD OF FREQUENCY SYNTHESIS
C. Lindholm, et al., Rand Corp., Santa Monica, Calif., July 1963, 39 p., 2 refs., RM-3756-PR, N63-20901.

. . . may be applied . . . to wideband (spread spectrum) techniques. . . .

SOME PROPERTIES OF THE FINITE CONVOLUTION
J. A. Sheehan, Mitre Corp., Bedford, Mass., 17 July 1962, 26 p., 9 refs., Technical memo. no. TM-3346, AD 291 868.

. . . In this paper, we shall impose upon r(tau) and f(t) the restriction that they are members of the class of functions on compact support, that is, functions which vanish outside finite intervals of the tau- or t-axis. Our main results are a set of existence and uniqueness (or non-uniqueness) theorems on the solution of r(tau) in short functions. A short function is, of course, simply the Fourier transform of a band-limited signal, and a short auto-correlation function is simply the Fourier transform of the square of the envelope of a band-limited signal.

OMBINED FREQUENCY AND TIME-SHIFT KEYED TRANSMISSION SYSTEMS
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 414/421.

1.316: Spread Spectrum Waveforms

Included: Wide band carrier signals; Waveforms in noise communication systems; Carrier pulses with linear frequency modulation; Pulse compression signals; Logarithmic phase modulation waveforms; Secure communications techniques with spread spectrum signals; FM ramp signals, swept frequency modulated waveforms; LIFMOP waveforms; Chirp-type signals.

Not Included: Pulse compression radar system; Matched filters; Correlation detection theory (2); Circuits and hardware for spread spectrum techniques; RADAS = random access discrete address systems (2).

Cross References: Orthogonal sets of digital waveforms (1.315); Digital sequences as wideband waveforms (1.314); WT product of digital waveforms (1.311); Pseudo noise sequences as data signals (1.314); Matched filter signal extractor for data systems (1.372); Correlation receivers for data systems (1.373); Frequency time shift keying (FTSK) system (1.334); Wide band modulation methods (1.920).

Principal Publications:

MODIFICATION OF PULSE COMPRESSION WAVEFORMS
C. E. Cook, Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 1058/1067.

A new signal technique, pulse compression, provides a means for increasing average power with no loss in pulse resolution and for avoiding peak power problems. One such technique, linear FM pulse compression, is described. The compressed pulse waveform is characterized by high signal "sidelobes" which make the signal undesirable for certain applications. Three approaches to improvement of the pulse shape are investigated which show that the sidelobes can be reduced to a reasonable value, although usually at the cost of some loss in pulse resolving capability.

NOISE-MODULATED DISTANCE MEASURING SYSTEMS
B. M. Horton, Proc. IRE, vol. 47, May 1959, p. 821/828.

Distance-measuring systems using random noise as the modulating function are described. The distance measurement is accomplished by correlating the modulation on the transmitted and received signals.

A METHOD OF SIDE-LOBE SUPPRESSION IN PHASE-CODED PULSE COMPRESSION SYSTEMS
E. L. Key, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Aug. 1959, 8 p., (Tech. rept. no. 209), AD 229 403.

This report presents a method whereby the side-lobe level of a phase-coded pulse auto-correlation function may be suppressed, in principle, to any desired level.

PULSE COMPRESSION AND CODED WAVEFORM TECHNIQUES
A.H. Nuttall, Melpar, Inc., Cambridge, Mass., March 1959, 180 p., (Rept. no. RADC TN-59-177), AD 219 116.

A signal generated by a bank of parallel filters is investigated for pulse compression and coded waveform possibilities. The outputs of the parallel bank are each multiplied by either plus or minus one, and added to form a noise-like transmitted signal. The construction of an approximate receiving matched filter with its inherent ambiguity and resolution are investigated. . . . A pulse compression ratio of 125 seems feasible.

LINEAR FM PULSE COMPRESSION (beats peak power limits)
C.E. Cook, et al., Space Aeronautics, vol. 34, no. 3, Sept. 1960, 124/129+148.

A PULSE COMPRESSION FILTER EMPLOYING A MICROWAVE HELIX
V.E. Dunn, Stanford U., Calif., 27 Oct. 1960, 45 p. (Tech rept. no. 557-1), AD 247 460.

The basic principles of pulse compression are discussed. It is shown that the desired phase characteristics of the compression filter could be interpreted as those of a length of a dispersive structure, and the desire group (and phase) velocity curves were derived . . .

THE CORRELATION FUNCTIONS AND ENERGY SPECTRA OF FM RADAR SIGNALS
S.E. Fal'kovich, Radio Engng: Transl. of Radiotekhnika vol. 15, no. 12, 1960, p. 16/24.

. . . assumption that the duration T of the signal is the same as the duration of . . . the modulation period . . . it is supposed that the signal can be regarded as a frequency-modulated oscillation . . .

SPECTRAL MEASUREMENTS OF SLIDING TONES
W. Gersch, et al., IRE Trans. Circuit Theory, vol. CT-7, Aug. 1960, p. 26/39.

LINEAR-SLOPE DELAY FILTERS FOR COMPRESSION (Correspondence)
T.R. O'Meara, Proc. IRE, vol. 48, Nov. 1960, p. 1916.

WIDE-BAND CARRIER COMMUNICATIONS, VOLUME IV. RANDOM SIGNAL CODING FOR FINITE MESSAGE SETS
T.L. Grettenberg, Lockheed Aircraft Corp., Sunnyvale, Calif., Technical rept. on Communications, June 1961, 65 p.,(Rept. no. 6-90-61-59, supersedes Stanford Electronics Labs., Rept. no. TR 2004-3, AD 262 357), AD 264 328.

The divergence between statistical hypotheses is used as a criterion for selection of a finite transmitter alphabet in a communication system. The members of the transmitter alphabet are sample functions from one of a finite set of normally distributed random processes. The receiver uses a maximum-likelihood decoding procedure, and the probability of error is evaluated for this receiver for a class of codes having orthogonal covariance functions.

A METHOD OF DESIGNING SIGNALS OF LARGE TIME-BANDWIDTH PRODUCT
E.L. Key, et al., IRE Intern. Conv. Rec., vol. 4, March 1961, p. 146/154.

. . . wherein the envelope shape and auto-correlation function may both be separately specified . . . The design problem hinges on an integral equation, for which an approximate solution, valid for large time-bandwidth products, is found by the method of stationary phase . . .

PRINCIPLES OF PULSE COMPRESSION
H.O. Ramp, et al., IRE Trans. Mil. Electronics, vol. MIL-5, no. 1, April 1961, p. 109/116.

OPTICAL PULSE EXPANSION/COMPRESSION
A. Reich, et al., Proc. Nat. Aerospace Electron. Conf., vol. 9, May 1961, p. 163/169.

The desirability of improving radar signal wave-form has led to the development of pulse compression techniques . . . An optical pulse expander-compressor has been designed and constructed. This system provides pulse expansion and pulse compression on a pulse-to-pulse basis in real-time . . .

WIDE-BAND CARRIER COMMUNICATIONS, VOL I. AMPLITUDE MODULATION.
J.J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., Oct. 1960, lv.,(Rept. no. LMSD-704011, vol. 1),AD 253 281.

. . . Wide bandwidth carriers are defined as time functions with unmodulated bandwidths much wider than that of the intelligence to be transmitted. Both predictable and random carriers are considered in some detail. Optimum demodulation (Bayes estimation) is compared with other forms of demodulation on the basis of output signal-to-noise ratios. Special forms of wide-band carriers are shown to have a bandwidth utilization equal to that of single-sideband sine wave carrier systems.

WIDE-BAND CARRIER COMMUNICATIONS. VOLUME II. FREQUENCY MODULATION OF RANDOM CARRIERS
J.J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., 1 Jan. - 18 March 1960, (Tech. rept. on Communications), Oct. 1960, 1 v.,(Rept. no LMSD-704016, Vol. 2), AD 253 282.

Random-carrier communications using frequency-shift modulation is described. This is accomplished by transmitting a frequency band of random energy in two forms; a reference carrier is transmitted on one frequency band, and a frequency-shift modulated version of the reference carrier is transmitted on a second band not overlapping the first. A basic description of this communication channel is presented, and its performance is computed and experimentally verified in terms of the output signal-to-noise ratio.

A STUDY IN DEMODULATION TECHNIQUES
J.A. Webb, Proc. Nat. Telemetering Conf., May 1961, 10-45/10-58.

. . . to explore spread-spectrum techniques, and to discuss the use of these techniques for secure communication purposes. Receiver characteristics and lock-on criteria for signal recovery are also discussed. . . .

ON THE DETECTION AND ESTIMATION PROBLEM FOR MULTIDIMENSIONAL GAUSSIAN RANDOM CHANNELS
J.K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N.Y., Nov. 1961, 26 p., (RADC-TR-61-214), AD 268 492.

. . . Such a channel is characterized by the property that a deterministic input results in a set of received waveforms which are sample functions of Gaussian processes. For the detection problem, a receiver is found which operates on the set of received waveforms and gives as outputs, voltages proportional to the logarithm of the likelihood functions of the possible transmitted signals. For the estimation problem, it is assumed that the intelligence-carrying signal is itself a sample function of a Gaussian process and a mathematical description is presented of a receiver which has as its output the maximum a posteriori estimate of this signal. Examples are presented in which optimum receivers are found for both the detection and estimation problem.

CLOSED-FORM SOLUTION FOR THE OUTPUT OF A FINITE-BANDWIDTH PULSE-COMPRESSION FILTER
Proc. IRE, vol. 49, no. 6, June 1961, p. 1086/1087.

RF PULSE COMPRESSION STUDY
J.G. Ferguson, Lockheed Aircraft Corp., Burbank Calif., Quarterly progrees rept. no. 2, for period ending 20 Sept. 1962, 20 Sept. 1962, 12 p. incl. tables, 1 ref., AD 297 142.

A PROPERTY OF LINEAR FREQUENCY MODULATION (Correspondence)
A.J. Goldman, Proc. IRE, vol. 50, no. 7, July 1962, p. 1711.

. . . A fact useful in connection with chirp radars is that a linear FM signal of arbitrary envelope, when passed through a suitable network with linear delay characteristic, suffers a reversal of the linear FM and a Fourier transformation of the functional form of the envelope. It is shown here that no other FM signal and delay network are related in this way . . .

EFFECTS OF PHASE ERRORS ON PULSE-COMPRESSION SYSTEMS (Correspondence)
H. L. Groginsky, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 321/322.

. . . phase-error tolerances for a wide class of pulse-compressions systems. . . . degradation of the ambiguity function for systems in which the phase error is either stochastic or deterministic

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART II. BINARY COMMUNICATIONS SYSTEMS USING WIDEBAND SIGNALS
J.C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961-June 1962 on Improved Information transfer Efficiency of Wideband Systems, July 1962, 151 p. incl. illus., 16 refs., (ASD TDR 62-611, pt. 2), AD 284 451.

Contents: The analysis of binary systems (using a signal-space concept) Linear receivers The application of linear receivers Nonlinear receivers Applications of nonlinear receivers Time compression methods Adaptive receivers.

A LARGE TIME-BANDWIDTH PRODUCT PULSE-COMPRESSION TECHNIQUE
R.C. Thor, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 169/173.

. . . system which utilizes a linear FM waveform has a theoretical upper limt to the magnitude of its compression ratio or time-bandwidth product. This limit is a function of the observed target's relative radial velocity, and the effect on the return signal is characterized by both a pulse stretching and amplitude reduction if the limit is exceeded. The use of a logarithmic phase-modulation signal waveform and a corresponding "matched" receiver possesses the desirable characteristics of the linear FM and in addition has no upper limit to the magnitude of the compression ratio. A single receive pulse-compression filter is matched for all target velocities. . . .

SECURE COMMUNICATIONS, A BIBLIOGRAPHY
North American Aviation, Inc., Downey, Calif., Rept. for 1956-1962, 19 April 1962, 35 p., (Rept. no. SID 62-518), AD 282 471.

PULSE COMPRESSION TECHNIQUES (Correspondence)
M. Bernfield, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1261.

. . . can be achieved by connecting a number of fundamental all pass, linear dispersive delay networks in series or by employing such series chains as fundamental elements for a parallel channel configuration. This communication presents a theoretical comparison of these pulse compression techniques. . . .

MATCHED FILTERING AND PULSE COMPRESSION
M. Bernfeld, et al, Sperry Engineering Review, vol. 16, Spring 1963, p. 44/53, 24 refs., A63-17586.

. . . compression of a long-duration signal into a narrow pulse, based on large time-bandwidth signal coding. . . . various aspects of the search for the theoretical optimum pre-detection filter are considered. . . . linear FM pulse-compression filter . . . dispersive time delay and range sidelobe reduction. Briefly outlined is the paired-echo technique of distortion analysis which has been used extensively to study the effects of networks and modulation distortion on pulse-compression signals.

ASYMPTOTIC BEHAVIOR OF THE SPECTRA OF RF PULSES WITH LINEAR FREQUENCY MODULATION
S. L. Borison, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 9 Oct. 1963, 29 p. refs., (Rept. 41G-5; AD 421 872), N64-17663.

. . . It is specifically shown that at frequencies (measured from the carrier frequency) much larger than the maximum FM deviation the effect of the FM is small. In particular, at a frequency 50 mc higher than the carrier frequency, the envelope of the spectrum of a 10 μsec rectangular pulse with 10-mc FM deviation is less than 1% above the envelope of the spectrum of a pulse with no FM. The spectrum of a cosine pulse with these same characteristics is increased by less than 3%.

PULSE-COMPRESSION PAIRED-ECHO EXPERIMENTS (Correspondence)
C. E. Cook, Proc IEEE, vol. 51, no. 2, Feb. 1963, p. 383/384.

It is of interest to note that the linear FM pulse-compression technique offers a direct means for instrumenting a laboratory analysis device that graphically demonstrates the effects of the various parameters of the paired-echo theory of signal distortion. . . .

DEMODULATION OF A SPECIAL AM-FM SIGNAL
D. W. Dearholt, New Mexico U. Engineering Experiment Station, Albuquerque; Sept. 1960, 64 p. incl. illus., 5 refs., (Technical rept. no. EE-34), AD 287 483.

. . . The swept frequency range of the generator is chosen so that the resonant frequency of the transducer lies within this range for all anticipated values of the parameter to be measured . . . . Demodulation is considered complete if correct relative values of the resonant frequency of the transducer are obtained . . . . Results obtained from an experimental peak marking circuit are compared with theoretical results.

COMMENT ON "EFFECTS OF PHASE ERRORS ON PULSE-COMPRESSION SYSTEMS" (Correspondence)
J. V. DiFranco, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 123.

. . . the effects of both phase and amplitude errors on pulse compression systems have been extensively reported in both the unclassified and classified literature. In addition, (time domain) multiplicative distortion has been treated. Some pertinent references . . .

SWEPT FREQUENCY MODULATION. A MEANS OF REDUCING THE EFFECTS OF IMPULSE NOISE
J. C. Dute, et al., Michigan U., Ann Arbor, Report on Telemetry and Command Destruct, Dec. 1962, 19 p., (ASD TDR 62-836), AD 297 798.

STUDY OF MICROWAVE R-F PULSE COMPRESSION
J. G. Ferguson, et al., Lockheed Electronics Co., Plainfield, N. J., Final technical rept., 25 Sept. 1962, 25 Sept. 1963, 115 p., ARPA Order 296 62, AD 421 982.

THE DESIGN OF FM PULSE COMPRESSION SIGNALS
E. N. Fowle, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 61/67.

. . . procedure for designing an FM signal of arbitrary envelope shape so that it will have a specified spectral modulus and hence, a specified autocorrelation function. The design procedure, which is based upon an approximate analysis, gives best results when the duration-bandwidth product of the signal is large, and it is therefore useful in the design of pulse compression signals. . . .

A PULSE COMPRESSION SYSTEM EMPLOYING A LINEAR FM GAUSSIAN SIGNAL
E.N. Fowle, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 304/312.

. . . radar pulse compression system . . . include the compression ratio, the detailed characteristics of the signal, the sidelobe level of the receiver output waveform (signal autocorrelation function), the sensitivity of the sidelobe level to Doppler frequency shift in the signal, and the relative complexity of the equipment required to generate and receive the signal. A signal of Gaussian envelope and linear frequency modulation is shown to have an autocorrelation function of Gaussian shape. . . . design and construction of equipment used to generate and receive the signal . . .

APPLICATION OF SWEPT-FREQUENCY MODULATION TECHNIQUES TO PCM TELEMETRY
E.K. Holland-Moritz, et al., Institute of Science and Tech., U. of Michigan, Ann Arbor, Final rept., May 1962-Aug. 1963, Jan. 1964, 122 p., Rept. no. 5097 17F, AD 432 244.

. . . It compares optical, acoustic, and electrical techniques for generating and processing SFM signals . . .

A LINEAR FM 1001:1 PULSE COMPRESSION SYSTEM
R.W. Jacobus, MITRE Corp., Bedford, Mass., July 1963, 21 p., TM 3529, ESD TDR63 237, AD 411 537.

. . . synthesized as a linear time-invariant filter, . . . The transmitted waveform is roughly rectangular in shape, has a bandwidth of 1 mc, and has a duration of one millisecond; the output of the matched-filter receiver is consequently (sin x)/x in shape (before side-lobe reduction) and has a duration of about two microseconds from null to null . . .

A WIDEBAND COMMUNICATION SYSTEM USING FREQUENCY SLOPE MODULATION (FSM)
H.G. Lafuse, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 346/357.

. . . The rf carrier of the system is a "chirp" type signal; i.e., a constant amplitude sinusoid whose instantaneous frequency varies linearly with time. The carrier frequency is swept periodically with the rate of change, or the slope, of the frequency during each period being determined by a modulating signal. In the FSM receiver the rf signal is mixed with the same signal delayed in time to produce a phase-difference signal . . . A shift in the center frequency of the envelope due to a change in the slope of the rf signal results in a change in the amplitudes of the harmonic components of the phase-difference signal . . .

Experimental data from an FSM system operating at C-band with a bandwidth of approximately 60 megacycles is presented . . . serves to establish the feasibility of wideband communication systems.

THE USE OF PULSE COMPRESSION IN MULTIPATH MEASUREMENTS
F.M. Lightfoot, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 319/324.

The determination of multipath interference is frequently important in the optimization of communication system design. Standard sounding techniques are compared with a pulse compression method from the standpoint of path resolution and in the requisite signal-to-noise ratio . . . .

DIGITAL PULSE COMPRESSION USING POLYPHASE CODES (Correspondence)
E.S. Lurin, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1262/1263.

Digital pulse compression is implemented by dividing the radar output waveform into finite intervals and coding the RF phase of these intervals in discrete steps. Upon reception, the signal is recombined by a process similar to correlation . . . provides large pulse compression ratios and high flexibility. If digital shift registers and logic circuits are used to initiate and decode the various codes, the advantages of perfect digital memories and crystal clock control make high pulse compression ratios feasible. . . . A digital system is outlined . . .

TAPPED DELAY LINE REALIZATIONS OF FREQUENCY PERIODIC FILTERS AND THEIR APPLICATION TO LINEAR FM PULSE COMPRESSION
R. Manasse, Mitre Corp., Bedford, Mass., Final Rept., May 1963, 21 p., TM 3506, ESD TDR63 232, AD 409 138.

It is shown that a linear network having an amplitude and phase response which is a periodic function of frequency can be synthesized with a tapped delay line with amplitude and phase weightings on each tap. The theory of this technique for the realization of frequency periodic filters is developed . . . employed in a large time-bandwidth product linear FM pulse compression network. The availability of high quality tapped quartz delay lines and the ease with which amplitude and phase adjustments can be made on each tap appear to make this technique attractive for a number of future applications.

SIGNAL ANALYSIS II
D. Middleton, Johns Hopkins U., Baltimore, Md., Feb. 1963, 111 p., 19 refs., N63-13423.

INTRODUCTION TO PULSE COMPRESSION
W. Rihaczek, Aerospace Corp., Los Angeles, Calif., 21 April 1963, 112 p., TDR169 3250 43 TN1, SSD TDR63 58 P1, AD 405 489.

The large variety of pulse compression schemes and other advances in modern radar, such as synthetic aperture processing, has made it difficult to achieve a thorough understanding of each principle and its place in radar. The report analyzes the principle of pulse compression and discusses their significance in the context of radar measurements in general. . . . survey . . . primary aim is to provide orientation.

Related Publications

PULSE COMPRESSION FILTER DESIGN
C.E. Cook, et al, Sperry Gyroscope Co., Great Neck, N.Y., Report No. 1, June 1959, Report No. EB5287-0014-1, 15 p., AD 217 887.

ON THE DETECTION OF SIGNALS IN NON-STATIONARY NOISE BY PRODUCT ARRAYS
J.B. Thomas, et al., J. Acoust. Soc. Am., vol. 31, April 1959, p. 453/462.

THE DEVELOPMENT OF EQUIPMENT FOR BANDWIDTH COMPRESSION OF RADAR SIGNALS BY MEANS OF STORAGE CAPACITORS AND THE APPLICATIONS FOR SUCH EQUIPMENT
K. Jekelius, Nachrichtentech Zeitsch., vol. 13, no. 5, May 1960, p. 225/233.

THE THEORY AND DESIGN OF CHIRP RADARS
J.R. Klauder, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 745/808.

THE THEORETICAL DESIGN OF WAVEFORMS FOR PULSED RADAR
C.S. Sorkin, General Atronics Corp., Bala-Cynwyd, Pa., 18 July 1960, 22 p. incl. illus., (Technical note no. 4; Rept. no. 770-207-11), (RADC TN 60-178), AD 242 254.

. . . FM pulses with uniform envelopes. Such structures allow for a large TW product and maximum efficiency of the transmitter. The principle of stationary phase may be applied directly to this class of pulses for quick evaluation of the Ambiguity Function and Fourier transforms. . . . Most of this work involves the two dimensional range-doppler ambiguity. It is shown that rapid FM is required for accurate measurements and reduced ambiguity.

A STUDY OF NANOSECOND PULSE TECHNIQUES IN RADAR TRANSMISSION
C.G. Bachman, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., 27 Feb. 1961, 299 p., (Report no. UB-1426-P-1), (RADC TR 61-247), AD 268 880.

. . . The relative merits of direct short pulse compression techniques to obtain high range resolution are explored. . . .

THE CASCADE PHASE SHIFT MODULATOR EMPLOYING NEGATIVE FEEDBACK
A. Boutross, et al., Electronics Research Labs., Columbia U., New York, 1 July 1961, 150 p., (Tech. rept. T-4/164; CU-5-61-AF-2233-ERL), RADC TN 61-187, AD 266 511.

A novel low noise FM ramp generator to be used as a component of an FM system is described. The FM ramp is generated by means of a cascade phase shift modulator in a negative feedback loop which is followed by a frequency multiplier to provide the required output frequency deviation of 400 kc in 2 ms . . . Measurements demonstrated that the generator meets the linearity requirements of the over-all FM System.

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P.H. Haas, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, Master's thesis, Aug. 1961, 68 p., 13 refs., (Rept. no. GE/EE/61-6), AD 270 272.

A survey . . . as applicable to the statistical analysis of communication is presented. Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

POST-WAR DEVELOPMENTS IN CONTINUOUS-WAVE AND FREQUENCY-MODULATED RADAR
W.K. Saunders, IRE Trans. Aerospace Navig. Electronics, vol. ANE-8, no. 1, March 1961, p. 7/19, 52 refs.

. . . survey of trends . . . with emphasis on systems designed to operate to short range. . . . systems which use a single local oscillator power. . . . various methods of analysis which may be used to study these systems. . . . Some information of a practical nature on microphonism, nonlinearities, feed-thru, and saturation . . . A bibliography . . .

THEORY OF COHERENT SYSTEMS
W.M. Brown, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 187/196.

A circuit theory model is derived for coherent radar, communication, sonar and antenna systems. The model involves linear time invariant operators and hence can be thought of as cascaded filters. The model provides insight for such systems not previously available, and it provides a unified approach to the analysis of all the above systems. . . .

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS
C. E. Cook, IRE Intern. Conv. Rec. Pt. 4, vol. 10, March 1962, p. 174/184.

REALIZATION OF MICROWAVE PULSE COMPRESSION FILTERS BY MEANS OF FOLDED-TAPE MEANDER LINES
V. E. Dunn, Stanford Electronics Labs., Stanford U., Calif., Oct. 1962, 130 p., (Technical rept. no. 557-3; Rept. no. SEL-E 62-113), (RADC TDR 62-551), AD 299 951.

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . Effective use of available signal power is found to be possible on badly behaved channels, provided there is sufficient bandwidth available for the optimization of performance. . . . a class of digital communication systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. . . .

FREQUENCY MODULATION TECHNIQUES AS APPLIED TO PULSE DOPPLER RADAR
G. R. Hetrich, IRE Intern. Conv. Rec. Pt. 5, vol. 5, March 1962, p. 76/86.

. . . Two methods of frequency modulating the transmitted carrier for ranging purposes are considered for a typical Pulse Doppler radar. . . . linear FM and sinusoidal FM. . . .

SIGNAL FIDELITY IN RADAR PROCESSING
W. A. Penn, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 204/218.

Usually in a radar signal-processing scheme, the primary consideration is the geometrical resolution of the system, or, if a particular measurement is desired, the accuracy of the system. . . . Usually, beyond these simple criteria, the matter of signal amplitude fidelity is not particularly stressed. In many processes, however, signal fidelity can be an important consideration in evaluating the over-all effect on the observer. In this paper the loss of information caused by signal interference in correlation or matched filter techniques is evaluated in an approximate manner. This is related to the invariance of the total integral of the Woodward ambiguity function. Degradation of the desired signal due to the statistical fluctuation of the signal itself is also considered. The distinction between pre-detection integration is made. . . . Finally . . . comments are made on the philosophy of providing adequate gray-level rendition in radar displays. Attention is given to reconciling the dynamic ranges of the display and the signals, and to the number of resolvable gray levels available in the signal. . . .

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO FM SIGNALS AND NOISE
D. L. Schilling, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., June 1962, 136 p., incl. illus. tables, refs., (Research rept. no. PIBMRI-1040-62), AD 295 555.

DATA PROCESSING TECHNIQUES
M. Shapiro, et al., Electronics Research Labs., Columbia U., New York, Final rept., 1 Oct. 1961, 31 June 1962, 30 June 1962, 192 p., incl. illus. tables, (Rept. no. F/180; CU-8-62), AD 295 618.

A two-stage receiver structure which may be used to process the received waveform from a general class of high time-bandwidth product radar transmissions is described. . . .

SIDELOBE SUPPRESSION IN A RANGE-CHANNEL PULSE-COMPRESSION RADAR
C. L. Temes, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 162/169.

DIGITAL FILTERS AND APPLICATIONS TO SEISMIC DETECTION AND DISCRIMINATION
J. F. Claerbout, Mass. Inst. of Tech., Cambridge, Feb. 1963, 89 p., AFCRL 63 604, AD 404 851.

The mathematics of filtering in discrete time are presented. Filters are defined for the purposes of (1) condensing waveforms into impulsive functions, (2) wave shaping, (3) noise suppression, (4) signal detection according to the criterion of maximum signal-to-noise output at an instant, and (5) the same over an interval. The behavior of the complex Fourier transforms of some of these filters is considered and connection is made with the theory of orthogonal polynomials.

A NEW METHOD OF FREQUENCY SYNTHESIS
C. Lindholm, et al., RAND Corp., Santa Monica, Calif., July 1963, 39 p., 2 refs., (RM-3756-PR), N63-20901.

. . . may be applied . . . to wideband (spread spectrum) techniques. . . .

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO AN FM SIGNAL IN THE PRESENCE OF GAUSSIAN NOISE
D. L. Schilling, IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 242/246.

. . . An Automatic Phase Control (APC) System is analyzed to determine its response to an FM signal and additive narrowband gaussian noise. Emphasis is placed on the system's response to a "ramp" type FM signal when the input S/N ratio is less than unity. . . . portion of a Doctoral Dissertation . . .

PULSE-COMPRESSION SUBSYSTEM FOR A DOWN-RANGE TRACKER
C.L. Temes, et al., IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 71/81.

PERFORMANCE PREDICTION METHOD FOR A CLASS OF FM-CW RADARS
N.D. Wallace, IEEE Trans. Aerospace, Proc. Internatl. Conf. Aerospace Support , vol. AS-1, no. 2, Aug. 1963, p. 38/45.

. . . the author has used the theory of zero crossings of random processes to analyze the errors due to receiver noise of a triangularly modulated FM-CW Radar. Curves are given that can be used to determine the percentage error in the range measurement as a function of signal-to-noise ratio, provided the shape of the noise spectrum is known. . . . The theory can be used in the preliminary design stages to optimize the receiver design.

A SPECTRUM COMPRESSION RADAR TECHNIQUE
W.E. Wood, et al., Army Missile Command, Huntsville, Ala., 8 Aug. 1963, 60 p. refs., (RE-TR-63-23; AD 425 675), N64-12220.

A LINEAR-FM RADAR PULSE COMPRESSION SYSTEM EMPLOYING THICKNESS-TAPERED DISPERSIVE DELAY LINES
R.G. Yost, Lincoln Lab., Mass. Inst. of Tech., Lexington, 11 July 1963, 20 p., Technical rept. no. 321, AD 419 468.

. . . At the option of the operator, the shape of the signal envelope can be made rectangular, Butterworth, or Gaussian. . . . An uncompensated Doppler frequency shift of one kilocycle per second will produce an error of 7 feet in the estimate of the range to an echoing object.

1.317: Multiple Signals as Waveforms

Included: Multi-digital operation; Multiple orthogonal signal transmission systems; Multi-epoch signals; Overlapping signals; Smearing techniques with overlapping signals; Super-position of signals in the same channel; Rotational transformation of signals; Multiple signals.

Not Included: Multiplex systems (2); Random access discrete address systems (RADAS) (2); Orthomux system (2).

Cross References: Higher order data systems in general (1.313); Digital sequences as waveforms (1.314); Signal theory in general (Sect. 1.14).

Principal Publications:

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., Nov. 1961, 16 p., Rept. no. RADC TN 61-182, AD 268 753.

The problem of detecting signals in noise is considered for the multiple input model, where each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals. Systems for computing likelihood ratios are examined in detail for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios is shown. Optimum signals are determined for the two-hypothesis problem.

PARTIAL ORDERING OF DISCRETE CHANNELS
T. T. Chang, et al., IRE Intern, Conv. Rec., Pt. 4, vol. 10, March 1962, p. 190/199.

. . . A discrete, finite, memoryless channel K_1 is said to include another such channel K_2 if it is possible to duplicate all of the transition probabilities of K_2 by interposing K_1 between pairs of suitably chosen pre- and post-channels. In general, it is not known what the necessary and sufficient conditions for inclusion are. . . .

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 274/280.

ON THE BINARY DATA TRANSMISSION ERROR RATES DUE TO COMBINATIONS OF GAUSSIAN AND IMPULSE NOISE
L. R. Halsted, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Dec. 1963, p. 428/435.

. . . The simultaneous transmission of orthogonal signals is discussed. This makes it possible to use signals having a long duration without reducing the data rate or causing inter-signal interference; this can be done without requiring additional bandwidth. . . .

AN ORTHOGONAL MULTIPLEXED COMMUNICATION SYSTEM USING MODIFIED HERMITE POLYNOMIALS
S. Karp, et al., Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 341/353.

. . . A pulsed multiplex system is outlined which transmits orthogonal signals and features excellent time bandwidth compression properties.

For nominal time-limiting and band-limiting, the signals preserve orthogonality better than comparable systems utilizing orthogonal sine or Legendre polynomial waveforms. This system generates as its basic signals modified Hermite polynomials which form an orthonormal basis. . . .

IMPROVEMENT OF ENERGY DETECTION AS A RESULT OF CHANNEL SUBDIVISION (Correspondence)
J. A. Knudson, Proc. IEEE, vol. 51, no. 6, June 1963, p. 955.

It has been shown than an energy detector can be calibrated to read likelihood ratio; thus, for that class of signals identified by their energy content alone, the energy detector becomes an optimum receiver. . . . the original bandwidth B is divided into L equal-width subchannels making the individual channel bandwidth B/L cps . . .

ROTATIONAL TRANSFORMATION OF SIGNALS
G. R. Lang, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 191/198.

A coding procedure based on a rotational transformation is applied to reduce the effect of non-Gaussian impulse noise in sampled data communication systems. The method, a near relative of the smearing techniques which have been suggested recently for continuous systems, provides a new and interesting view of many accepted coding systems and their relative properties. Attention is directed toward the effect of the transformation on the amplitude distribution of signals and to the existence of signals which do not benefit from a smearing technique is respect to their resistance to isolated impulse interference. The behavior of certain nonorthogonal transformations is also discussed in contrast to the purely rotational transformations.

A BOOLEAN-FUNCTION-MULTIPLEXED TELEMETRY SYSTEM
R. C. Titsworth, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 2, June 1963, p. 42/45.

By inserting encoded data from several sources into a Boolean function at the transmitter, and using correlation techniques at the receiver, it is shown that a very efficient telemetry of multiple-address system can be devised. The optimum logic is derived and proper channel codes are indicated. . . .

AN EFFICIENT DEMODULATOR FOR AN ANALOG PSEUDONOISE MULTIPLEX SYSTEM
H. L. VanTrees, Lincoln Lab., Mass. Inst. of Tech., Lexington, 2 July 1963, 25 p., Rept. no. 65G3, AD 410 795.

The advantages of wide band pseudo noise communications system are well known. A disadvantage which has restricted its use is the bandwidth requirement. In order to compensate for the large bandwidth, one may put several wide band carriers in the same bandwidth . . . each carrier acts as an uncorrelated noise to every other carrier . . . Unfortunately, we have been unable to perform a rigourous analysis of the system behavior. It is felt that the concept involved is new and interesting and should be presented in its current state of development.

REPRESENTATION AND DETECTION OF MULTIPLE-EPOCH SIGNALS
T. Y. Young, Johns Hopkins U., Carlyle Barton Lab., Baltimore, Md., May 1963, 60 p., 14 refs., RADC-TDR-63-142, AD 405 028, N63-16789.

. . . procedure for the detection of the individual epochs of overlapping signals and to represent them properly. . . . may be corrupted with random Gaussian noise of zero mean. . . .

Related Publications:

BINARY TO TERNARY CONVERSION BY LINEAR FILTERING
J. K. Wolf, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., May 1962, 8 p. incl. illus., 3 refs., RADC TDR 62-230, AD 278 264.

A simple linear filter consisting of a delay element and an adder is described for converting a random stream of binary pulses into a stream of ternary pulses . . . Another simple linear filter is described for reconverting the stream of ternary pulses into the stream of binary pulses. Results of an experimental implementation of such a system are presented. Also, a generalization of this scheme for binary to N-ary to binary conversion is discussed.

ON THE SELECTION OF AN ORTHOGONAL SIGNAL ENSEMBLE FOR THE TRANSMISSION OF BINARY DATA
L. R. Halsted, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 66/74.

. . . considers binary data transmission systems in which signal interference may be caused by a combination of signal blanking and fading, additive impulse noise, and additive nonwhite gaussian noise. For each disturbance the paper shows how the error rate can be improved by the suitable choice of a signal ensemble, and it discusses the choice of a good signal ensemble for a given combination of these disturbances. The systems are assumed to use ideal linear correlators for signal detection and to have minimum bandwidth for transmitting the data in binary form. The paper also illustrates the role of n-by-n orthogonal matrices in the choice of a signal ensemble to transmit a block of n information bits. . . .

THE SYNTHESIS OF NONLINEAR FEEDBACK SHIFT REGISTERS
K. B. Magleby, Stanford Electronics Labs., Stanford U., Calif., Oct. 1963, 89 p., Rept. no. 63 118, TR 6207 1, AD 428 081.

Two domains that describe the behavior of a feedback shift register were developed. These are the sequence and polynomial domains, which are analogous to the frequency and time domains in the description of continuous systems. The domains are related by an expansion of orthogonal functions. . . . In the procedure, the output sequences are mapped to the roots of irreducible polynomials, thereby providing an algebraic description of the register's behavior. To synthesize the shift register in the sequency domain, several properties of the output sequences are needed. . . . The cycles and output sequences of a simple, circulating shift register are used to synthesize an arbitrary feedback shift register.

M-OUT-OF-N DECISION LOGIC
M. Raship, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 131/141.

A formal algebra is developed for the analysis and synthesis of switching networks made up of m-out-of-n decision elements. An m-out-of-n decision element is described by a threshold function in which the weights are fixed at unity, and the threshold is a positive integer . . .

Section 1.32
Digital Amplitude Modulation Systems

This is the first of three sections to deal with specific data transmission systems. Amplitude modulation systems in the form of on-off keying are the oldest data systems and are classified as double sideband systems. Understandably, there have been no new publications for on-off systems in recent years. Vestigial sideband data systems on the other side have gained in importance as they permit a higher data rate than FSK systems when operating over the same bandwidth. Multi-level AM systems are easy to instrument and offer still higher rates but require channels with very low noise. However in space communications applications the tendency is towards phase modulation systems, which will be discussed in section 1.34.

Notice also that single sideband systems are not represented in this list of AM data systems. The reason is the strong distortion of digital waveforms when transmitted over ordinary SSB systems. Only very complex phase-lock arrangements on both terminals, together with a highly accurate synchronization system, could prevent these distortions. When data systems operate over SSB carrier channels in multiplex systems, they are actually double modulation systems, carrying the data on an audio sub-carrier. One efficient combination is VSB-SSB, for example.

1.322: Double Sideband Amplitude Modulation in Data Transmission Systems

Included: On-off keying; Double sideband suppressed carrier data systems.

Not Included: Amplitude modulators; Operational modems; Envelope detectors; Theory of power law detection (2).

Cross References: Amplitude modulation in general (1.22); Double sideband modulation for analog signals (1.222); Teletype systems (1.382); CO modulation in teletype transmission (1.382).

Principal References:

AN EVALUATION OF AM DATA SYSTEM PERFORMANCE BY COMPUTER SIMULATION
R. A. Gibby, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 675/704.

. . . suitable for programming on a high-speed digital computer. These equations contain expressions that specify in general terms the transmission-frequency characteristics of a transmission medium. A data signal composed of a train of raised-cosine shaped pulses is generated in the stimulating process. . . . performance of a double-sideband AM data system is evaluated from measurements of the maximum vertical opening, or aperture, of the eyepattern formed by the received signal. This aperture is related to the system performance in terms of signal-to-noise ratio and error rate of the system.

1.324: Vestigial Sideband Data Systems

Included: Asymmetrical sideband systems for data transmission.

Not Included: Operational modems.

Cross References: Vestigial sideband modulation method (1.224).

Principal Publications:

A 2500-BAUD TIME-SEQUENTIAL TRANSMISSION SYSTEM FOR VOICE-FREQUENCY WIRE LINE TRANSMISSION
G. Holland, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 180/184.

The Sebit-25 is a full duplex terminal equipment designed to transmit digital data at rates up to 2500 baud. . . . binary information . . . is converted to minimum bandwidth and used to amplitude modulate a 2500 cycle carrier. The resulting signal is converted to vestigial sideband prior to transmission, to further compress the bandwidth. . . .

AN AM VESTIGIAL SIDEBAND DATA TRANSMISSION SET USING SYNCHRONOUS DETECTION FOR SERIAL TRANSMISSION UP TO 3,000 BITS PER SECOND
F. K. Becker, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 97/101.

. . . Carrier recovery and synchronous detection are performed in the receiver. The system is asynchronous and will operate at any bit speed up to its maximum. Satisfactory operation has been achieved at 2,000 bits per second over the switched telephone network, and at 3,000 bits per second over equalized voice band circuits. . . . appears to be economically advantageous when compared with other systems of the same speed capability. . . .

A 1,650-BIT-PER-SECOND DATA SYSTEM FOR USE OVER THE SWITCHED TELEPHONE NETWORK
S. Brand, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 652/661.

. . . engineering of a data system for use on the switched message network . . . the conditions imposed by this specific application are shown to influence the selection of signal characteristics, and the choice of raised-cosine pulse shaping is given support by a brief treatment of some pulse transmission fundamentals. . . . results of a field trial are summarized . . . factors such as delay distortion, attenuation distortion, and transmission loss limited the performance obtained. . . . The principal transmission features of the terminals are: 1. Two levels only—no framing. 2. Vestigial sideband (VSB), or amplitude modulation. Carrier-2,200 cps; modulation-50%. 3. Line signal approximately 700 cps to 2,600 cps. 4. Automatic gain control (AGC) range—35 db (decibels). . . .

1.325: Multi-Level AM Data Systems

Included: M-ary AM data systems; Higher order AM systems.

Not Included: Multi-level multiplex systems (2).

Cross References: Multi-level PCM systems (1.518); Higher order data systems in general (1.313); Quantization problems of multi-level coders (1.511); Pulse amplitude modulation methods (PAM) (1.420).

Principal Publications:

DISTRIBUTION OF SIGNALLING ENERGY IN PULSE LEVEL MODULATION SYSTEMS
W. E. Cory, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 304/311.

. . . relationship between the number of permissible pulse energy levels, the pulse signalling and detection energy level distributions, and the information capacity.

TRANSMISSION OF MULTI-LEVEL DIGITAL SIGNALS THROUGH NOISE-FREE DISTORTING CHANNELS
L. W. Hill, Proc. Instn. Elect. Engrs., London (Part B), vol. 109, no. 44, March 1962, p. 165/173.

. . . The transmission of digital information by variation of the energy level of pulses of fixed shape is limited by channel distortion even in the absence of noise. . . . The case of a channel with an exponentially decaying impulse characteristic, for which the maximum rate is independent of the number of levels, is of special interest as a large class of passive linear networks has this characteristic at least asymptotically. . . .

A RAKE SYSTEM FOR LUNAR RELAY COMMUNICATIONS
S. Kasowski, IEEE Intern. Conv. Rec. Pt. 8, vol. 11, March 1963, p. 197/214, 15 refs.

. . . The transmission technique investigated is a multilevel, matched filter type using wideband, binary, pseudorandom sequences. It is studied specifically for transmission of digitalized information on a moon bounce link, i.e., for communication between two distant ground stations using the moon as a reflective scatterer relay.

Related Publications:

ERROR-CORRECTING CODES FOR MULTIPLE-LEVEL TRANSMISSION
J. MacWilliams, Bell Syst. Tech. J., vol. 40, no. 1, Jan. 1961, p. 281/308.

A q-level alphabet is defined as a row vector space over a finite field with q elements. The letters of the alphabet are the rows of the vector space, each consisting of n symbols from the ground field. The weight of a letter is the number of nonzero symbols it contains. The minimum weight of the letters of the alphabet, excluding zero, is denoted by d.

Section 1.33
Digital Frequency Modulation Systems

For many decades frequency shift keying (FSK) was the generally preferred method for teletype transmission. There are many varieties of systems based on this method, depending on the use of one or two oscillators at the sending end and on the particular type of receiving system applied. The analysis of these various classes of FSK systems may be quite different from class to class. It may be based on on-off keying with frequency diversity in one special case and on analog FM analysis in another extreme case. Most of the publications on FSK are dated prior to 1958 and are not included here.

Multiple shift keying systems are the counterpart of multi-level AM systems and, again depending on their design details, may also be considered as PCM-FM systems. They are a particular class of higher order data systems.

Frequency-time shift keying (FTSK) systems are a still more sophisticated class of systems, which are closely related to the so-called RADAS systems (random access discrete address systems), which shall be discussed in volume two of this series. They are also related to the systems with spread spectrum waveforms, which are the subject of subdivision 1.316.

Space communications systems apply many variations of frequency modulated data transmission systems, primarily in the form of FM-FM telemetry systems. The requirement for multiplexing many subchannels and for transmitting them together over the same radio frequency carrier leads to double and triple modulation systems. They will be referenced in division 1.9.

1.332: Binary Frequency Shift Keying (FSK) Systems

Included: Datacom unit; FM transmission subset; Dicon receiver; Noncoherent binary FSK; FSK over fading channels.

Not Included: Decision theory for FSK detection (2); Anti-multipath communications systems (2); Frequency diversity systems (2); Special FSK detection circuits; Theory of envelope detection (2); Discriminator circuits; Frequency tracking; Phase-lock demodulators.

Cross References: Fundamentals of frequency modulation (1.232); Teletype transmission systems (1.382); PCM-FM systems (1.934); Statistical characteristics of fading channels (1.612).

Principal Publications:

FREQUENCY SHIFT TELEGRAPHY—RADIO AND WIRE APPLICATIONS
J. R. Davey, et al., AIEE Trans., vol. 66, 1947, p. 479/494.

THEORETICAL COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N. Y., May 1958, 69 p., AD 148 803.

Ground-Air data communication links are analyzed and compared on the basis of the error probability attained as a function of the received signal-to-noise ratio. For the case of frequency-shift keyed (FSK) modulation it is shown that the lowest error rate can be obtained by using a detector which incorporates two matched filters and a synchronized sampling and decision circuit.

OPTIMAL FREQUENCY DEVIATION IN ONE-CHANNEL TELEMETERING SYSTEMS
Iu. I. Chugin, Automation Remote Contr., vol. 19, April 1958, p. 339/348.

THE EFFECT OF LOG-NORMAL FADING ON FSK; A VERY SIMPLE MODEL
J. Mott-Smith, Air Force Cambridge Research Center, July 1958, AD 160 792.

THE EFFECTS OF PULSE SHAPE AND FREQUENCY SEPARATION ON FSK TRANSMISSION THROUGH FADING
G. L. Turin, IRE Nat. Conv. Rec., vol. 6, March 1958, p. 217/224.

THEORETICAL DIVERSITY IMPROVEMENT IN FREQUENCY-SHIFT KEYING
J. N. Pierce, Proc. IRE, vol. 46, May 1958, p. 903/910.

. . . error rate has been found. If signal amplitude and phase are exactly known prior to reception of the signal, coherent combina-

tion and detection are optimum; for dual diversity, correlation of the fading on the separate antennas does not give a large loss if the correlation coefficient is moderate.

REDUCTION OF ADJACENT-CHANNEL INTERFERENCE COMPONENTS FROM FREQUENCY-SHIFT-KEYED CARRIERS
A. D. Watt, et al., IRE Trans. Commun. Syst., vol. CS-6, no. 2, Dec. 1958, p. 39/47.

AN FM DIGITAL SUBSET FOR DATA TRANSMISSION OVER TELEPHONE LINES
L. A. Weber, AIEE Winter Gen. Meeting, no. 430, 1958.

THEORETICAL ERROR PROBABILITIES FOR FREQUENCY-SHIFTKEYED TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague, Netherlands, Sept. 1959, 65 p., AD 226 924.

AN EXPERIMENTAL AUTOMATIC COMMUNICATION SYSTEM FOR AIR TRAFFIC CONTROL
W. R. Deal, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 71/76.

. . . Ground/Air/Ground . . . under development for the Bureau of Research and Development, Federal Aviation Agency, . . . operable in both VHF and UHF . . . permits choice of FSK-carrier or FSK-AM modulation. Up to 500 aircraft may be interrogated and reply on a single channel in a time period of two minutes or less. Information is binary coded and transmitted by time-division multiplex techniques at a data rate of 750 bits per second.

PERFORMANCE ANALYSIS OF A DATA LINK SYSTEM
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-7, May 1959, p. 14/24.

. . . the present air-traffic-control (ATC) system must be improved by a far most efficient and partially automatic system. As a result of both analytical and experimental work, two preferred modulation types have been chosen for further investigation (FSK-AM) and FSK. RCA is developing both systems.

EXTENSION OF NULL-RECEPTION ANALYSIS TO BINARY COMMUNICATION SYSTEMS EMPLOYING ENVELOPE DETECTION, INCLUDING FSK
J. J. Metzner, et al., New York U., Coll. of Engrg., July 1959, 120 p., Scientific Report No. 8, AFCRC TN-59-562, AD 226 363.

IDEAL BINARY PULSE TRANSMISSION BY AM AND FM
E. D. Sunde, Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1357/1426.

. . . It is shown that intersymbol interference can be avoided in binary pulse transmission by FM without the need for a wider channel band than is double-sideband AM, for equal pulse transmission rates . . . partial pulse shaping by premodulation and postdetection low-pass filters is also considered.

ON THE DETECTION OF STOCHASTIC SIGNALS IN ADDITIVE NORMAL NOISE
D. Middleton, Lincoln Lab., MIT, Lexington, 28 Dec. 1960, AD 250 287.

Optimum detection of FSK and on-off normal stochastic signals in additive normal noise backgrounds is examined. (AD 112 385) . . . A specific example of weak-signal operation involving 2 narrow-band FSK noise signals is considered, . . . the degradation of performance because of spectral overlap between signal channels is computed. Also included in the present study is a general treatment of colored-noise backgrounds, as well as specialization to the white-noise cases, and a short discussion of on-off vs. FSK operation in the threshold situation.

DESIGN FEATURES OF A NEW FREQUENCY SHIFT CARRIER TELEGRAPH SYSTEM
M. L. Stephens, Commun. Electronics, no. 46, Jan. 1960, p. 927/934.

FEASIBILITY STUDY OF THE USE OF PHASE SHIFT KEYING OVER AN IONOSPHERIC SCATTER TRANSMISSION CIRCUIT
R. W. Swanson, General Electric Co., Syracuse, N. Y., Final rept., March 1960, 1v. incl. illus., (AFCRL TR60-131), AD 245 165.

. . . diversity reception . . . 49.6 mc with dual equal-gain frequency diversity . . . could transmit data at a rate of 11.1 or 55.5 nine-bit-messages per second. (Nominal 100 or 500 bits per second). . . . Field testing . . . carried out over the National Bureau of Standards Ionospheric Scatter Link between Havana, Illinois and Boulder, Colorado. . . . results obtained demonstrated the feasibility of using phase shift keying as a modulation technique for the transmission of binary information over an ionosphere scatter path under normal scattering conditions.

FREQUENCY-SHIFT MODULATION OF BINARY-CODED SIGNALS FOR TRANSMISSION OVER TELEPHONE CIRCUITS
M. Jeppsson, ITT Elect. Commun., vol. 37, no. 2, 1961, p. 103/116.

A COMPARISON OF FREQUENCY-SHIFT ANTI-MULTIPATH SIGNALING TECHNIQUES FOR DIGITAL COMMUNICATION SYSTEMS
W. B. Jones, Jr., IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 83/87.

EXPERIMENTAL DETECTOR STUDY
A. Tepfer, RCA Defense Electronic Products, New York. Final rept. on Task 3. 28 April 1961, 17 p. (Rept. no. CR-61-419-13), AD 259 558.

A laboratory study of error-rate performance of a PCM-FM system and an investigation of some experimental detector techniques were conducted. The variation of the error rate as a function of the signal strength was determined as the frequency deviation was varied and as the carrier frequency was displaced from its normal position in the middle of the IF amplifier. The effects of carrier reinsertion in the receiver and of a time-varying IF filter synchronous with the received signal were investigated.

FM RECEPTION UNDER CONDITIONS OF STRONG INTERFERENCE
J. van Slooten, Philips Tech. Rev., vol. 22, no. 11, July 1961, p. 352/360.

AIR WEAPONS CONTROL SYSTEM 412L. INTRODUCTION TO FSK DATA TRANSMISSION
General Electric Co., Syracuse, N.Y., 30 Sept. 1961, 58 p., 7 refs. (Rept. no. AWCS-CS-3), AD 272 108.

The Frequency Shift Keying (FSK) data transmission system used in the AWCS 412L site-to-site data link is described. The effect of envelope delay on the FSK signal is analytically examined and comparisons are made with actual laboratory results. A theoretical prediction of error rate versus signal-to-noise ratio is compared to experimental results obtained by laboratory simulation using the actual data transmission equipment.

A LABORATORY COMPARISON OF MAXIMAL-RATIO COMBINERS AND OPTIMAL SELECTORS FOR FADING HFSK (Correspondence)
IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 320/321.

. . . Experiments concerning diversity reception according to the theory originated by Kahn. The procedure consists of sending HFSK telegraph signals and receiving these signals with a dual diversity receiving system.

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1961, p. 1613/1629.

. . . for multiplexed binary telegraph signals that are used to frequency-modulate an RF carrier that is subsequently corrupted by fading and noise. Frequency-shift keying, amplitude keying, and phase-shift keying are considered. It is shown that most telegraph errors occur when the carrier fades below threshold . . . The analysis pertains most directly to troposcatter systems, but the general conclusions regarding the effect of FM threshold should be relevant also for fading transmission paths such as those met in line-of-sight and telemetry . . .

OPTIMUM BINARY FM RECEPTION USING DETECTION AND I-F SHAPING
A. A. Meyerhoff, et al., RCA Rev., vol. 22, no. 4, Dec. 1961, p. 698/728.

DER EINFLUSS VON SPEZIELLEN SENDEFUNKTIONEN UND UBERTRAGUNSFAKTOREN AUF DEN EINSCHWINGVORGANG VON FREQUENZMODULIERTEN TELEGRAPHIEZEICHEN (The Influence of Special Sending Functions and Transmission Factors on the Transient Behavior of FM Telegraphy Signals) (In German)
H. Jurgens, Frequenz, vol. 15, no. 12, Dec. 1961, p. 377/386 and Frequenz, vol. 16, Jan. 1962, p. 1/8.

ERROR PROBABILITIES FOR DATA TRANSMISSION OVER FADING RADIO PATHS
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague, Netherlands, Feb. 1962, 148 p., incl. illus., tables, refs. (SADTC Technical memo., no. TM-26), AD 273 846.

. . . Various methods of keying are considered, with particular emphasis on frequency-shift keying.

JAMPROOF AUTOMATIC FREQUENCY CONTROL. VOLUME II. SIMULATOR EQUIPMENT STUDIES
R. Bates, et al., Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., Jan. 1962, 1v. (Rept. no. BSR-546, vol. 2), (ASD TR 61-661, vol. 2), AD 270 530.

. . . Constructed to augment analytical studies of automatic frequency control systems under noise, doppler and jamming conditions. Chosen for simulation was a frequency shift keyed, baud synchronous, integrate and dump, digital data link.

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS (Phase 2 Report)
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y. Rept. for Jan. 1961-Jan. 1962. 20 Feb. 1962, 311 p. incl. illus., refs., (Rept. no. UA-1420-S-2), (RADC TDR 62-134), AD 276 847.

. . . analysis of the degradation of the performance of noncoherent binary FSK and carrier keyed systems due to a frequency offset of the received signal. . . .

EXPERIMENTAL EVALUATION OF AN OPTIMUM DETECTOR FOR FSK TRANSMISSION THROUGH A RAYLEIGH FADING CHANNEL
E. E. Cossette, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y. Nov. 1962, 22 p. incl. illus., 6 refs. (Rept. no. RADC TDR 62-554), AD 291 892.

. . . This receiver was instrumented, through use of simulation techniques, to evaluate experimentally the performance of such a system. The measurements resulted in a family of curves giving the probability of transmission error as a function of the ratio of signal energy per bit to noise power density with the keying interval as a parameter. The results showed an improvement over existing FSD receivers.

WEAK SIGNAL COMMUNICATION TECHNIQUES
P. M. Dollard, et al., Bell Telephone Labs., Inc., Whippany, N.J. Interim rept., 1 May 1961-30 April 1962 on Phase 1. 30 April 1962, 121 p., AD 299 219.

DESCRIPTORS: . . . Communication theory, . . . Frequency-shift keyers, Frequency modulation, Phase-locked communication systems . . .

STATISTICAL PROPERTIES OF THE DICON RECEIVER
J. A. Dumanian, Lincoln Lab., Mass. Inst. of Tech., Lexington, 2 March 1962, 11 p. illus., 3 refs. (Rept. no. 52 G-2) (AFESD TDR 62-85), AD 275 278.

. . . frequency-shift keying and energy detection. . . . The final bit decision is performed by subtracting the outputs of two channel receivers tuned to the two information frequencies and determining the sign of the result. Results were obtained for a variety of parameters representative of the range of experimental conditions expected in West Ford communications.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A. B. Glenn, et al., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 168/173.

. . . These last two systems were the noncoherent frequency shift keyed (FSK) and the differentially coherent phase shift keyed (DPSK) . . .

DIGITAL TROPOSPHERIC SCATTER
J. R. Poppe, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 669/674.

. . . Using simple, proven binary detection methods—such as frequency shift keying— substantial range improvement is shown over multichannel FM (frequency-modulated) or SSB (single-side-band) tropospheric scatter schemes, at the sacrifice of analog capability. . . .

EXPERIMENTAL DATA TRANSMISSION SYSTEM FOR SWITCHED TELEPHONE LINES
H. Marko, et al., Electr. Commun., vol. 37, March 1962, p. 238/251.

. . . Frequency modulation has been favored because of its simplicity of equipment and adjustment and the minor effects of changes in signal-to-noise ratio. . . .

SPECTRAL DENSITY AND AUTOCORRELATION FUNCTIONS ASSOCIATED WITH BINARY FREQUENCY-SHIFT KEYING
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2355/2385.

BINARY DATA TRANSMISSION BY FM OVER A REAL CHANNEL
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2387/2426.

. . . Illustrative examples evaluated include Sunde's method of suppressing intersymbol interference in band-limited FM . . . It is found that a performance from 3 to 4 db poorer than that theoretically attainable from binary PM is realizable over a variety of filtering situations.

OPTIMUM JAMMING OR INCOHERENTLY RECEIVED FSK SIGNALS
L. I. Bluestein, Lincoln Lab., Mass. Inst. of Tech., Lexington, 26 June 1963, 25 p., AFESD TDR 63 89, AD 413 482.

. . . found for a situation in which the two time-limited signals occupy separate frequency bands, and the receiver is ignorant of the RF phase of the signal. The jammer has at his disposal power-limited Gaussian noise . . . A quantity analogous to distance . . . defined; it is this quantity which the jammer seeks to minimize.

A NUMERICAL DATA TRANSMISSION SYSTEM (In French)
M. Coiron, et al., Onde. Electr. vol. 43, no. 431, Feb. 1963, p. 141/147.

. . . in the field of modulation speed specified at 1200 Bauds, gives the advantage of a relatively simple equipment designed to give reliable and versatile service coupled with the facility for easily connecting a magnetic recorder at each terminal. The equipment was made for the French Firing Range.

"THE RAPIDATA S" SYNCHRONOUS SYSTEM FOR THE HIGH SPEED TRANSMISSION OF INTELLIGENCE (In French)
A. Girinsky, et al., Onde Electr., vol. 43, no. 431, Feb. 1963, p. 186/198.

. . . This method of transmission is synchronous type using frequency modulation. It is suitable for use on telephone circuits . . . Reliability of transmission is ensured by an automatic device for the detection of errors which transmits the intelligence in block form and

obtains the repetition of any among them which are distrubed. Auxiliary equipment makes it possible to check the operation of the device and to extract the statistical information on errors. . . .

SIGNALING WITH FREQUENCY-SHIFT-KEYED COSINE WAVES
E. D. Hanson, et al., Army Electronics Research & Development Labs., Fort Monmouth, N.J., Nov. 1963, 21 p., AELRDL TR2363, AD 436 824.

A very efficient binary signaling technique (from the standpoint of bandwidth utilization) is described. The power density spectrum . . . compared with that of sinusoidal diphase and rectangular diphase. . . . An experimental model operating at 16 kilobits per second was constructed. It was tested over the special service channel of the Frequency Division Multiplexing Equipment AN/TCC-7).

SPECTRAL DENSITY DISTRIBUTIONS OF SIGNALS FOR BINARY DATA TRANSMISSION
H. J. Pushman, J. Brit. Instn. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

. . . The spectral density distribution for f.m. at 600 bauds with frequencies of 1200 c/s and 1900 c/s . . . are also determined and results presented.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 43/51.

. . . including all possible conditions of nonorthogonality of signal, and correlations in the noise processes. These forms include frequency-shift keying with noncoherent detection, generalized to all noncoherent detection systems utilizing two basic waveforms, and phase-shift keying with a noisy reference signal, generalized to all coherent detection systems utilizing a single basic waveform. . . .

GROUND-AIR-GROUND DATA TRANSMISSION SYSTEMS TESTS
A. J. Uryniak, RADC, Griffiss Air Force Base, N.Y., July 1963, 21 p., RADC RAU TM 63 2, AD 414 629.

. . . to check the feasibility of Air/Ground/Air Narrow Band FSK Data System utilizing frequency diversity and doppler correcting techniques. . . .

RADIOTELEGRAPHY
M. V. Verzunov, Joint Publications Research Service, Washington, D.C., 3 March 1964, 71 p. Transl. into ENGLISH of a Russian pamphlet, Moscow, Mil. Publishing House of the Defense Min. USSR, 1961 p. 1/80, (JPRS-23500; OTS64-21706), N64-18054.

. . . covers . . . (1) radiotelegraphic methods and radiotelegraph signal parameters; (2) amplitude keying . . . (3) frequency keying . . . (4) telegraph keying in multichannel operation; (5) phase keying . . . (6) methods of improving radiotelegraphy-communications stability; and (7) remote-transmitter keying.

DIVERSITY RECEPTION OF NONFADING FREQUENCY SHIFT KEYING
J. K. Wolf, Rome Air Development Center, Griffiss AFB, N.Y., Jan. 1964, 23 p. refs., (RADC-TDR-63-475), AD 431 870, N64-17302.

. . . Both a noncoherent receiver system and a coherent receiver system are considered . . . compared for both manmade and natural interference . . .

Related Publications:

AN IMPROVED DECISION TECHNIQUE FOR FREQUENCY-SHIFT COMMUNICATIONS SYSTEMS
E. Thomas, Proc. IRE, vol. 48, no. 12, Dec. 1960, p. 1998/2003.

FAA DEVELOPMENT IN AIRCRAFT DATA COMMUNICATIONS
W. R. Deal, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 79/84.

. . . This two-way time division multiplex system was designed primarily for operation at 750 bits per second, and provided both frequency-shift keyed carrier (FSK) and tone-shifted amplitude-modulation (FSK-AM) options. . . .

FSK/PM THRESHOLD IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif., Technical documentary rept., 15 Aug. 1962, 1v. incl. illus. 6 refs. (Rept. no. WDL-TR1870), AD 284 800.

An experimental study . . . to determine means of improving the threshold of the Advent FSK/PM command link. . . .

AN ANALYSIS OF INHERENT DISTORTION IN ASYNCHRONOUS FREQUENCY-SHIFT MODULATORS
L. R. Bowyer, et al., Bell Syst. Tech. J., vol. 41, no. 6, Nov. 1962, p. 1695/1736.

In many commonly used frequency-shift modulators, a phase error occurs at the time of switching. If a demodulator is used which utilizes only the zero-crossing information, then this phase error will cause time jitter in the received data transitions. . . . a set of sufficient conditions is derived for jitter-free frequency-shift modulation, and an implementation of a modulator satisfying these conditions is described.

A 250 kw LF FREQUENCY SHIFT TRANSMITTER
H. J. P. Boxall, et al., Proc. Instn. Radio Engrs. Australia, vol. 23, no. 12, Dec. 1962, p. 722/728.

The paper reviews the development of naval communications in Australia, leading to a description of the re-designed 250 kw LF transmitter at Belconnen. . . .

HIGH SPEED DATA TRANSMISSION (In French)
H. Cohn, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 199/206.

. . . different considerations which determine the choice and the make-up of a telephone line data transmission . . . a multiplex telegraphic device "TOR" which gives automatic correlation of transmission errors, and "DIGITRAN", a device for medium and high speed data transmission . . . test results obtained over a looped link of a total length of 1800 kms. TOR multiplexes 4 channels of 200 bauds each. DIGITRAN can operate at 600, 1200 and 2400 bauds.

ON FSK PARITY CHECKING (Correspondence)
N. M. Blachman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121/123.

. . . compares the error probabilities for a fixed-information-transmission-rate FSD channel, with and without one parity-checking bit per word, for various word lengths, any word whose parity does not check at the receiver being retransmitted. . . .

1.333: Multiple Frequency Shift Keying (MFSK) Systems

Included: Double frequency shift keying; multi-frequency data-phone service; Quantized frequency modulation techniques; M-ary FSK systems; Orthomatch data system.

Not Included: Diveristy transmission and reception systems (2); Multi-variate decision systems (2).

Cross References: PCM-FM systems (1.934); Higher order data transmission systems (1.313); Multi-level data AM systems (1.325); Multiphase PhM data systems (1.344).

Principal Publications:

MULTIPLE FREQUENCY SHIFT TELETYPE SYSTEMS
D. B. Jordan, et al., Proc. IRE, vol. 43, Nov. 1955, p. 1647/1655.

MULTIFREQUENCY NARROWBAND REMOTE CONTROL SYSTEMS (In Russian)
F. A. Katkov, Ukrainian SSR, Kiev., State Publisher of Technical Literature, 1960, 208 p.

PERFORMANCE OF A MULTI-FREQUENCY-SHIFT TELETYPE SYSTEM
E. L. Maxwell, et al., National Bureau of Standards, Boulder, Colo., 3 Oct. 1960, 18 p., illus. (NBS rept. no. 6719), AD 249 995.

. . . operating in the VLF band was tested against thermal and atmospheric noise. . . . experimental results and gave a 3 to 5 db advantage in the carrier-to-noise ratio at the receiver input terminals in a 1 kc effective bandwidth. . . . over normal binary FSK teletype. . . . When operating against atmospheric noise at 6-10 db advantage over normal binary FSK was experimentally obtained.

PHASE-SENSITIVE DETECTION WITH MULTIPLE FREQUENCIES
B. O. Pedersen, IRE Trans. Instrument., vol. I-9, no. 3, Dec. 1960, p. 349/355.

The multiple-frequency type of phase-sensitive detector differs from the conventional detector in that the signal frequency is a multiple of the reference frequency. Conventional phase-sensitive detectors may be readily adapted for multiple-frequency operation. Two detector circuits employing diodes are analyzed and discussed in detail. The circuit configuration required for even harmonic signals differs slightly from that required for odd harmonic signals. . . . As a practical application, the use of a second harmonic phase-sensitive detector in a flux-gate magnetometer, which leads to a simplification of the magnetometer circuit, is described. . . .

A LONG RANGE DIGITAL COMMUNICATIONS SYSTEM
A. J. Strassman, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, 383/389.

. . . high-frequency, digital data communication system using the quantized frequency-modulation (QFM) technique and the quantized phase-modulation (QPM) technique. QFM is a synchronous frequency shifting technique that can provide a predetermined amount of gap protection between successively transmitted pulses on the same subchannel frequency. The design of the system provides for a basic bit rate of 1000 bits/sec. and is capable of expansion to 8000 bits/sec. . . .

STATISTICAL PROPERTIES OF M-ARY FREQUENCY-SHIFT-KEYED MODULATED CARRIERS
H. Zabronsky, RCA Rev., vol. 22, no. 3, Sept. 1961, p. 431/460.

. . . statistical properties of frequency-shift-keyed and phase-shift-keyed modulated carriers through a limiter plus other devices, in the presence of white Gaussian noise.

DOUBLE FREQUENCY SHIFT DEMODULATOR DEVELOPMENT AND SIGNAL DETECTION STUDY

Page Communications Engineers, Inc., Washington, D. C., Final rept. 24 May 1960-21 July 1961, July 1961, 1v. (Rept. no. PCE-R-8643A), (RADC TR 61-210), AD 263 455.

In double frequency shift systems, the received signal is often perturbed by frequency selective fading. A decision threshold computer (DTC) is described which achieves a substantial improvement in received signal reliability by using the normally detrimental effects of this phenomenon to provide additional orders of diversity. An experimental demodulator with superior performance characteristics was developed, incorporating the DTC Technique to reduce teleprinter errors during selective fading. . . .

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE—A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS

E. Arthurs, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 336/372.

. . . a geometric interpretation of the detection problem is presented on a tutorial level. . . . this technique is used to derive the optimum detector for each of three basic data transmission systems: m-level Phase Shift Keyed, m-level Amplitude Shift Keyed and m-level Frequency Shift Keyed. Corresponding probability of error curves are derived, compared and discussed with reasonable detail. . . .

THEORETICAL DIVERSITY IMPROVEMENT IN MULTIPLE FREQUENCY SHIFT KEYING

P. M. Hahn, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 177/184.

. . . (MFSK) is a modulation suitable for transmitting digital data under fading conditions. . . . the MFSK signals on the several diversity channels are presumed to be perturbed independently by Rayleigh fading and additive white Gaussian noise. Also, it is assumed that fading is slow and that envelope, cross-correlation (matched filter) detection is used. . . .

A MULTIFREQUENCY DATA SET FOR PARALLEL TRANSMISSION UP TO 20 CHARACTERS PER SECOND

B. R. Saltzberg, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 101/105.

. . . This data set, as part of the general DATA-PHONE service, provides economical data transmission well-suited to data collection of relatively short messages from many transmitters to a single receiver. It transmits alphabetic and numeric characters, asynchronously, using parallel multifrequency signaling techniques. The system has been field tested over a wide variety of telephone facilities with very satisfactory results. . . . The speeds vary widely from above 2,000 bits per second to less than 100 bits per second. . . . In designing . . . system . . . the network characteristics and limitations must be kept in mind constantly . . . This data system uses multi-frequency signaling . . . because of the simplicity of the transmitting equipment. However, such considerations as limited bandwidth, frequency shift, delay distortion, echo, noise, and over-all net loss require special attention and play important roles in the final design objective of the system. . . . A modified FM transmission method was therefore chosen. Carrier at a rest frequency in each band is turned on at the start of a transmission. The data message controls the shift to data frequencies. . . . 3. Coding: Two-out-of-eight for numeric, three-out-of-twelve (or three-out-of-fourteen) for alpha-numeric. . . .

THE ERROR RATES IN MULTIPLE FSK SYSTEMS AND THE SIGNAL-TO-NOISE CHARACTERISTICS OF FM AND PCM-FS SYSTEMS

H. Akima, Central Radio Propagation Lab., National Bureau of Standards, Colorado Springs, Colo., 25 March 1963, 55 p., 35 refs., Technical note no. 167, AD 402 243.

. . . evaluated for wide ranges of system parameters, assuming . . . a fading-free signal and an additive white Gaussian noise. It is shown that the required intrinsic SNR for an assigned value of symbol error rate in multiple FSK systems can be reduced by increasing the number of frequencies in the keying. Comparison of the threshold in band-dividing FM systems with that in PCM-FS systems shows the latter cannot be lower than the former . . . Brief discussions on the threshold effects in frequency-lock and phase lock FM demodulators suggest that the threshold of these feedback FM demodulators can not be improved beyond that of a band-dividing one.

THE "MARATHON" SYSTEM OF TELETRANSMISSION, PRINCIPLES AND APPLICATIONS (In French)

J. Fuzeillier, Onde Elcctr., vol. 43, no. 431, Feb. 1963, p. 170/176.

. . . designed and developed by the C. S. F. . . . is especially applicable to industrial installation . . . Bipolar FSK system on tone-subcarriers . . . two examples of its use in two types of links: one by telephone line between two stations, the other by radio links connecting three stations.

THE ORTHOMATCH DATA TRANSMISSION SYSTEM

B. G. Kuhn, et al., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 3, Sept. 1963, p. 63/66.

. . . Envelope-orthogonal signals in the transmitter and matched filters in the receiver are employed; Orthomatch at 16 levels requires 5.6 db less power than orthogonal incoherent

PCM and 1.9 db less power than biphase PCM. Calculated and measured comparison of Orthomatch and a typical PAM-FM system shows an 11.5 db power advantage for Orthomatch. . . . Among the many possible incoherent sets the one chosen . . . is composed of sinusoids of duration T_0 sec with frequencies spaced successively by $1/T_0$ cps. The receiver corresponding to the chosen signal set consists of a set of matched filters, followed by envelope detectors, samplers and a "greatest-of" decision circuit. . . . Amplitude quantization of the analog input voltage to 16 levels. The 16 levels are represented in transmission by 16 discrete transmitter frequencies. . . . Frame sync and 40-kc timing information are transmitted on a 17th frequency which is biphase (0 - 180°) modulated. The biphase modulation is a binary code of length 255 bits which has an optimized autocorrelation function for correlation detection. . . .

A LIMIT FOR THE PROBABILITY OF ERROR FOR LARGEST-OF-SELECTION (Correspondence
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 494/496.

. . . When frequency is utilized as the orthogonal modulation parameter there results a multiple-frequency shift-keyed (F_mSK) tranmission.

DOUBLE FREQUENCY-SHIFT KEY DEMODULATION STUDY
Page Communications Engineers, Inc., Washington, D. C., Final rept., 4 April 1962-30 June 1963, Aug. 1963, 1v. Rept. no. PCE R—52 0028A, RADC TDR63 395, AD 422 929.

. . . detection of received signals in double frequency-shift keying systems is reported . . . earlier . . . a variable decision technique was applied to an experimental DFSK demodulator and, in controlled tests, achieved a substantial reduction in teleprinter errors during frequency selective fading . . .

WEAK SIGNAL COMMUNICATION TECHNIQUES
Bell Telephone Labs., Inc., Whippany, N.J. Final rept., May 1961 - April 1963, July 1963, 96 p., AD 417 037.

. . . a more complete analysis of the performance of multilevel FSK systems . . .

Related Publications:

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . a class of digital communication systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. . . .

1.334: Frequency Time Shift Keying (FTSK)

Included: Side stepping systems; FT dodging waveforms; Combined frequency and time-shift keyed data systems; Frequency hopping systems; QFM system of National Cash Register Co.

Not Included: RADAS = random access discrete address systems (2); Anti-multipath communication systems (2).

Cross References: Spread spectrum waveforms (1.316); Higher order data transmission systems (1.313).

Principal Publications:

FREQUENCY SHIFTS IMPROVE PULSE COMMUNICATIONS
J. L. Hollis, Electronics, vol. 32, no. 19, June 1959, p. 66/69.

New technique overcomes multipath problems in long-range pulse transmission. Transmitter and receiver simultaneously shift frequency so that receiver is sensitive only to the transmission arriving by the shortest path.

AN EXPERIMENTAL EQUIPMENT TO REDUCE TELEPRINTER ERRORS IN THE PRESENCE OF MULTIPATH
J. L. Hollis, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 185/188.

. . . A commonly used four-channel multiplex system has a bit length of 6.7 milliseconds and is thus seriously affected by differences in path delay greater than approximately 3 milliseconds.

. . . This paper describes a method of . . . synchronously shifting the frequency of the transmitter and receiver following transmission of each bit. The receiver is thus responsive to the signalling element propagated by the shortest path and rejects the long path signals by filter selectivity. . . . The compatibility of the multipath equipment with existing equipment and the ability to reduce the error rate substantially, under conditions of ground-scatter multipath propagated by the F layer, have been successfully demonstrated. . . .

A FREQUENCY STEPPING SCHEME FOR OVERCOMING THE DISASTROUS EFFECTS OF MULTIPATH DISTORTION ON HIGH-FREQUENCY FSK COMMUNICATION CIRCUITS

A. R. Schmidt, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 44/47.

. . . it is practical to employ four-channel time division multiplex systems under multipath conditions that would otherwise render them useless.

AFC FOR FREQUENCY HOPPING SYSTEMS
T. J. Rey, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 202/208.

. . . stabilizing the frequency of a voltage-tunable oscillator near any one of many discrete frequencies. A delay line takes the place of the conventional cavity in the discriminator. . . .

EXPERIMENTS IN FREQUENCY DIVERSITY FOR TROPOSCATTER SYSTEMS
W. S. Patrick, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 217/232.

. . . previously reported work which showed that relatively closely spaced frequencies experience substantially uncorrelated fading when propagated through a tropospheric scatter mechanism. . . . Experiments have been carried out over other distances with different combinations of frequencies and spacings. For an overall bandwidth of 8 mc, which is a practical limit, the optimum combination seems to be four frequencies spaced 2 mc apart. This combination provides approximately fourth-order diversity. Digital data have been transmitted using Time Shift Keyed (TSK) signals. This system (FSK) in conventional systems, shows a substantial advantage over the simple AM system used previously. . . . a digital "one" is made up of a mark-space pattern, and a digital "zero" is made up of a space-mark pattern. . . .

COMBINED FREQUENCY AND TIME-SHIFT KEYED TRANSMISSION SYSTEMS
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 414/421.

. . . the two possible states of a binary waveform are represented by the order of two pulses which occur on different frequencies, for instance, f_1 and f_2. For example, if the ordered pair (f_1, f_2) represents a Mark, then (f_2, f_1) represents a Space. The power spectrum, as well as the performance of both coherent and noncoherent systems in an interference environment, is investigated. . . . FTSK's dual frequency diversity is shown to provide a substantial antifading capability to both coherent and noncoherent transmissions. Furthermore, it is observed that FTSK offers the potential for: 1) complete rejection of CW and other forms of narrow-band interference, 2) simplified post-detection signal coupling circuits, 3) enhanced performance of digit synchronization circuits and 4) error detection and correction. . . .

Related Publications:

SINGLE PULSE AFC SYSTEM
J. G. Isabeau, IRE Intern. Conv. Rec., vol. 5, March 1961, p. 278/284.

. . . uses a fast feedback loop in order to reach steady state in less than 1 μ sec . . . used in conjunction with a radar transmitter, the frequency of which is altered from pulse to pulse . . .

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. The magnitudes of the shifts are to be selected such that the received waveforms, (corresponding to different possible transmitted-pulse positions) can be observed independently, . . .

A LIMIT FOR THE PROBABILITY OF ERROR FOR LARGEST-OF-SELECTION (Correspondence)
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 494/496.

. . . multiple-time shift-keyed (T_mSK) transmissions . . . frequency is utilized as the orthogonal modulation parameter . . .

Section 1.34
Digital Phase Modulation Systems

Phase modulation is a very efficient modulation method for data transmission over space communications links. In contrast to SSB, it retains the dc component and the phase information in any information or signal waveform, provided the equipment is properly designed. It requires, similarly to SSB, a minimum bandwidth only. Symmetrical band distortions cause less information impairment than in any other comparable modulation method. Coherent phase demodulators (theoretically the optimum detection system) can be readily applied.

In phase-keying systems, it is likewise usual to discriminate between binary, multiphase and hybrid data systems.

The combination of phase modulation with the application of long binary sequences as digital waveforms led to the development of a very important class of data systems for space application: The phase coherent coded data transmission systems. They are specifically referenced in subdivision 1.345.

1.340: Phase Modulation Data Transmission Systems in General

Included: Phase modulated data systems over fading channels; Phase shift keying systems in general.

Not Included: Phase lock loops; Phase modulators; Phase demodulators.

Cross References: Statistical characteristics of fading channels (1.612); Phase modulation for analog information (1.233); FSK-PM modulation method (1.940); PCM-PS modulation method (1.940).

Principal Publications:

AUTOMATIC CONTROL OF RADIO FREQUENCY PHASE SHIFT
S. N. Broady, et al., Electronic Communications, Inc., Timonium, Md., Oct. 1959, 36 p., Final rept., AFCRC TR-59-363, AD 231 847.

Research was conducted (1) to investigate electronically controllable phase shifter devices suitable for operation in the 200 to 1500 Mc/sec frequency band and (2), to investigate and develop feed-back techniques to provide precision electronic control of these devices.

PERFORMANCE OF DIGITAL PHASE-MODULATION COMMUNICATION SYSTEMS
C. R. Cahn, IRE Trans. Commun. Syst., vol. CS-7, no. 1, May 1959, p. 3/6.

PULSE PHASE-CHANGE SIGNALING IN THE PRESENCE OF IONOSPHERIC MULTIPATH DISTORTION
S. G. Lutz, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 102/110.

ANALYSIS OF A PHASE MODULATION COMMUNICATIONS SYSTEMS
R. L. Choate, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 221/227.

COMPARISON OF PSK VS FSK AND PSK-AM VS FSK-AM BINARY CODED TRANSMISSION SYSTEM
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 87/100.

PHASE-SHIFT KEYING IN FADING CHANNELS
H. B. Voelcker, Proc. Inst. Elect. Engrs., London, Part B, vol. 107, no. 31, Jan. 1960, Paper 3125 E.

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1961, p. 1613/1629.

. . . for multiplexed binary telegraph signals that are used to frequency-modulate an RF carrier that is subsequently corrupted by fading and noise. Frequency-shift keying, amplitude keying, and phase-shift keying are considered. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., 3 Jan. 1961, Rept. no. UA-1420-S-1, RADC TR 61-58, AD 256 584.

. . . performance of several types of Phase Shift Keyed (PSK) systems . . . The performance of m-state differentially coherent multiplexed PSK data links operating over a Rayleigh fading tropospheric scatter link is analyzed. . . .

TRANSMISSION OF SIGNALS BY PULSE-PARAMETER COMPARISON METHOD
N. T. Petrovich, Radio Engng: Transl. of Radioteknika, vol. 16, no. 1, 1961, p. 1/9, 12 refs.

. . . a method . . . based on comparison of parameters of individual pulses, which permits the use of new techniques in communications. Also discussed is one of its specific applications in pulse carrier-wave phase comparison (relative phase telegraphy RPT). It is shown that RPT makes noiseproof coherent reception practically possible in communications channels affected by fluctuation noise. . . . the zero value of a pulse parameter, (phase, frequency, amplitude . . . used to transmit information is

set by the value of this parameter in one of the discrete pulses preceding the given pulse. . . . To simplify the memory element, it is convenient that the nth pulse be compared with the preceding pulse . . . and that transmission be achieved by an equal-value code (in which the elementary pulses are of equal duration). . . . The method of transmission based on comparison of parameters has been studied in detail by us for two specific cases—comparison of phases and comparison of frequencies of the carrier oscillation of the elementary pulses. . . .

MINDESTPHASENSYSTEME (Minimum Phase Systems) (In German)
G. Wunsch, Nachrichtentech. vol. 11, no. 3, March 1961, p. 99/102.

DETERMINATION OF THE SPECTRUM OF A CARRIER PHASE-MODULATED BY A BI-PHASE SUBCARRIER
R. Chin, et al., Philco Corp., Palo Alto, Calif., Technical operating rept., 25 Jan. 1962, 18 p. incl. illus., table, Rept. no. WDL-TR1900, AD 296 415.

. . . spectrum of a bi-phase subcarrier, that switches phase every bit period, phase-modulating a carrier. . . . worst case with regard to bandwidth. . . . the minimum IF bandwidth is twice the sum of the subcarrier frequency and one-half the switching frequency. . . . components beyond the third harmonic are appreciably small and may be neglected. . . .

DIFFERENTIAL MODULATION DATA TRANSMISSION SYSTEM USING PHASE INVERSION (In French)
J. Claisse, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 148/152.

. . . designed and built by the Societe Anonyme de Telecommunications. This phase inversion system of differential modulation occupies the normal telephone channel bandwidth . . . The device is original in its method of demodulation and carrier regeneration.

A MULTICHANNEL PHASE SYSTEM
V. G. Dolotov, Foreign Technology Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 24 Jan. 1963, 4 p., Trans. no. FTD-TT-62-1636 from Soviet Patent no. 145919, (722250/26), 18 March 1961, AD 298 216.

NOISE IMMUNITY OF PHASE SHIFT KEYING IN SIGNAL FADING (Translation)
I. V. Dulenko, Telecommunications and Radio Engineering, Part I-Telecommunications, Nov. 1962, p. 66/68, A63-19197.

. . . The error probability in a channel with slow fading is assessed, using the method of Fink. . . .

ADAPTIVE TECHNIQUES FOR LONG RANGE TRANSMISSION OF PULSE CODE MODULATION TELEMETRY DATA
D. H. Ellis, et al., Dynatronics, Inc., Orlando, Fla., Final rept., June 1960-May 1961, Aug. 1962, 244 p. incl. illus., tables, refs., ASD TR 61-198, AD 288 076.

. . . The type of modulation (phase) for the R. F. link is shown by theoretical analysis to be superior to any other. . . .

NON-GAUSSIAN ATMOSPHERIC NOISE IN BINARY-DATA, PHASE-COHERENT COMMUNICATION SYSTEMS
B. Shepelavey, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 280/284.

Performance evaluation of a binary-data phase-coherent system is presented for the case when interference is confined to the non-Gaussian component of atmospheric noise. . . . a mathematical model of the non-Gaussian component of atmospheric noise in narrow bandwidths is formulated which, for high instantaneous noise voltages, coincides exactly with the empirical atmospheric noise data. . . . a technique is developed whereby the effects of the entire atmospheric noise can be approximated by a combination of the non-Gaussian and Gaussian components with different power densities. . . .

TRANSIENTS IN RESONANT SYSTEMS WITH PHASE-KEYED OSCILLATIONS (Translation)
V. V. Sokolov, et al., Telecommunications and Radio Engineering. Part I-Telecommunications, April 1963, p. 34/40, A64-12172.

. . . It is shown that when the phase is keyed through an angle other than 180°, and when the signal is detuned relative to the mid-band frequency of the resonant system, the transients occur in different ways for a phase step-change toward positive or negative values . . . this phenomenon should be taken into consideration in the design of phase telegraphy receivers.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 43/51.

. . . including all possible conditions of non-orthogonality of signal, and correlations in the noise processes. These forms include frequency-shift keying with noncoherent detection, generalized to all noncoherent detection systems utilizing two basic waveforms, and phase-shift keying with a noisy reference signal, generalized to all coherent detection systems utilizing a single basic waveform.

The unified result is achieved by exploiting a fundamental relationship between noncoherent and coherent operation. Also, some useful and not widely-known mathematical techniques involving the Q function are presented and utilized in the derivations. . . .

RADIOTELEGRAPHY
M. V. Verzunov, Joint Publications Research Service, Washington, D. C., 3 March 1964, 71 p., Transl. into English of a Russian pamphlet Moscow, Mill. Publishing House of the Defense Min. USSR, 1961, p. 1-80, JPRS-23500; OTS64-21706, N64-18054.

. . . covers . . . (1) radiotelegraphic methods and radiotelegraph signal parameters; (2) amplitude keying . . . (3) frequency keying . . . (4) telegraph keying in multichannel operation; (5) phase keying . . . (6) methods of improving radiotelegraphy-communications stability; and (7) remote-transmitter keying.

FSK/PM THRESHOLD IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif., Technical documentary rept., 15 Aug. 1962, 1 vol. incl. illus., 6 refs., Rept. no. WDL-TR1870, AD 284 800.

An experimental study . . . to determine means of improving the threshold of the Advent FSK/PM command link. . . . construction . . . of a . . . command link simulator . . . considerable supporting data were obtained in the form of time waveform photographs, spectrum photographs and plots, and system response curves. The results indicate the desirability of using coherent tones and pre-modulation filtering in the transmitter as well as the obvious need for an optimum detector. Theoretical investigations of the bit sync problem in the receiver emphasize the need for additional work to investigate a number of interesting detection schemes.

Related Publications:

STATISTICAL PROPERTIES OF M-ARY FREQUENCY-SHIFT-KEYED MODULATED CARRIERS
H. Zabronsky, RCA Rev., vol. 22, no. 3, Sept. 1961, p. 431/460.

. . . statistical properties of frequency-shift-keyed and phase-shift-keyed modulated carriers through a limiter plus other devices, in the presence of white Gaussian noise.

SENSITIVE COMMAND NETWORK (SCN) NOISE EVALUATION TESTS (WG-11)
R. G. Lenz, et al., Boeing Co., Seattle, Wash., 22 Jan. 1963, 58 p., Document no. D2 9233, vol. 7, AD 435 782.

Errors introduced in a diphase message in the Sensitive Command Network are investigated.

1.342: Binary Phase Modulation Data Systems

Included: Bi-phase data transmission systems; Phase reversal data systems; Diphase PCM cable systems (Stelma); Diphase modem (Motorola); Hallicrafters phase reversal system; IBM binary phase modulation set; Differentially coherent phase-reversal system; COBI = coded biphase data transmission modem.

Cross References: Phase modulation for analog signals (1.233); 201 A and 201 B subset of Bell Telephone (1.343); Dibits (phase quadrature biphase waveforms) (1.343); Four phase data transmission systems (1.343).

Principal Publications:

AN EXPERIMENTAL MODULATION-DEMODULATION SCHEME FOR HIGH-SPEED DATA TRANSMISSION
E. Hopner, IBM Journ. Res. Developm., vol. 3, Jan. 1959, p. 74/84.

. . . transmitting binary data over private telephone lines. A brief review of alternative approaches is given, with a description of the laboratory model. Performance of the equipment is reported with the reliabilities experienced at 600, 1000, 1600, and 2400 bits per second.

IMPROVED PHASE MODULATOR-DEMODULATOR
M. George, International Business Machines Corp., Rockville, Md., Quarterly progress rept. no. 1, 5 Sept. 1960, 36 p. incl. illus., AD 266 540.

Effort concerns the transferring of digital data over voice communications channels. The contractor (IBM) will develop and construct a digital modulator-demodulator using transistor circuits, phase modulation, and bit synchronism. Progress is presented on the logic design and on the electrical design of each circuit. Progress was satisfactory. Almost all of the circuits were designed and most were tested.

IMPROVED PHASE MODULATOR-DEMODULATOR
M. George, International Business Machines Corp., Rockville, Md., Quarterly progress rept. no. 2, 1 Sept.-30 Nov. 1961, 30 Nov. 1961, 23 p. incl. illus., AD 274 054.

IMPROVED PHASE MODULATOR-DEMODULATOR
J. G. Puente, International Business Machines Corp., Rockville, Md., Quarterly progress rept. no. 3, 1 Dec. 1961-28 Feb. 1962., 28 Feb. 1962, 39 p. incl. illus., AD 274 660.

IMPROVED PHASE MODULATOR-DEMODULATOR
J. G. Puente, International Business Machines Corp., Rockville, Md., Quarterly progress rept. no. 4, 1 March-31 May 1962, 31 May 1962, 41 p. incl. illus., AD 284 038.

COBI DATA TRANSMISSION TESTING IN THE UNITED KINGDOM
P. L. Grant, Lincoln Lab., Mass. Inst. of Tech., Lexington, 27 March 1962, 20 p. incl. illus., 2 refs., Rept. no. 25G-8, AFESD TDR 62-82, AD 275 152.

. . . summarizes the data obtained during the measurement of the coded biphase (COBI) data transmission modem over the private wire services in the United Kingdom. . . .

AN AUTOMATIC-FREQUENCY-CONTROLLED PHASE-SHIFT-KEYED DEMODULATOR
W. Hannan, et al., RCA Rev., vol. 22, no. 4, Dec. 1961, p. 729/752.

. . . The principles of binary phase-shift-keyed (psk) demodulators are reviewed with regard to their use in airborne or satellite communications systems where large frequency errors due to doppler shift and oscillator drift are unavoidable and short lockup time is essential.

SPECIFICATIONS FOR A COBI DATA TRANSMISSION MODEM
E. J. Hofmann, Lincoln Lab., MIT, Lexington, 18 July 1961, 47 p., Rept. 25G-0035, AD 261 546.

CARRIER PHASE REVERSAL TRANSMITS DIGITAL DATA OVER TELEPHONE LINES
J. R. Masek, Electronics, vol. 34, no. 21, May 1961, p. 56/58.

SYNCHRONOUS DEMODULATION OF PHASE-REVERSING BINARY SIGNALS, AND THE EFFECT OF LIMITING ACTION
D. G. Tucker, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 77/82.

AN OPTIMUM SELF-SYNCHRONIZED COMMUNICATION SYSTEM
S. S. Chang , et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 110/116.

. . . The transmitted signal consists of two-phase modulation (0 and 180 degrees) of a sinusoidal carrier. . . . The output . . . is squared so that the resulting signal is statistically the same when the transmission is the in-phase carrier tone burst or the out-of-phase carrier tone burst. . . .

DESIGN PLAN FOR DIPHASE PCM CABLE SYSTEM
R. Couturier, Stelma, Inc., Stamford, Conn., 29 May 1962, 23 p. incl. illus., AD 294 767.

. . . proposed design . . . for a cable repeater referred to as the unattended repeater . . . The equipment is to provide diphase transmission mode in a pulse code modulation system, as replacement for the dipulse transmission mode. . . . It consists in this application of a variable frequency wave, where three successive reversals at the higher frequency (i.e., one full cycle) represents a logical 0 and where deletion of the second reversal in a group of three (resulting in a half cycle of a wave at the lower frequency) represents a logical 1.

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. Couturier, Stelma Inc., Stamford, Conn., Quarterly progress rept. no. 2, 16 Sept.-15 Dec. 1962, 15 Dec. 1962, 28 p., Rept. no. 2, AD 298 585.

THE COBI DATA TRANSMISSION MODEM
K. H. Morey, Lincoln Lab., Mass. Inst. of Tech., Lexington, 23 May 1962, 54 p. incl. illus., tables, 9 refs., Technical rept. no. 263, AFESD TDR 62-97, AD 277 501.

The COBI (coded biphase) data transmission modem employs phase-reversal modulation and code translation as a means of transmitting serial digital data over voice-bandwidth telephone circuits . . . a history of data systems leading to COBI, a brief discussion of telephone-circuit characteristics, and a summary of the theory basic to phase-reversal modulation. . . . extensive tests to which COBI has been subjected and some of the results . . . specifications for a COBI modem, as well as procedures for its alignment and testing, are appended.

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., 10 Dec. 1962, 1 vol. incl. illus., tables, Quarterly rept. no. 1, 11 Sept.-10 Dec. 1962, Rept. no. 5, AD 297 366.

Performance of the Di-phase modem in the presence of white noise is evaluated at 150, 300, 600, and 1200 bps. . . .

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. Couturier, Stelma, Inc., Stamford, Conn., Quarterly Progress rept. no. 3, 15 Dec. 1962-15 March 1963, 1 vol., AD 409 919.

. . . unattended cable repeaters TD-206 X-1 and modification of multiplexers TD-204 XC-3)/U (Combiner B unit), . . . Cable repeater TD-206(X-1)/G design was almost completed, when severe coupling problems showed up in a complete circuit configuration. The clock amplifier and cable driver were redesigned for different voltage levels, and improved as to efficiency and performance . . .

A POINT-TO-POINT DATA TRANSMISSION SYSTEM USING MF RADIO
P. J. Ferrell, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 325/330.

. . . The data is sent as Differential Phase Reversal Modulation (DPRM) and demodulated by a Delayed Reference Product demodulator.

Timing is non-linearly extracted from the "raw data" and used to regenerate the original NRZ data. Degradation factors and bit error probabilities are derived for this system and a comparison with the "Integrate and Dump" demodulator is drawn. The performance is described in both a Gaussian and atmospheric noise environment. . . .

DATA TRANSMISSION TESTING FROM DONNELLEY FLATS, ALASKA, TO SUNNYVALE, CALIFORNIA OVER A NETWORK OF CARRIER EQUIPMENT
P. L. Grant, Lincoln Lab., Mass. Inst. of Tech., Lexington, 21 Feb. 1963, 10 p., illus., table, Rept. 25-G-11, AD 402 067.

. . . made from 27 June 1962 to 28 July 1962 evaluating the coded biphase data modem over a combination of K-carrier, TD-2 (microwave), and submarine cable . . .

RADIO TRANSMISSION OF DIPHASE SIGNALS
J. J. Kolarcik, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 289/296.

. . . Amplitude Modulation with modified diphase signals was studied. . . . Modified Diphase is a differential-phase modulation technique, where modulation is performed by reversing the phase of a square wave every time a Mark is to be transmitted. No change in phase is made when a space is transmitted. The resulting square wave is filtered to remove the high-frequency energy, and is then transmitted. . . .

LONG RANGE COMMUNICATIONS INTERFERENCE STUDY
A. Krinitz, Melpar, Inc., Falls Church, Va., Technical note no. 4 on Radio Frequency Interference in Digital Two-Phase Coherent Communication Systems, March 1963, 47 p., Technical note no. 4, RADC TDR 62-360, vol. 4, AD 298 167.

DESCRIPTORS: . . . Microwave relay systems . . . Statistical functions, Communication satellites (Active), Communication satellites (Passive), Signal-to-noise ratio.

SPECTRAL DENSITY DISTRIBUTIONS OF SIGNALS FOR BINARY DATA TRANSMISSION
H. J. Pushman, J. Brit. Instn. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

. . . The distributions for relevant p. m. systems are derived . . .

REAL-CHANNEL ASPECTS OF AN ERROR-FREE DATA TRANSMISSION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUITS
W. G. Schmidt, IEEE Trans. Commun. Syst., CS-11, no. 1, March 1963, p. 69/72.

. . . The modulation system used for purposes of these tests is a differentially coherent 1200 bit-per-second phase-reversal system which uses internal coding for purposes of enabling the regeneration of the BIT TIMING and BLOCK START signals at the receiver. . . .

LONG-RANGE COMMUNICATIONS INTERFERENCE STUDY
S. Seideman, Melpar, Inc., Falls Church, Va., Final rept., March 1963, 61 p., RADC TDR 62-411, AD 298 623.

TESTS ON HIGH SPEED TRANSMISSION OF CODED INFORMATION OVER AN EXPERIMENTAL LINK BETWEEN FRANCE AND HOLLAND (In French)
J. Touchard, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 207/213.

. . . The telegraphic speed was 1000 Bauds . . . The circuit was a normal telephone channel . . . The terminal equipment consisted of simplified versions of that supplied by the Philips Telecommunication Industry to the American airline company (United Air Lines) for its seat reservation system.

Related Publications:

PHASING INVERTING MODULATOR/DEMODULATOR FOR THE TRANSMISSION OF DATA ON TELEPHONIC CIRCUITS (In French)
J. M. Pierret, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 177/185.

. . . development of methods different from those which have been applicable at telegraphic speeds. . . . inversion modulation seems to be the most satisfactory for the transmission of binary data . . . description of a modulator/demodulator developed for examination of data transmission on telephone circuits using this kind of modulation.

1.343: Four Phase Data Transmission Systems

Included: 201A and 201B binary phase quadrature subsets; Rixon Sebit-25 data system; Dibits; Differentially coherent phase-shift keying (Collins); Air-to-ground data system of Litton systems; AN-GSC-4 data modem; AN-TYC-2 data system; Quaternary phase shift data systems; Hughes HC-270 four phase data modem; Quad-phase modem of Motorola.

Not Included: Multiplexing methods (2); Phase modulators; Phase demodulators; Phase-lock loops; Matched filter design; Theory of correlation detection (2).

Cross References: Bi-phase data transmission systems (1.342); Phase modulation for analog signals (1.233); Matched filter signal extractors (1.372); Correlation receivers (1.373); Higher order data systems in general (1.313).

Principal Publications:

KINEPLEX, A BANDWIDTH-EFFICIENT BINARY TRANSMISSION SYSTEM
R. R. Mosier, et al., Commun. Electronics, Jan. 1958, p. 723/728.

THEORETICAL ERROR RATES OF "DIFFERENTIALLY COHERENT" BINARY AND "KINEPLEX" DATA TRANSMISSION SYSTEMS
J. G. Lawton, Proc. IRE, vol. 47, Feb. 1959, p. 333/334.

MEASURED PERFORMANCE OF THE SEBIT-25 DATA SYSTEM OVER WIRE LINE FACILITIES AT 2500 BITS PER SECOND
J. L. Hollis, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 134/137.

DIGITAL DATA TRANSMISSION AT 5400 BIT/SEC OVER PRIVATE LINE, TELEPHONE FACILITIES
F. K. Morioka, et al., Proc. Nat. Electronics Conf. vol. 16, Oct. 1960, p. 45/53.

The theory, description, and preliminary field test data of the feasibility model for the Digital Communications Set, AN/GSC-4 are presented . . . to demonstrate the feasibility of transmitting synchronous binary data at rates up to 5400 bits-per-second over private line telephone facilities of nominal 4 KC bandwidth with error rates not exceeding 1 in 10^5 bits transmitted. . . . inclusion of data conversion equipment which would allow the AN/GSC-4 to transmit SAGE dipulse signals at rates up to 2600 bits-per-second and 16 channels of mixed-speed, non-synchronous teletypewriter data. . . .

A REAL TIME TELEMETRY DATA TRANSMISSION SYSTEM
H. E. Rennacker, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 4, June 1960, p. 194/202.

. . . describes a modularly expansible system which can utilize either 3 kc voice lines, or HF ratio facilities with a high degree of spectrum conservation.

. . . The unit marked TE-206T is a Kineplex transmitter with a capability of handling eight 300 bit per second input channels and using this information to modulate a 3 kc voice channel. . . .

AN/TYC-2 DATA SYSTEM
Collins Radio Co., Burbank, Calif., 1 July-30 Sept. 1960, 6 p., AD 248 718.

. . . This system is designed to transmit and receive digital data by means of phase shifted audio tones via a voice communications channel. Transmission rate is 300 characters per second, each consisting of 8 parallel bits . . . Present major effort concerned the development of a keyed filter circuit. . . .

A LONG RANGE DIGITAL COMMUNICATIONS SYSTEM
A. J. Strassman, et al., IRE Trans. Commun. Systems, vol. CS-9, no. 9, Dec. 1961, p. 383/389.

. . . quantized phase-modulation (QPM) technique. . . . System peripheral equipments provide digital inputs from facsimile and voice (Vocoder), as well as from multispeed teletype. Highly miniaturized modular construction is used throughout for all equipments and installations. . . .

PHASE-MODULATION DATA SETS FOR SERIAL TRANSMISSION AT 2,000 and 2,400 BITS PER SECOND
P. A. Baker, Commun. Electronics, vol. 81, no. 61, July 1962, p. 116/171.

. . . Pairs of serial binary digits, called dibits, are encoded by the transmitter to generate line signal elements conveying information by means of relative shifts of the carrier-frequency phase angle. . . . use of differentially coherent detection in the receiver. In-phase and quadrature components of the received line signal are delayed for a period of time corresponding to one signal element and are then modulated with the incoming signal to produce baseband data signals. Bit synchronization timing circuits in the receiver continuously recover a timing wave from the line signal. . . . Two models of the data set will be available. The 201A and 2,000 bits per second is designed for use on the switched network . . . Two thousand four hundred bits per second operation is possible on point-to-point private lines with the 201B. . . .

HC-270 FOUR-PHASE DATA MODEM (Correspondence)
J. N. Buterbaugh, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 464/466.

. . . GLOBECOM introductory paper covered wireline transmission facilities, a comparison of representative transmission techniques . . . and the basic reasons for selecting a differentially coherent, four-level, phase shift keying system to obtain data rates up to 4800 bits/second. . . . Additional features of the system were described in a WESCON paper in August, 1961. . . . The purpose of the present correspondence is to outline briefly the characteristics of the HC-270, and to describe in greater detail the usual design approaches involved in the receiver detection scheme. . . .

AN/GSC-4 DATA MODEM SERVICE TEST MODEL DEV DEVELOPMENT
G. G. Fairbanks, et al., Collins Radio Co., Burbank, Calif. Final Rept., 1 Dec. 1962, 1v., RADC TDR 62 171, AD 416 328.

. . . a flexible full-duplex, compact unit capable of conveying synchronous digital data over telephone voice facilities of nomina 4 kc bandwidth at a maximum of 5400 bits per second . . . encodes either 2 or 3 channels of information on each tone in order to minimize the frequency spectrum bandwidth required for high-speed data transmission . . . The modem exhibits error rates of less than 1 x 10 to the -6th power at 28 db signal-to-white noise . . . Typical 2400 bits per second error rates are in the neighborhood of 1 x 10 to the -6th power at 15 db signal-to-noise ratios . . .

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A. B. Glenn, et al., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 168/173.

. . . differentially coherent phase shift keyed (DPSK) . . . subject to statistically independent Rayleigh fading with the same signal spectral density as the desired signal plus an undesired signal which is not fading. . . .

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., 10 Dec. 1962, 1v. incl. illus., tables, Quaterly report no. 1, 11 Sept.-10 Dec. 1962, (Rept. no. 5), AD 297 366.

. . . Quad-phase modem operating back-to-back and through tandem channels of the AN/TCC-7. Frequency translation and its effect upon the various modems is discussed. Problems involved in using the AN/VRC-12 radio set in digital data transmission are discussed. The new data generator and correlator are discussed and a block diagram of the system is presented.

SIMPLIFIED PSK DATA TERMINAL
Litton Systems, Inc., Canoga Park, Calif., Final rept., June 1963, 1v, AD 413 538, N63-19791.

. . . using a differentially coherent phase-shift keying modulation technique. . . developed to demonstrate the practicability of such a device for Federal Aviation Agency air to ground data transfer applications. . . .

ERROR RATE APPROXIMATIONS FOR DIFFERENTIAL PHASE SHIFT KEYING
J. J. Bussgang, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 75/86.

. . . analysis of the performance of a model of the Differential Phase Shift Keying (DPSK) system. . . . deriving the test statistic for choosing between any two phases when an arbitrary phase is transmitted. . . . The exact expression for the probability of a binary digit error in a 4-phase system is derived. . . .

HC-273 MODULATOR/DEMODULATOR FOR HF RADIO LINKS
E. Enriquez, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 92/101.

. . . in spite of greatly favorable s/n ratio, pulse smear . . . requires the use of relatively long pulses . . . this implies low signaling rates on a per-subchannel basis. . . . four-phase modulation of the subcarrier provides the means to attain higher than normal bit rates, since twice the normal bit rate/channel is obtainable. This approach is not new . . . Hughes has extensively investigated this problem area and as a result has developed a data modulator/demodulator equipment for ionospheric circuits designed to satisfy the stated requirements of high speed, high reliability, general applicability, and reasonable cost. . . .

Related Publications:

ANALYSIS OF MULTIPLE TONE CLIPPING
C. J. Styers, IRE Intern. Conv. Rec., vol. 8, March 1961, p. 134/149.

. . . study of the consequences of clipping in a multiple-tone system . . . Mathematical expressions furnish the exact number of j^{th} order; intermodulation terms; including the number of signal terms, in-phase noise terms, and randomly-phased noise terms.

From these expressions is obtained a net peak-signal to rms-noise voltage ratio as a function of the clipping level. The effect of clipping upon the binary error rate is investigated.

TIME-FREQUENCY DUALITY
P. Bello, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 18/33.

. . . The usefulness of time-frequency duality stems from the fact that two situations which may be quite distinct physically can have identical behavior patterns except for an interchange of the roles played by time and frequency. . . . Another benefit to be obtained from time-frequency duality is the generation of new ideas for communication signal processing techniques. We illustrate this type of benefit by constructing the dual of the Kineplex communication system. . . .

1.344: Multi-phase Data Systems

Included: M-ary phase shift data systems; Nymph narrow band multiphase modulation; SECO system of MIT; Phase quantization data transmission systems; Quantized phase modulation (QFM).

Not Included: Quantizing circuits; Multi-variate deciders.

Cross References: Multilevel AM data systems (1.325); Multi-frequency data systems (1.333); Higher order data systems (1.313); Quaternary phase-shift systems (1.343); QFM system of National Cash Register Co. (1.344); Quantization theory (1.551).

Principal Publications:

A DIGITAL DATA TRANSMISSION SYSTEM USING PHASE MODULATION AND CORRELATION DETECTION
F.A. Losee, Nat. Aeron. and Navig. Electronics Conf., Dayton, Ohio, May 12-14, 1958, p. 88/93.

NOTATIONS FOR BALANCED POLYPHOSE (POLYPHASE) SYSTEM AND THEIR OPERATIONAL METHODS. I. PROPOSITION ON NOTATIONS FOR BALANCED POLYPHOSE (POLYPHASE) SYSTEM
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. 11, no. 1, 1959, p. 45/54.

Considers the relation between spatial and electrical phase angle in a balanced polyphase system. . . . a general notation is developed for dealing with these systems. . . . Operational methods. . .

NOTATIONS FOR BALANCED POLYPHASE SYSTEM AND THEIR OPERATIONAL METHODS. II. OPERATIONAL METHODS BY NOTATIONS FOR BALANCED POLYPHASE SYSTEM
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. II, no. 3-4, 1960, p. 155/177.

Multiplication, addition and subtraction of the systems. . . . are derived by consideration of the general term for the qth phase. The authors conclude that the derived results constitute the basic modulation and demodulation theory of polyphase systems, and will be of use in considering polyphase communication systems. . . .

AN ANALYSIS OF MULTI-PHASE RF MODULATION FOR PCM TELEMETRY
F. H. Goodenough, Proc. Nat. Telemetering Conf., May 1961, p. 14-61/14-82.

A LONG RANGE DIGITAL COMMUNICATIONS SYSTEM
A. J. Strassman, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 388/389.

. . . quantized phase-modulation (QPM) technique.

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE—A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS
E. Arthurs, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 336/372.

. . . a geometric interpretation of the detection problem . . . used to derive the optimum detector for each of three basic data transmission systems: m-level Phase Shift Keyed, m-level Amplitude Shift Keyed and m-level Frequency Shift Keyed. . . .

PHASE QUANTIZATION IN DETECTION OF SIGNALS WITH NOISE BACKGROUND (In Russian)
L. B. Cherniak, Radiotekhnika i Elektronika, Aug. 1963, p. 1326/1333.) Radio Engineering and Electronic Physics, Aug. 1963, p. 1285/1291, 9 refs., Translation, A64-17670.

APPLICATION OF SEQUENTIAL DECODING TO HIGH-RATE DATA COMMUNICATION ON A TELEPHONE LINE (Correspondnece)
I. L. Lebow, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 124/126.

. . . some preliminary experimental results . . . the transmission medium is a toll-grade nonswitched, K-carrier telephone voice channel. Virtually error-free communication of 6000-9000 data bits per second has been achieved. . . . The structure of the encoder-decoder (referred to as SECO), as well as some experimental results obtained with its use on a binary-symmetric channel, have been reported previously. . . .

DIGITAL PULSE COMPRESSION USING POLYPHASE CODES (Correspondence)
E. S. Lurin, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1262/1263.

Digital pulse compression is implemented by dividing the radar output waveform into finite intervals and coding the RF phase of these

intervals in discrete steps. Upon reception, the signal is recombined by a process similar to correlation . . . provides large pulse compression ratios and high flexibility. If digital shift provides large pulse compression ratios and high flexibility. If digital shift registers and logic circuits are used to initiate and decode the various codes, the advantages of perfect digital memories and crystal clock control make high pulse compression ratios feasible. . . . A digital system is outline . . .

Related Publications:

GENERAL PRINCIPLES OF POLYPHASE VACUUM TUBE OSCILLATOR
T. Takagi, et al., Rep. Res. Inst. Elect. Commun., Tohoku Univ. (Japan), vol. 11, no. 3-4, 1960, p. 179/201.

The theory . . . is extended to a general consideration of the polyphase vacuum tube oscillator. . . . it is shown that there is a multiplicity of possible modes and corresponding frequencies. . . .

ON THE OPTIMUM PERFORMANCE OF N-ARY SYSTEMS HAVING TWO DEGREES OF FREEDOM
R. W. Lucky, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 2, June 1962, p. 185/192.

. . . the n possible symbols correspond to n vectors in a 2 WT_0 dimensional signal space. This paper considers the theoretical properties of a class of digital systems were the signal space is two-dimensional. Such systems are both amplitude- and phase-modulated. Approximate expressions are derived for the average probability of error for these systems as a function of the placement of the n symbol vectors in the two dimensional signal space. . . .

POLYPHASE CODES WITH GOOD NON-PERIODIC CORRELATION PROPERTIES
R. L. Frank, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 43/45.

N-phase codes are described which have an autocorrelation function with one main peak and very small side peaks. With N phases an N long pulse sequence is generated. Properties have been verified for N up to 8 and a rule for main peak-to-side-peak ratio is conjectured for larger N. For N greater than 5, the ratio is substantially better than the best ratios which have been shown for binary bipolar codes. Doppler shift effects appear to be similar to those of linear FM radar pulse compression . . . A comparison of the performance of higher-order polyphase codes with similar length binary codes indicates a superiority in the polyphase codes.

1.345: Coded Phase Coherent Data Systems

Included: Code words for synchronization of coded data systems; Digilock data transmission system; Duobinary techniques of Lenkurt Electric Co.; Multilock data system of Robertshaw-Fulton Control Co.; Phase multilock system.

Not Included: Synchronization of data systems in general; Telemetry systems; Coding theory for binary sequences (2).

Cross References: Binary sequences as digital waveforms (1.314); Synchronization of PCM systems (1.523); Phase modulation for analog signals (1.233).

Principal Publications:

A SIMULTANEOUS NON-INTERFERING SINGLE CHANNEL SERVO AND VOICE TRANSMISSION SYSTEM
C. A. Crafts, et al., Proc. Nat. Symp. Telem., no. 11.1, Sept. 1958, p. 1/6.

. . . in connection with the Phase Multilock Communications System . . .

SPECTRUM CONVERSION WITH PHASE MULTILOCK COMMUNICATION
M. D. McFarlane, et al., In: 1959 Conf. Proc. Nat. Conv., Mil. Electronics.

DIGITAL TELEMETRY SYSTEM
R. W. Sanders, Nat. Symp. Space Electronics Telemetry, no. 6.3, Sept. 1959, p. 1/10.

AN OPTIMUM SELF-SYNCHRONIZED SYSTEM
S. S. L. Chang, et al., New York U. Coll. of Engineering, N.Y., 8 June 1960, AD 242 919.

Synchronous detection is often used as the model for the modulation scheme of feedback systems. Present effort considers the synchronization problem then present. A self-synchronized PSK system is discussed and analyzed to show that when the signal-to-noise ratio exceeds a few db synchronization is almost perfect.

A specific modulation scheme is discussed and analyzed to serve as a transmission scheme to be used in feedback communication system. One optimum scheme for transmission in the presence of additive noise is binary PSK using a modified equal-weight Reed Code and synchronous detection. This technique also permits the synchronizing carrier at the receiver to be generated from the message signal itself, so that phase drifts due to multipath and doppler can be automatically and correctly compensated for.

DIGILOCK COMMUNICATION SYSTEM
R. W. Sanders, 1960 IRE Wescon Conv. Rec., part 5, p. 125/131.

'DIGILOCK' SYSTEM PASSES FIRST FLIGHT TEST
A. H. Collins, Missiles Rockets, vol. 9, no. 25, Dec. 1961, p. 29 + 31.

. . . Employing only 0.25-watt transmitted power, the first digilock system developed for the Air Force Systems Command's Special Weapons Center by Space-General Corp. was flown Dec. 4. . . .

ON CODED PHASE-COHERENT COMMUNICATIONS
A. J. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-7, no. 1, March 1961, p. 3/14, AD 243 735.

. . . this paper considers the result of encoding independent equiprobable binary words or sequences of independent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white Gaussian noise and detected by correlating them with their stored or locally generated replicas at the receiver . . . It is shown that in the limit as the code word length and the bandwidth approach infinity, the received information rate approaches the channel capacity for only one value of the above ratio.

ERROR RATES IN COHERENT COMMUNICATION SYSTEMS
A. V. Balakrishnan, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 86/89.

In coherent PCM communication systems where the noise is additive and Gaussian (such as in space communication systems) two classes of nonredundant coding are of special interest. One is Regular Simplex Coding which yields the lowest possible error rate for fixed SNR. The other is Bi-orothogonal Coding because of its many desirable features from the practical point of view. . . .

OPTIMUM MESSAGE TRANSMISSION IN A FINITE TIME
S. S. L. Chang, et al., IRE Trans. Inform. Th., (Intern. Synp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 215/224.

The basic problem of transmitting information through a noisy channel in a finite time with the least error is considered. The transmitted signals are either peak or average power limited, and the interference is presumed to be additive white gaussian noise. It is shown that the optimum signals are sequences of binary waveforms resembling a $(2^m - 1, m)$ Slepian group code, the generators of which can be obtained from a modified Reed Code.

An analysis is also made of near-optimum codes which allow some inequality in the distance between code words in signal space. The advantage of these near-optimum codes is that for a small sacrifice in error probability, either the information rate can be substantially increased, or the bandwidth of the system greatly reduced. The details of these systems are given and the results show that a many-fold improvement is obtained. . . .

AN INTEGRATED "ERROR-FREE" COMMUNICATION SYSTEM
J. C. Hansen, Philco Corp., Palo Alto, Calif., 31 Dec. 1962, 17 p. incl. illus., Tech. note no. WDL-TN62-13, AD 401 182.

. . . a system is proposed which combines the functions of command, synchronization, range, and range rate on one two-way radio link. . . . employing comma-free words which have been coded for error detection. The coding is such that synchronization obtains the same high degree of reliability as the information. . . . offers relative ease of implementation common to the class of cyclic codes.

DIGILOCK TELEMETRY SYSTEM FOR THE AIR FORCE SPECIAL WEAPONS CENTER'S BLUE SCOUT, JR.
R. M. Jaffe, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 1, March 1962, p. 44/49.

SYNCHRONIZATION OF TELEMETRY CODES
J. J. Stiffler, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 112/117.

A well-known means of efficiently transmitting information over the continuous white Gaussian channel involves the encoding of successive blocks of data into sequences of binary digits (called code words). Efficient decoding of these sequences in turn necessitates a knowledge of the instants in time at which one code word ends and the succeeding word begins.

This paper presents a method for obtaining this synchronization which neither decreases the channel capacity nor increases the complexity of the encoding equipment. . . .

SYNCHRONIZATION METHODS FOR BLOCK CODES
J. J. Stiffler, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 25/34.

Efficient use of block codes to communicate over a telemetry channel is dependent upon the knowledge of the instants, in time, that one code word ends and the succeeding waveform begins. This word synchronization is the subject of concern in this paper. Two . . . techniques . . . The first relies upon the identification of periodically transmitted prefixes, which unavoidably increase the redundancy . . . The second . . . eliminates the need for prefixes entirely and relies instead upon certain properties of the code itself. Both these techniques are investigated more closely as applied to binary orthogonal codes.

MULTILOCK HIGH SPEED DATA MODEL—MODEL 6005. (Final Engineering Report.)
Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Anaheim, Calif., March 1, 1963, 47 p., 4 refs., (Rept. 909-026-019), N63-16493.

. . . adapted for operation with a ground-air-ground digital communications link. The modems employ phase-shift modulation techniques with synchronized data rates up to 1200 bits per second.

. . . Error rates of less than 1 in 10^5 bits were recorded for line signal-to-noise ratios of 15 db or greater. Error-free data transmission was achieved in the absence of noise over a dynamic range of 50 db on the demonstration input.

BINARFOLGEN LINEAR RUCKGEKOPPELTER SCHIEBEREGISTER, ERZEUGUNG, EIGENSCHAFTEN UND ANWENDUNGS-BIESPIELE (Binary Effects of Coupled Linear Feedback Shift - Register, Generation, Characteristics and Examples of Application)
H. H. Leibelt, Deutsche Versuchsanstait fur Luft- und Raumfahrt, Oberpfaffenhofen, (W. Germany), Inst. fur Flugfunk und Mikrowellen, Nov. 1963 89 p. refs. In GERMAN Available from Vereinigte Universitats-u, Fachbuchhandlungen, R. Wagner Str. 1, Cologne, W. Germany, (DVL-307), N64-15032.

The characteristics of the binary effects generated by a coupled-feedback linear shift register are discussed. Emphasis is placed on investigations of period length, the correlation function, and the number of effects with maximum-period length.

FASTER DIGITAL COMMUNICATIONS WITH DUOBINARY TECHNIQUES
A. Lender, Electronics, vol. 36, March 22, 1963, p. 61-65, A63-14097

Description of a duobinary technique for increasing the transmission rates of data systems over band-limited channels. The technique permits doubling the number of times per second one binary state can be switched to the other while preserving the binary form of the original signal. By compressing the bandwidth of a train binary digits by a factor of two, the duobinary coding allows a given data channel to accommodate twice as many duobinary digits as binary digits. The basic system, the wave shape, and the eye patterns are described.

THE DUOBINARY TECHNIQUE FOR HIGH-SPEED DATA TRANSMISSION
A. Lender, IEEE Trans. Commun. Electronics, vol. CS, no. 66, May 1963, p. 214/218.

THE SYNTHESIS OF NONLINEAR FEEDBACK SHIFT REGISTERS
K. B. Magleby, Stanford Electronics Labs., Stanford U., Calif., Oct. 1963, 89 p., Rept. no. 63 118, TR 6207 1, AD 428 081.

. . . The cycles and output sequences of a simple, circulating shift register are used to synthesize an arbitrary feedback shift register.

TRANSMISSION OF TELEMETRY DATA BY MEANS OF GROUP CODES
E. V. Mitriaev, (Radiotekhnika i Elektronika, vol. 8, June 1963, p. 923/929.) In Russian, Radio Engineering and Electronic Physics, vol. 8, June 1963, p. 935/940. Translation, A64-17556.

Discussion of a method of optimum representation of digital data by group code combinations. The method is stated to minimize the mean risk with the power of the loss function $s > 1$ and with uniform probability distribution. Statement of the problem, properties of the group code combination-transformation matrix, the best permutation and its properties, and an example of optimum correlation are considered. . . .

REFLECTIVE MULTIPATH EFFECTS ON BINARY PSK TRANSMISSIONS
V. F. Volertas, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 343/349.

The effects of reflective multipaths on pseudo-random, binary PSK transmissions with quadrature detection are investigated. The paper considers reflective multipaths with long delays and reflective multipaths with delays shorter than a keying element duration. . . .

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATION
J. K. Wolf, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 422/427.

The effects of filtering a random binary sequence with certain finite memory linear and nonlinear filters are considered. Of interest are the statistical properties of the filtered sequence such as the power spectral density and amplitude distribution function, as well as methods for recovering the original sequence. Applications of these techniques to communication systems are discussed. . . .

Related Publications:

A METHOD OF OBTAINING ARBITRARY PHASES OF AN M-SEQUENCE
R. C. Curry, Rochester U., N.Y., Nov. 1960, 44 p., AD 248 455.

. . . If an m-sequence is generated by an N-stage shift register which has been modified by the addition of logical feedback, a sequence delayed by up to a maximum of ((2 to the power N)—1) digits can be obtained by adding modulo 2 the outputs of various stages of the shift-register generator. A method is given for determining from which stages the outputs should be added to obtain any specified delay

. . . Also described is the network of modulo 2 adders which are used to obtain the delayed sequence. A program is given in the appendix for generating the phase-table with a digital computer (IBM 650).

EXPERIMENTAL AUTOCORRELATION OF BINARY CODES
D. F. DeLong, MIT Lincoln Laboratory, Oct. 1960.

MAXIMUM-WEIGHT GROUP CODES FOR THE BALANCED M-ARY CHANNEL
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 550/555.

AN OPTIMIZATION PROCEDURE FOR A SINGLE-LINK UNI-DIRECTIONAL DIGITAL COMMUNICATION SYSTEM IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE AND FOR DETECTION INDEPENDENT OF FADING
L. Kurz, New York U. Coll. of Engineering, N.Y., 15 Sept. 1960, 51 p. (Scientific rept. 3), (AFCRL TN 60-1101), AD 250 210.

CODING THEORY AND ITS APPLICATIONS TO COMMUNICATIONS SYSTEMS
L. Baumert, et al., Jet Propulsion Lab., CIT, Pasadena, Calif., 31 March 1961, 84 p. (Tech. rept. 32-67), AD 257 752.
A general theory of binary sequences with desirable correlation properties is developed for application to the design of digital communication systems.

DATA LINE TECHNIQUES
Armour Research Foundation, Chicago, Ill., 1 April 1961, 458 p., 62 refs., AD 263 144.

. . . a review of pertinent theoretical material and a survey of wire line digital communication techniques to support suggestions for improving channel utilization. Increased utilization dictates the use of longer code elements in terms of time-bandwidth units, extensive terminal line equalization, and anti-impulse noise techniques. The theoretically optimum encoding-decoding systems based on performance are multilevel differentially coherent PSK (phase shift keyed).

III. THE MARINER PLANETARY COMMUNICATION SYSTEM DESIGN
B. D. Martin, Proc. Natl. Telemetring Conf., vol. 2, no. 8-3, 1962.

. . . will be used on the first Mariner spacecraft, a Venus probe, to be launched during the summer of this year. While the basic deisgn philosophy and implementation techniques remain essentially the same, the major system difference between that reported here and that used in the Mariner is the deletion of the S-band transponder system. . . .

COMMAND TECHNIQUES FOR THE REMOTE CONTROL OF INTERPLANETARY SPACECRAFT
J. C. Springett, Proc. Natl. Telemetering Conf., vol. 2, no. 8-4, May 1962.

. . . The design and operation of an interplanetary spacecraft command system is influenced by many factors, some of which are unique to deep space. Of prime importance is the need for high accuracy and reliable performance. . . . emphasis will be given mainly to command modulation, detection, and decoding techniques. . . .

AN INTERESTING DECOMPOSITION PROPERTY FOR THE SELF-PRODUCTS OF RANDOM OR PSEUDORANDOM BINARY SEQUENCES (Correspondence)
W. J. Gill, IEEE Trans. Commun. Syst., CS-11, no. 2, June 1963, p. 246/247.

QUASI-RANDOM CODE GENERATOR AND ERROR DETECTOR
P. McNelis, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 158/160.

Republic Aviation Corporation has developed a 100-megacyle digital data transmission (DDT) system. The system performs real-time multiplexing and the transmitting of pulse code-modulated (PCM) information at a nominal serial bit rate of 20 megabits per second. . . . The quasi-random code generator and error detector . . . was designed as a simulator and a test device for operation in conjunction with the r-f link of the digital data transmission system. . . . provides a serial pulse pattern simulating a PCM information source. . . .

Section 1.37
Special Receiving Problems In Digital Communications

Because of their special importance in space communications, it is desirable to single out two subdivisions on data transmission receiving problems: The matched filter signal extractor and the correlation receiver. References to these two problem areas are presented in this volume. Otherwise, it was necessary to exclude receiving problems, discussions of circuitry and equipment and detection theory from this volume because of space limitations. Detection and decision theory has a special division in volume two. The other subjects are not to be included in this series of bibliographies.

1.372: Matched Filter Extractors

Included: Bayes' matched filters; Dispersive filter design; Stripline all-pass networks; Microwave rf pulse compression filters; Digital matched filters; Smearing-desmearing techniques with matched filters; Tripulse as matched filter response to a dipulse.

Not Included: Matched filter design theory; Matched filter synthesis; Radar signal processing; Digital filters in general (3A); Anti-multipath receiving systems (2); RAKE detection system (2); Spatial filtering (2).

Cross References: Spread spectrum waveforms (1.316); Special sets of orthogonal waveforms (1.315); Wide band communication systems (1.920); Correlation receivers in data links (1.373); Chirp-type of waveforms (1.316).

Principal Publications:

PULSE COMPRESSION FILTER DESIGN
C. E. Cook, et al., Sperry Gyroscope Co., Great Neck, N. Y., Report No. 1, June 1959, Report No. EB5287-0014-1, AD 217 887.

IMPULSING OF LINEAR NETWORKS IN INTEGRATED DATA SYSTEMS
G. K. McAuliffe, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 189/194.

Waveforms useful in data transmission may be obtained by impulsing suitable linear networks, and these same networks may be used, in certain cases, as receiving matched filters. A filter design for certain low-pass waveforms is described, together with a procedure for realizing band-pass analogs of these low-pass waveforms. . . .

A MATCHED FILTER DETECTION SYSTEM FOR COMPLICATED DOPPLER SHIFTED SIGNALS
R. M. Lerner, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 373/385.

DESIGN AND ANALYSIS OF CIRCUITRY FOR A MATCHED FILTER SYSTEM
W. A. Petersen, Lincoln Lab., Mass. Inst. of Tech., Lexington, 24 August 1960, 30 p. incl. illus., Rept. no. 25G-0001, AD 244 771.

. . . The circuit requirements of a Matched Filter System are discussed. The filters are 600 μsec, 100-tap, acoustical delay lines. Herein presented is a general description of the system, its requirements, and the design considerations and detailed analysis of the transistorized circuits devised to meet these requirements.

AN INTRODUCTION TO MATCHED FILTERS
G. L. Turin, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 311/329.

. . . In a tutorial exposition, the following topics are discussed: definition of a matched filter; where matched filters arise; properties of matched filters; matched-filter systhesis and signal specification; some forms of matched filters.

ON THE POTENTIAL ADVANTAGE OF A "SMEARING, DE-SMEARING" FILTER TECHNIQUE IN OVERCOMING IMPULSE NOISE PROBLEMS IN DATA SYSTEMS
R. A. Wainwright, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 223/241.

OPTIMUM APPROXIMATION TO A MATCHED FILTER RESPONSE (Correspondence)
IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 409/410.

RADIATION INCORPORATED SIGNALING SYSTEM STUDY
D. D. Baxter, Radiation Inc., Orlando, Fla., Special rept., 1 June 1961-31 May 1962, 31 May 1962, 98 p. incl. illus., 48 refs., AD 283 320.

. . . the concept of the matched filter is discussed and applied as the optimum detector for the signals in question.

SYNTHESIS OF SIGNAL GENERATORS AND MATCHED FILTERS
N. DeClaris, et al., Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 111.

THE LINK CONNECTION AS AN ADAPTIVE MATCHED FILTER

N. A. Liskov, Cornell U. School of Electrical Engineering, Ithaca, N.Y., 30 Aug. 1961, 42 p., 4 refs., Technical rept. no. 66; Research rept. no. EE 509, AD 270 847.

. . . Link amplifier with variable transconductances between its grid and plate delay lines, can be used as an adaptive matched filter. On the assumption that the unknown input signal is fixed and repeats every T seconds for a number of cycles, it is shown that the optimum adjustment procedure is to set each transconductance equal to the average of the corresponding input sample of signal plus noise. Several types of averagers are discussed and the RC averager is chosen as the most desirable. An electronically controlled, linear, variable-gain amplifier and several sampling systems are suggested for the actual instrumentation of the adaptive matched filter.

SOME RESULTS ON NEW CLASSES OF MATCHED FILTERS

D. Middleton, Rand Corp., Santa Monica, Calif., 12 July 1961, 34 p., Rept. no. RM-2625, AD 261 027.

MATCHED FILTERS IN COMMUNICATION AND LOCATION SYSTEMS

G. E. Sample, Texas Instruments Apparatus Division Progress Report SP4-A61, Feb. 1961.

MATCHED FILTERS AND INTERSYMBOL INTERFERENCE

D. W. Tufts, Cruft Lab., Harvard U., Cambridge, Mass., 20 July 1961, 19 p., Technical rept. no. 345, AD 263 882.

ON THE POTENTIAL ADVANTAGE OF A SMEARING-DESMEARING FILTER TECHNIQUE IN OVERCOMING IMPULSE-NOISE PROBLEMS IN DATA SYSTEMS

R. A. Wainwright, IRE Trans. Commun. Syst., vol. CS 9, no. 9, Dec. 1961, p. 362/366.

THE INFLUENCE OF FADING SPECTRUM ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS

P. A. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 160/168.

. . . derives general expressions for the binary error probabilities of incoherent and differentially coherent matched filter receivers employing post-detection diversity combining. In the analysis it is assumed that the transmitted signals occupy a bandwidth much smaller than the coherence bandwidth of the medium so that "flat" fading may be assumed. . . .

BAYES' OPTIMUM FILTERS DERIVED USING WIENER CANONICAL FORMS

D. B. Brick, et al., IRE Trans. Inform. Th., Intern. Symp. Brussels 1962, vol. IT-8, no. 5, Sept. 1962, p. S35/46.

. . . many forms of previously synthesized Bayes' structures. . . . have been valid primarily for processes obeying Gaussian or other special statistics and/or for the limiting cases of small or large signal-to-noise ratios. In many cases, they have involved the use of so-called Bayes' matched filters followed by zero-memory quadratic (or non-linear) and finite-memory linear operations. . . .

STUDY OF MICROWAVE R-F PULSE COMPRESSION

J. G. Ferguson, et al., Lockheed Electronics Co., Plainfield, N.J., Final technical rept., 25 Sept. 1962, 25 Sept. 1963, 115 p., AD 421 982.

In studying the feasibility of using stripline all-pass networks to provide a wideband dispersive network for use in pulse-compression radar, work was concentrated on bandwidths of 400 megacycles centered at 3 gigacycles. The dispersive filter design was based on a synthesis technique using lumped constant all-pass networks. . . .

A NEW DIGITAL MATCHED FILTER COMMUNICATION TECHNIQUE

G. E. Goode, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 371.

Abstract Only. . . .

SIMULTANEOUS DETECTION OF TWO SIGNALS WITH ADAPTIVE MATCHED FILTERS

C. C. Tappert, Cornell U., School of Electrical Engineering, Ithaca, N.Y., 1 May 1962, 35 p., Research rept. no. EE531; Technical rept. no. 71, AD 419 502.

. . . an adaptive matched filter system can separate and individually detect the presence of two unknown input signals (of a certain restrictive class of signals) that occur simultaneously. The matched filters of this system are link amplifier structures with variable active parameters.

MATCHED FILTERING AND PULSE COMPRESSION

M. Bernfeld, et al., Sperry Engineering Review, vol. 16, Spring 1963, p. 44/53, 24 refs., A63-17586.

. . . compression of a long-duration signal into a narrow pulse, based on large time-bandwidth signal coding. . . . various aspects of the search for the theoretical optimum predetection filter are considered. . . . linear FM pulse-compression filter . . . dispersive time delay and range sidelobe reduction. Briefly outlined is the paired-echo technique of distortion analysis which has been used extensively to study the effects of network and modulation distortion on pulse-compression signals.

DIGITAL FILTERS AND APPLICATIONS TO SEISMIC DETECTION AND DISCRIMINATION

J. F. Claerbout, Mass. Inst. of Tech., Cambridge, Feb. 1963, 89 p., AFCRL 63 604, AD 404 851.

The mathematics of filtering in discrete time are presented. Filters are defined for the purposes of (1) condensing waveforms into impulsive functions, (2) wave shaping, (3) noise suppression, (4) signal detection according to the criterion of maximum signal-to-noise output at an instant, and (5) the same over an interval. The behavior of the complex Fourier transforms of some of these filters is considered and connection is made with the theory of orthogonal polynomials.

ON THE USE OF COMPLEX FILTERS
R. B. Crane, Institute of Science and Tech., U. of Michigan, Ann Arbor, March 1963, 54 p., Rept. no. 2900-368-T, AD 299 787.

ELECTRON TUBE RESEARCH
N. De. Claris, et al., Cornell U., School of Electrical Engineering, Ithaca, N.Y., Progress rept. no. 4, Nov. 1963, 73 p., AD 434 849.

The design of a matched filter and coded-pulse generator having impulse responses which consist of a carrier frequency multiplied by the corresponding low-pass impulse response is presented. . . .

A SIMPLE DERIVATION OF THE MATCHED FILTER CONCEPT (Correspondence)
N. C. Hekimian, Proc. IEEE., vol. 51, no. 2, Feb. 1963, p. 373/374.

. . . is intended to provide an intuition-satisfying grasp of a subject that usually is treated in purely mathematical terms. The use of phasor collineation in this derivation is not new, but is believed that the use of ratio-square combining is.

A LINEAR FM 1000:1 PULSE COMPRESSION SYSTEM
R. W. Jacobus, MITRE Corp., Bedford, Mass., July 1963, 21 p., TM3529, ESD TDR63 237, AD 411 537.

. . . synthesized as a linear time-invariant filter . . . The transmitted waveform is roughly rectangular in shape, has a bandwidth of 1 mc, and has a duration of one millisecond; the output of the matched-filter receiver is consequently (sin x)/x in shape (before side-lobe reduction) and has a duration of about two microseconds from null to null . . .

USE OF RECIRCULATORS FOR COMPRESSION OF FREQUENCY-MODULATED PULSES
V. V. Lebedev, Joint Publications Research Service, Washington, D. C., 13 Jan. 1964, 14 p., refs., Transl. into English of an article from Radiotekhnika (Moscow), vol. 18, no. 11, Nov. 1963, p. 62/70, JPRS-22706; OTS-64-21270, N64-13088.

. . . utilizing multiple circulators of an FM (frequency modulation) signal in a delay line with feedback with the goal of isolating the signal noise . . . frequency demodulation of the input signal . . . compression of a frequency modulated pulse . . . the isolation of an FM signal in noise by utilization of a recirculator.

MATCHED FILTER APPROXIMATION ERRORS (Correspondence)
M. J. Levin, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 254.

. . . a simple, easily visualized expression for the deterioration in output signal-to-noise ratio caused by approximation errors in a matched filter (or correlation) detector. . . .

STRETCHING PULSES WITH THE LINK STRUCTURE
D. Mitchell, Cornell U., School of Electrical Engineering, Ithaca, N.Y., Jan. 1964, 53 p., Rept. no. TR 78, AD 432 967.

A theoretical and experimental study of a pulse-stretching network using the link structure is presented. The Bessel filter has a good low-pass approximation to the ideal transmission line for use in the link structure. . . . used in taking photographs of a 5-ns input pulse and the resulting output pulse . . .

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATION
J. K. Wolf, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 422/427.

The effects of filtering a random binary sequence with certain finite memory linear and nonlinear filters are considered. Of interest are the statistical properties of the filtered sequence such as the power spectral density and amplitude distribution function, as well as methods for recovering the original sequence. Applications of these techniques to communication systems are discussed. . . .

A LINEAR-FM RADAR PULSE COMPRESSION SYSTEM EMPLOYING THICKNESS-TAPERED DISPERSIVE DELAY LINES
R. C. Yost, Lincoln, Lab., Mass. Inst. of Tech., Lexington, 11 July 1963, 20 p., Technical rept. no. 321, ESD TDR63 551, AS 417 528.

. . . Ultrasonic dispersive delay lines that are thickness-tapered to provide a linear group time delay characteristic over a frequency band of 2 mc are used as the signal expansion and compression devices. For the poorest case, the time sidelobes in the receiver output waveforms are shown to be 35 db below the peak response.

Related Publications:

PULSE TRANSMISSION STUDY
H. Fiege-Kollmann, Westinghouse Electric Corp., Baltimore, Md., Oct. 1959, Technical note no. 1, rept. no. RADC TN-58-359, AD 206 043.

. . . Two generating methods . . . (1) Modulation technique . . . (2) Mutations technique with excitation of band-pass filters (matched to the desired waveform, . . .

GAUSSIAN-RESPONSE FILTER DESIGN
M. Dishal, Elect. Commun., vol. 36, no. 1, 1959, p. 3/26.

Filters having a gaussian response shape are useful in pulse systems because of the small under- and overshoots or ringing they produce following rapid signal changes. This paper gives a resume of the magnitude, phase, impulse response, step response, and effective thermal noise bandwidth of perfect gaussian filters. A physically realizable approximation to the magnitude characteristic is then given. The complex frequency roots of this approximation (up to the 9th order) are supplied. . . . design stagger-tuned systems, lossless and uniformly lossy filters resistively loaded on one end only, and. . . resistively loaded on both ends . . . 7 tables . . . example . . .

A HIGHLY VERSATILE CORRECTOR OF DISTORTION AND IMPULSE NOISE
E. D. Gibson, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 543.

. . . utilizes a "scrambler" (or predistorter) . . . called the ISIC (Inter-Symbol Interference Corrector) and a fixed, "smear" filter. The descrambler consists of another ISIC and a "desmear" filter.

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P. H. Haas, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, Master's thesis, Aug. 1961, 68 p., 13 refs., Rept. no. GE/EE/61-6, AD 270 272.

A survey . . . as applicable to the statistical analysis of communication is presented. Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

IMPROVED DELAY LINE TECHNIQUES
S. W. Tehon, et al., General Electric Co., Syracuse, N. Y., Final rept., Jan. 1961, 110 p., RADC TR 61-57, AD 254 700.

. . . materials for ultrasonic delay lines and of wire-type lines with dispersive characteristics suitable for use in pulse compression systems . . .

EXPERIMENTS IN THE IMPROVEMENT OF THE IMPULSE RESPONSE OF TELEPHONE CIRCUITS
H. L. Yudkin, Lincoln Lab., Mass. Inst of Tech., Lexington, 27 Nov. 1961, 6 p., Rept. No. 25G-4, AD 269 557.

. . . high-pass filtering . . . perfect phase equalization (matched filtering) . . . It is also shown that matched filtering results in a more desirable pulse than is obtained by the combination of both matched and high-pass filtering.

ANALYSIS OF MATCHED-FILTER RADAR MULTIPATH RETURNS AT 435 MC
J. M. Goodman, Naval Research Lab., Washington, D. C., Interim rept., 17 April 1962, 21 p. incl. illus., tables, 5 refs., NRL rept. no. 5657, AD 275 296.

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATIONS SYSTEMS. PART I. INFORMATION EFFICIENCY OF BINARY COMMUNICATION SYSTEMS
J. C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Inc., Tech. rept. on Improved Information Transfer Efficiency of Wideband Systems, 121 p., July 1962, incl. illus., tables, 18 refs., ASD TDR 62-611, pt. 1, AD 284 450.

An . . . analysis is given for a group of matched filter systems which includes both coherent and non-coherent matched filter detection of amplitude and frequency shift keyed signals.

MULTIPATH AND SCATTERED COMMUNICATION TECHNIQUES
D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., Tech. rept. on Flight Sciences, May 1962, 10 p. incl. illus., 16 refs., rept. no. 6-90-62-42, AD 275 343.

. . . The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channel models. . . .

SPATIAL FILTERING
W. D. Montgomery, et al., General Dynamics/Astronautics, San Diego, Calif., 1962, 34 p., illus., 8 refs., AD 282 766.

. . . of two-dimensional pictorial data as an extension of one-dimentional filter theory is applied to the problem of enhancing the detection of localized objects which are superimposed upon a noisy background. Four types of filters are derived. These are the Linear, Quadratic, General Statistical, and Decision filters. Each filter is of the matched type, the different designs being associated with various degrees of knowledge about the noise statistics. A computer simulation of the linear and general statistical filters was done and examples are shown.

SIGNAL FIDELITY IN RADAR PROCESSING
W. A. Penn, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 204/218.

. . . In this paper the loss of information caused by signal interference in correlation or matched filter techniques is evaluated in an approximate manner. This is related to the invariance of the total integral of the Woodward ambiguity function. . . .

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 274/280.

. . . A multidimensional matched filter is considered and its relationship to the likelihood ratios are shown. . . .

DESIGN OF INPUT WAVEFORMS TO YIELD TIME-LIMITED ORTHOGONAL OUTPUTS
J. B. Campbell, et al., Northeastern U., Boston, Mass., March 1963, 59 p., 7 refs., AFCRL-62-907, N63-19808.

. . . Restraints imposed on both input and output sets are that the functions be real-valued, of finite energy and time-limited. It is shown that the proposed solution involves finding a set of real-valued, finite-energy pulses ($p_k(t)$) which are "sufficiently differentiable" for the rational system function and which have the property that the set ($N(B)\ p_k(t)$) is orthogonal, N (B) being the polynomial of differentiation equivalent to the polynomial N(s). . . .

ROTATIONAL TRANSFORMATION OF SIGNALS
G. R. Lang, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 191/198.

. . . The method, a near relative of the smearing techniques which have been suggested recently for continuous systems, provides a new and interesting view of many accepted coding systems and their relative properties. . . . The behavior of certain nonorthogonal transformations is also discussed in contrast to the purely rotational transformations.

1.373: Correlation Receivers for Data Transmission Links

Included: Clipper cross correlator.

Not Included: General radio receiver problems; Theory of correlation detection (2).

Cross References: Spread spectrum waveforms (1.316); Digital sequences as data waveforms (1.314); Correlation processes in signal theory (1.114).

Principal Publications:

CORRELATION DETECTION OF SIGNALS PERTURBED BY A RANDOM CHANNEL
T. Kailath, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 361/366.

OUTPUT SIGNAL-TO-NOISE CHARACTERISTICS OF CORRELATORS
B. R. Mayo, et al., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 4, June 1960, p. 70/74.

This paper presents a detailed analysis of the output signal-to-noise ratio for a correlator consisting of a multiplier followed by an RC averager. Both the signal and the noise are assumed to be band-limited functions with Gaussian amplitude distribution; but no restrictions are imposed on either the input signal-to-noise ratio or the product of the bandwidth and the time constant of the averager. A family of curves are plotted relating output and input signal-to-noise ratios for values of RC Δf ranging from 0.1 to 100. . . .

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P. H. Haas, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, Aug. 1961, 68 p., (Rept. no. GE/EE/61-6), AD 270 272.

Master's thesis . . . A survey . . . as applicable to the statistical analysis of communication is presented . . . Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

IMPULSE RESPONSE OF LINEAR SYSTEMS USING CORRELATION AND DIRECT MEASUREMENT
B. E. Berson, Rochester U., N.Y., Aug. 1962, 58 p. incl. illus. 17 refs., AD 281 770.

If a pseudo-random noise sequence is used as the input to a linear system, then by suitably correlating the output of the system and a delayed version of the input, the impulse response of the system can be obtained. The effect of the finite size of the sequence auto-correlation function upon the expected results is analyticaly determined. . . . a simple method of obtaining a delayed sequence . . . Measurements . . . on low pass rc filters . . . A polarity-coincidence correlator was used . . .

KORRELATIONSELEKTRONIK, GRUNDLAGEN UND ANWENDUNG DER KORRELATIONS - ANALYSE IN DER MODERNEN NACHRICHTEN-, MeB- UND REGELUNGSTECHNIK; (2 Aufl.) (Correlation Electronics, Fundamentals and Application of Correlation Analysis in Modern Communications and Control Technique. Second edition) (In German)
F. H. Lange, Berlin, Verlag Technik, 1962, 381 p.

ON CERTAIN STRATEGIES OF SIGNAL DETECTION USING CLIPPER CROSSCORRELATION (SINGLE SIGNAL SIZE)
G. P. Patil, et al, Office of Research Administration, U. of Michigan, Ann Arbor, Oct. 1962, 37 p., incl. illus. tables, 6 refs. (Technical rept. no. 128; Rept. no. 3674-1-T), AD 288 028.

. . . . signal detection . . . using clipper crosscorrelator . . . Strategies are developed . . . Four such strategies are suggested which arise in a very natural way, and their interrelations are studied. Efficiency of the clipper crosscorrelator in relation to the usual crosscorrelator is defined and investigated in the setup as described.

CORRELATION FUNCTIONS IN A TAPPED DELAY LINE MODEL OF THE ORBITAL DIPOLE CHANNEL
P. Bello, IEEE Trans. Inform. Th., vol. IT-9, Jan. 1963, p. 2/11.

. . . Autocorrelation and cross-correlation functions are computed for the tap functions in terms of assumed statistics for the motion of illuminated dipoles. It is shown that when a certain inequality involving the transmitted signal bandwidth is satisfied, these correlation functions become identical to those which would arise from the corresponding tap-gain functions of a suitably defined channel consisting of a continuum of motionless scintillating uncorrelated scatterers. . . .

USE OF RECIRCULATORS FOR COMPRESSING FREQUENCY-MODULATED PULSES
V. V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 60/68.

The possibility of using circulating memory devices (recirculators) for the optimum extraction of a frequency-modulated pulse in noise is considered. A comparison with the usual filters using dispersive delay lines is carried out. . . .

THE DETECTION OF CHIRPED RADAR SIGNALS BY MEANS OF ELECTRON SPIN ECHOES
W. B. Mims, Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1127/1134.

. . . a device in the receiver delays the earlier portions in such a way that all the received energy is concentrated into a short pulse . . . One way of obtaining the differential delay of frequency components is by passing the received signal through a dispersive network. An alternative scheme involving the generation of electron spin echoes is suggested here. It is readily adaptable to waveforms having a variety of frequency sweeping functions, and it offers the possibility of operating with exceptionally high time compression factors. . . .

Related Publications:

PROCEDURE FOR THE EVALUATION OF CORRELATION TRACKING AND RANGING (COTAR)
C. H. Tapper, Land-Air, Inc., Point Mugu, Calif., 14 Aug. 1961, 164 p., (Rept. no. 30), In cooperation with the Cubic Corp., San Diego, Calif.), AD 264 009.

. . . Evaluation tests at the Pacific Missile Range of the correlation tracking and ranging (COTAR) system, as a radar acquisition device. The instrumentation system is described. The theory of operation and supporting mathematics is presented to explain the method of determining directional cosine functions for the X and Y axes of its specialized antenna field by measuring the phase difference in signals received. Working forms, data reduction procedures, and computer programming developed for these evaluation and acceptance tests are included.

Section 1.38
Special Data Transmission Systems

1.382: Teletype systems (TTY)

Included: Hand-sent Morse code transmissions; CO modulation systems; Voice frequency teletype systems; Teletype signal distortions; Radio telegraphy; Special TTY synchronization problems; ISB = independent sideband radio telegraphy; Telegraphy transmission systems.

Not Included: Multiplexing systems (2); HF radio communications; Error correction codes (2); Fundamentals of synchronization.

Cross References: Fundamentals of CO modulation (1.222); Distortions in transmission channels (Sect. 1.62); Propagation effects on data transmission (Div. 1.6).

Principal Publications:

SINGLE CHANNEL RADIOTELETYPE COMMUNICATION
H. B. Voelcker, Jr., IRE Nat. Conv. Record, vol. 6, March 1958, p. 237/244.

SOME MODERN DEVELOPMENTS IN TELEGRAPH TRANSMISSION EQUIPMENT
W. F. S. Chittleburgh, Elect. Commun., vol. 35, no. 4, 1959, p. 230/239.

A NON-SYNCHRONOUS APPROACH FOR IMPROVED COMMUNICATIONS RELIABILITY
C. H. Stewart, II, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 141/150.

. . . One approach to the provision of increased performance reliability is . . . to minimize detector bandwidth. By using sequential combinations of two audio frequency tones to define the combinatorial possibilities of the standard five-bit teleprinter code, the per-tone sampling

period is increased by a factor in excess of three times that of the start-stop system. The nonsynchronous characteristic of this coding scheme allows optimum use of a variable bandwidth, so that the system can be operated at the maximum circuit capacity for all conditions.

EIGENSCHAFTEN VON TELEGRAPHIE-UBERTRAGUNGSSYSTEMEN MIT FREQUENZMODULATION BEI STORUNGEN DURCH RAUSCHEN (Characteristics of Telegraphy Transmission Systems with Frequency Modulation under Noise and Disturbances) (In German)
H. H. Voss, Entwicklungs-Ber. Siemens-Halske, vol. 22, April 1959, p. 46/52.

TELEGRAPHIEVERZERRUNGEN UND FEHLERHAUFIGKEIT BEI WECHSELSTROMTELEGRAPHIE INFOLGE VON UNTERBRECHUNGEN UND PHASENSPRUNGEN, TEIL II (Distortions of Telegraphy Signals and Error Probability for Tone Telegraphy under Conditions of Short Interruptions and Phase Distortions. Part II) (In German)
H. Zuhrt, et al., Nachrichtentech. Zeitsch., vol. 12, July 1959, p. 347/351.

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1960, p. 1613/1629.

FREQUENCY-MODULATED VOICE-FREQUENCY TELEGRAPH SYSTEMS FOR RADIO TELEGRAPH SERVICES
C. S. Hunt, Post Office Electr. Engrs. J., vol. 53, April 1960, p. 21/23.

SSB/ISB SYSTEMS FOR LONG-DISTANCE RADIOTELEGRAPHY
W. Lyons, vol. 79, no. 2, Feb. 1960, p. 146/149.

CARRIER TO NOISE REQUIREMENTS FOR TELETYPE COMMUNICATION VIA NON-FADING OR FADING UHF CARRIERS
R. W. Plush, et al., Nat. Bureau of Standards, Boulder, Colo., Feb. 1960, NBS rept. no. 5585, AD 233 741.

ADDITION OF TELEGRAPH SIGNALS IN A COMMON RESISTANCE
V. M. Rozov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 111/120.

MEASURED STATISTICAL CHARACTERISTICS AND NARROW-BAND TELETYPE MESSAGE ERRORS ON A SINGLE-SIDEBAND 600-MILE-LONG ULTRAHIGH-FREQUENCY TROPOSPHERIC RADIO LINK
E. F. Florman, et al., J. Res. Nat. Bureau Stand., vol. 64D, no. 2, March-April 1960, p. 125/133.

A study is made of the case of double reception of telegraph signals with d.c. addition in a common resistance. . . .

A NOTE ON ERROR STATISTICS IN FADING RADIOTELETYPE CIRCUITS (Correspondence)
H. Voelcker, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 558.

DETECTION AND INFORMATION RATE OF TELEGRAPHIC SIGNALS
D. A. Bell, IRE Trans. Commun. Syst., vol. CS-9, March 1960, p. 70/77.

. . . decision-making, rather than demodulation. . . . Various error-correcting codes are compared with the second formula. It is shown that correlation-detection is equivalent to minimum-distance detection provided all code groups are of equal mean power, and that a binary-coded signal can always be adjusted to the constant-power state.

A PROPOSED ELECTRONIC METHOD FOR HIGH-SPEED TELEPRINTERS
N. N. Biswas, Commun. Electronics, vol. 80, no. 54, May 1961, p. 115/117.

. . . Among the noteworthy features of the new method are the following: 1. the start signal is replaced by a reset signal RS, consisting of two positive pulses separated by a NO pulse, each of 10-ms duration. 2. The stop pulse is replaced by a negative pulse of 10-ms duration. 3. A space is transmitted by a NO pulse and a mark by a positive pulse of 10-ms duration. . . . 4. During the periods of no transmission, that is, when the line is idle, there is no current flowing in the line. . . . 5. The new code always needs a double-current system for transmission. . . each character has 14 units, with each unit of 10-ms duration. The teleprinter receiver in this method is completely electronic. . . .

APPLICABILITY OF CODING TO RADIO TELETYPE CHANNELS
A. B. Fontaine, Lincoln Lab., MIT, Lexington, 27 Oct. 1961, 6 p. (Rept. 25G-3), AD 266 827.

Approximately 300 hours of radio teletype data were analyzed . . . to determine the applicability of coding theory to radio teletype channels. . . . error detect and repeat schemes with about 10% redundancy will reduce the probability of error to a negligible amount.

ANALYSIS OF OPTIMUM NON-LINEAR FILTERS AND THE RECEPTION OF BINARY TELEGRAPH SIGNALS
V. Klezha, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 5, 1961, p. 20/35.

. . . all a priori information about the signal and noise is used in the form of n-dimensional distribution laws governing the probability of the signal and noise. The author calculates the noise immunity of a special filter for telegraph signals in the presence of Gaussian noise. . . .

THE APPLICATION OF A HAMMING ERROR CORRECTING CODE TO A STANDARD TELETYPE EQUIPMENT
R. W. Levell, J. Brit. Instn. Radio Engrs., vol. 22, no. 5, Nov. 1961, p. 377/392.

. . . describes apparatus which enables a standard single-channel teletype equipment to be converted for use with a Hamming error correcting code. The added apparatus is of small size and involved little interference with existing equipment. . . .

TELEGRAPH DISTORTION ON HIGH-SPEED FREQUENCY SHIFT DATA TRANSMISSION SYSTEMS
M. Maniere, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 259/270.

START-STOP DATA TRANSMISSION WITHOUT THE STOP ELEMENT
R. M. M. Obermann, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1960, p. 259/270.

. . . This increases the telegraph speed from 400 characters per minute to 500 characters per minute.

TELEGRAPH DISTORTION AND DISTORTION MEASURING
H. H. Wusteney, Commun. Electronics, vol. 80, no. 54, May 1961, p. 104/109.

CO-MODULATION, A NEW METHOD FOR HIGH-SPEED DATA TRANSMISSION
F. deJager, et al, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 285/290.

. . . primary objective is to increase the speed of transmission in a given bandwidth. . . . lower frequencies . . . are suppressed . . . using two carrier-voltages differing 90^{o} in phase. . . . pilot signal . . . for phase-reference . . . The name CO-modulation stands for complementary orthogonal modulation. . . .

THE EFFICIENT UTILIZATION OF A TELEGRAPHY CHANNEL FOR THE TRANSMISSION OF INFORMATION (In German)
H. Marko, Nachrichtentech. Zeitsch., vol. 15, no. 9, Sept. 1962, p. 451/452.

VOICE-FREQUENCY TELEGRAPHY SYSTEMS
V. S. Gurov, et al, Joint Publications Research Service, Washington, D. C., June 6, 1963, 219 p., refs., Transl. into English of a monography "Sistemy Tonal'noga Telegrafirovaniya", Moscow, Svyazizdat, 1962 p. 3-206, (JPRS-19591; OTS-63-31001) N64-10510.

. . . circuit features, layout of the voice-frequency telegraph equipment, specific design features of the systems, and transistorized voice-frequency telegraphy systems.

AN INPUT/OUTPUT TYPEWRITER FOR COMMUNICATING WITH A DIGITAL COMPUTER
J. Mitchell, Mitre Corp., Bedford, Mass., March 1964, 44 p. Rept. no. TM 3838, ESD TDR64 81, AD 435 108.

. . . A modification of a standard Selectric typewriter, has been designed for use with the Phoenix computer through the low-speed buffer or with the MITRE 7030 computer through the System Design Laboratory (SDL) display consoles.

THE RTA-60 PAGE TELETYPE
V. V. Novikov, Joint Publications Research Service, Washington, D. C., 24 March 1964, 12 p. Transl. into English of a Russian from the book "Inzhenerno-Tekhnicheskiy Spravochnik po Elektrosvyazi Telegrafiya", Moscow, State Publishing House of Lit. on Probl. of Commun. and Radio 1963, p. 222/229, (JPRS-23836; OTS-64-21876), N64-18317.

The apparatus consists of a transmitting set (keyboard sender, automatic responder, and transmitter) receiving set (electromagnet, teletype device, receiving typesetting and resetting devices, coders and decoders, printing block, and reperforator) . . .

SREDNIAIA DLITEL'NOST' LOZHNYKH IMPUL'SOV I METOD EDINICHNYKH ISKAZHENII DLIA ANALIZA POMEKHOUSTOICHIVOSTI TELEIZMERENIIA (Mean Duration of False Signals, and the Method of Unit Distortions for the Analysis of Telemetering Noise Stability (In Russian, with summary in English)
N. V. Pozin, Avtomatika i Telemekhanika, vol. 24, Sept. 1963, p. 1272/1278, 11 refs., A64-11211.

Evaluation of the mean duration of false signals at the input of a low-frequency channel of a telemetering receiver . . . method of unit distortions for calculating the noise resistance of telemetry signal transmissions . . .

KRITERII TOCHNOSTI TELEIZMERENIIA PRI VOZDEISTVII POMEKH KANALA SVIAZ (Criterion for Telemetering Accuracy in the Presence of Communication-Channel Noise (In Russian)
N. V. Pozin, Avtomatika i Telemekhanika, vol. 24, Dec. 1963, p. 1712/1717, A64-13120.

Determination of the telemetering error induced by channel noise and instability of telemetering devices. A dimensionless criterion, termed the noise-proof factor, is derived for the analysis of the effectiveness of interference killing in individual telemetering techniques.

THE ANALYSIS OF MULTIPLE SIGNAL DATA
J. W. Smith, IEEE Trans. Inf. Theory, vol. IT-10, no. 3, July 1964, p. 208/214.

This paper discusses the automatic processing of data containing multiple signals. In particular, filters which modify their structures in order to recognize initially unknown waveforms in Gaussian noise and an unknown signal environment are investigated experimentally. . . .

The results demonstrate the possibility of using filters of the new type for automatically processing data although the relevant waveforms may be unknown a priori. . . . Problems which fit into the broad category described are: 1) Radar detection in a multiple emitter environment; 2) Multiple signal communications systems such as hand-sent Morse code; 3) Medical or reconnaissance data.

DEVELOPMENT OF TELETYPEWRITER GROUP AN/GGA-2(XW-2)
M. V. Vlack, et al., 27 Nov. 1963, 83 p., RADC TDR64 98, AD 436 895.

Development is reported of a highly efficient, solid-state error-detection and correction system (AN/GGA-2(XW-2)) for use in long-haul digital-data radio teletypewriter links . . .

RADIOTELEGRAPHY
M. V. Verzunov, Joint Publications Research Service, Washington, D. C., 3 March 1964, 71 p. Transl. into ENGLISH of a Russian pamphlet, Moscow, Mil. Publishing House of the Defense Min. USSR, 1961, p. 1/80, (JPRS-23500; OTS64-21706), N64-18054.

. . . covers . . . (1) radiotelegraphic methods and radiotelegraph signal parameters; (2) amplitude keying . . . (3) frequency keying . . . (4) telegraph keying in multichannel operation; (5) phase keying . . . (6) methods of improving radiotelegraphy-communications stability; and (7) remote-transmitter keying.

SYNCHRONIZATION OF DIGITAL SYSTEMS BY MEANS OF A TRANSISTORIZED TRANSMITTER DISTRIBUTOR
R. A. Woerner, Illinois University, Urbana Engineering Experiment Station, 20 Jan. 1964, 36 p., Rept. no. TR22, AD 430 597.

. . . a general purpose transistorized data synchronizer. . . . the system has the capabilities of synchronizing data transmission between a number of transmitting and receiving systems. The main function of the distributor is to control the flow of data between Teletype equipment and various digital systems. . . . capable of transferring up to 8 channels of parallel data. . . . Only five channels of data can be transmitted in the serial to parallel modes since the present Teletype equipment transmits 5 data bits per word. . . . The present speeds are 60, 75, or 100 words/minute. . . .

MINIMUM SIGNAL TO NOISE-DENSITY RATIOS FOR TRANSMISSION OF TELETYPE AND SPEECH
F. F. Yates, Aerospace Corp., El Segundo, Calif. Engineering Div., Jan. 1964, 12 p. refs., (SSD-TDR-63-215; TDR-269(4111)-7; AD 429 202), N64-15825.

. . . requirements of a phase-modulation communication channel . . . Three typical communication services are analyzed: (1) 100 wpm teletype . . . (2) 3 kc voice, 80% word intelligibility, (3) 3 kc voice, 30 db output base band signal-to-noise ratio (measured for a sinusoidal test tone) . . .

Related Publications:

APPLICATIONS OF REDUNDANT CODES TO A DIGITAL COMMUNICATION SYSTEM
R. L. Sharma, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 241/249.

. . . An error detecting scheme is discussed for a card-to-card or tape-to-tape digital communication system. Hamming code is analyzed for application to a teletype data. M-sequence codes are also investigated and are shown to be best suited for group synchronization and some selective calling systems. . . .

OPTIMIZATION OF A NONLINEAR CONTROL SYSTEM WITH A RANDOM TELEGRAPH SIGNAL INPUT
A. T. Fuller, J. Electronics Control, vol. 10, no. 1, Jan. 1961, p. 61/80.

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R. O. Rowlands, IRE Intern. Conv. Rec. Pt. 4, vol. 10, March 1962, p. 185/189.

. . . This paper attempts to fill the need of the engineer who is designing a signal detection system and who wants a rough idea of the relative merits of the various basic detection methods that are available. Five common binary detection systems are analyzed and formulas are derived for the signal-to-noise ratios required to give the same probabilities or error in each system. The effects of varying the duration of the signal and the bandwidth of the noise are discussed for each system, and the region is defined within which the detectability of the signal is improved by clipping. . . . 1. Ideal Correlator . . . 2. Square-Law Detector . . . 3. Two-Channel Correlator . . . 4. Sign Correlator . . . 5. Two-Channel Sign Correlator . . .

A MAGNETIC AMPLIFIER FOR LOW-LEVEL TELEGRAPH SIGNALS
L. A. Rioual, J. Brit. Instn. Radio Engrs., vol. 25, no. 6, June 1963, p. 541/546.

In the design of submerged repeaters for submarine telegraph cables, the need arises for a circuit capable of amplifying very low frequency signals with great reliability. It is highly desirable that the bulk of the apparatus be reduced to a minimum. A repeater circuit is described, in which a magnetic amplifier is used for frequency conversion of the telegraph signals. . . .

TRANSISTORIZED 2-24 CHANNEL CARRIER TELEGRAPH EQUIPMENT
K. Takahashi, et al., IEEE Trans. Commun. Electronics, vol. CE, no. 66, May 1963, p. 207/213.

. . . The transistorized 2X24-channel carrier telegraph equipment consists of two FM (frequency modulation) type 24-channel systems in a bay, as recommended by the CCITT . . . frequency range of 420 to 3,180 cps.

DOUBLE FREQUENCY-SHIFT KEY DEMODULATION STUDY

Page Communications Engineers, Inc., Washington, D.C., Final rept., 4 April 1962 - 30 June 1963, Aug. 1963, lv. Rept. no. PCE R--52 0028A, RADC TDR63 393, AD 422 929.

. . . detection of received signals in double frequency-shift keying systems is reported . . . earlier . . . a variable decision technique was applied to an experimental DFSK demodulator and, in controlled tests, achieved a substantial reduction in teleprinter errors during frequency selective fading . . . the decision logic was refined and simplified . . . Actual performance was tested over a 2500-mile radio path in comparison with a conventional DFSK system. In single-diversity operation, the experimental demodulator performed as well as the conventional system in dual diversity. With both systems in single diversity, it appeared to outperform the conventional demodulator by about 40 to 1 in error rate . . .

1.383: Multi-Functional Data Transmission Systems

Included: LOGICOM (Canadian system); DEFT system of General Dynamics; Simultaneous phase and amplitude modulation in data systems.

Cross References: Hybrid modulation methods in general (1.280); PACM-FM modulation method (1.934).

Principal Publications:

COMBINED AM AND PM FOR A ONE-SIDED SPECTRUM (Correspondence)
N. Chakrabarti, Proc. IRE, vol. 47, Sept. 1959, p. 1663.

COMBINED DIGITAL PHASE AND AMPLITUDE MODULATION COMMUNICATION SYSTEMS
C.R. Cahn, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 150/155.

. . . investigated for the asymptotic case of a high signal-to-noise ratio. A simple and excellent approximation to the probability of error is derived for both coherent and phase-comparison demodulation. In addition, a simple expression is derived for the asymptotic degradation of phase-comparison demodulation . . . When the number of bits per sample of the signal is large, a combination of digital amplitude and phase modulation is found to make more efficient use of transmitter power than phase modulation alone.

PERFORMANCE OF COMBINED AMPLITUDE AND PHASE-MODULATED COMMUNICATION SYSTEMS
J.C. Hancock, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 232/237.

LOGICOM: A DIGITAL COMMUNICATION SYSTEM
D.C. Coll, Defense Research Telecommunications Establishment, Canada, Feb. 1961, (DRTE rept. no. 1055), AD 254 313.

. . . was used as a demonstration of: information source coding, error detection and correction through use of redundant coding for transmission, burst transmission, and visual display of received message. LOGICOM was constructed with the use of logic modules.

A COHERENT DIGITAL AMPLITUDE AND PHASE MODULATION SCHEME
C.N. Campopiano, et al, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 90/95.

. . . a technique for a combination of amplitude and phase modulation for digital communication. . . . assumes phase coherence between transmitter and receiver. . . . we also assume baud synchronization. . . . involves the simultaneous and independent amplitude modulation of two carriers of the same frequency . . . are in quadrature with each other. The demodulation process consists of the separation of the in-phase and quadrature components followed by amplitude detection. This scheme appears to be easier to implement than either the system studied by C.R. Cahn or the system investigated by J.C. Hancock and R.W. Lucky. . . . channels perturbed by additive, narrow-band, zero-mean Gaussian noise. . . .

ON THE OPTIMUM PERFORMANCE OF N-ARY SYSTEMS HAVING TWO DEGREES OF FREEDOM
R.W. Lucky, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 185/192.

. . . the n possible symbols correspond to n vectors in a 2 WT_0 dimensional signal space. This paper considers the theoretical properties of digital systems where the signal space is two-dimensional. Such systems are both amplitude-and phase-modulated. Approximate expressions are derived for the average probability of error for these systems as a function of the placement of the n symbol vectors in the two-dimensional signal space. . . .

DEFT WIRE-LINE STUDY
General Dynamics/Electronics, Rochester, N.Y., Griffiss AFB, N.Y., Advanced Development Lab., Sept. 1963, 83 p., 6 refs., (RADC-TDR-63-358), AD 419 483, N63-22405.

. . . consideration of methods for adapting DEFT, a high-capacity communications system for use on the telephone network, and determination of the performance of an experimental DEFT modem over a leased long-distance telephone circuit . . . (7000 bits per second, or more) . . . Performance data was accumulated for 125 hours of testing of a single channel capable of handling 50 bits/second in a 20 cps band. A "K"-carrier loop was used as the transmission medium . . . Alignment drifts in the equipment were determined . . .

DIVISION 1.4
SAMPLING MODULATION METHODS

A large class of modulation methods is referred to as pulse modulation systems. Communications engineers use abbreviations, or three letter codes, for the various subclasses. P is used for pulse modulation; PAM stands for pulse amplitude modulation, PPM for pulse position modulation; PWM for pulse width modulation; and so on.

Control engineers use the same modulation methods under the designation of sampled data systems. The control system designer's problems are different. Noise and distortions are of less importance to him than stability and transient behavior.

Yet there are many common problems between communications and control engineering in the treatment of these modulation systems. The sampling process in the time domain and its theory is one of them. This is why we gave this division the title "sampling modulation methods." Section 1.41 deals with such common fundamentals.

The following three sections contain references to special classes of sampling modulation methods. Pulse amplitude modulation is the carrying of the sampled information in the amplitude domain (section 1.42); pulse frequency modulation and pulse repetition rate modulation are representatives of sampled frequency modulation methods (section 1.43); and three versions of the so-called time modulation methods may be considered as a kind of sampled "phase modulation" (section 1.44).

A special section (1.47) is devoted to a selection of references describing related publications of sampled data control systems.

There are other possibilities for sampling modulation methods which have not demanded as much attention as the above mentioned methods. They are referenced in section 1.48. Pulse slope modulation is one of them.

Section 1.40

1.400: Sampling Modulation Methods in General

Included: Pulse modulation methods; Semi-analog modulation methods.

Not Included: Time division multiplex systems (2).

Cross References: Sampled data transmission systems (control applications) (Sect. 1.47); Pulse code modulation methods (Div. 1.5); Comparison of modulation methods (Div. 1.8); Multiple modulation methods (Div. 1.9).

Principal Publications:

UNTERSUCHUNGEN AN PULSMODULATIONS-VERFAHREN, TEIL I, II, III (Investigations of Pulse Modulation Methods) (In German)
H. Hunicke, Nachrichtentech., vol. 8, Oct. 1958, p. 456/460, vol. 8, Nov. 1958, p. 501/510, vol. 9, Jan. 1959, p. 29/35.

CLASSIFICATION AND EVALUATION OF COHERENT SYNCHRONOUS SAMPLED-DATA TELEMETRY SYSTEMS
A. Viterbi, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, 15 June 61, 10 p., Technical rept. no. 32-123, AD 260 585.

An analysis is given of the various types of continuous wave and pulse modulation for the transmission of sampled data over channels perturbed by white gaussian noise. Optimal coherent synchronous detection schemes for all of the different modulation methods are shown to belong to one of two general classes: (1) linear synchronous detection, and (2) correlation detection. The figures of merit, mean-square signal-to-error ratio and bandwidth occupancy, are determined for each system and compared.

RADIO TELEMETRY (In Russian)
F. I. Barsukov and M. V. Maksimov, Moscow, Oborongiz, 1962, 184 p.

. . . elements of radio telemetering systems with frequency, time, code, and combined division of channels. Particular attention is devoted to the problems of encoder and decoder construction in radio telemetering systems and also to the features of transmitter-receiver and antenna systems. . . . intended for those familiar with the principles of radio engineering. . . .

SAMPLED DATA MODULATION SYSTEMS
R. Sanders, IN: Space Communications, Edited by A. V. Balakrishnan, New York, McGraw-Hill Book Co., Inc., 1963, p. 104/122, A64-11236.

Survey of three classes of modulation techniques: (1) that which transforms a signal waveform into some continuously variable modulation parameter where no sampling or time quantization of the signal source is performed prior to modulation; (2) that involving continuously variable modulation parameters; and (3) that commonly referred to as any general method of digital transmission . . . Included . . . synchronization requirements in class (2) modulation systems; PCM systems; bandwidth requirements for PCM systems; error correction and detection methods in PCM systems; and orthogonal systems.

PAM, PDM, AND PCM TECHNIQUES IN APPLICATION TO DIGITAL TELEMETRY ON VOICE BANDWIDTH FACILITIES
C. Yanis, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 139/151.

. . . The requirements of these telemetry modes in terms of link conditions, tone equipment, and terminal equipment is examined. Conclusions are reached regarding adaptability to high speed, multiplexing, and hardware requirements.

Section 1.41
Fundamentals of Sampling Modulation Methods

The theory for this class of semi-analog modulation methods incorporates elements of the theory of discrete communication systems and of the analysis of continuous communications channels. Historically it is important to note that this class emerged from pulse communications systems operating as time division multiplex systems. A pulse communications systems theory was actually developed several years prior to the original publications of communications theory. The limitation of this bibliography to the period 1958-1963 excludes most of the original papers in pulse communications analysis.

The relatively easy design of synchronous time division systems, as compared to asynchronous systems, leads to the general acceptance of a constant sampling rate. It is only recently that the few earlier papers on asynchronous (adaptive) sampling processes have been given more attention. It can be expected that such more sophisticated, but highly efficient, non-synchronous sampling processes will be applied in the future. Most of the problems associated with these advanced systems are subjects of the various divisions of volume 2 of this series.

This analytical section is further subdivided to single out the more important theoretical areas, such as special transforms (1.411), the sampling theorem (1.412), the discussion of pulse train spectra (1.413) and references to a variety of sampling processes (1.414 and 1.418).

1.410: Analysis of Time Discrete Systems

Included: Periodic pulse modulated time series; Time jitter in pulse communications systems; General theory of pulse systems; Books on the theory of pulse systems; Theory of semi-analog systems; Theory of digital-analog systems; Timing errors in sampled systems; Bandwidth limitations in pulse communications systems; Distortions in pulse systems.

Not Included: Intersymbol crosstalk in time division systems (2); Analysis of non-synchronous pulse communications systems (2); Coding of time-discrete systems (2).

Cross References: Theory of pulse code modulation systems (1.510); Pulse distortions in transmission channels (Sect. 1.62).

Principal Publications:

SOME SIMPLIFYING ADDITIONS TO BASIC SAMPLED-DATA THEORY
C. O. Carlson, IRE WESCON Conv. Rec., Pt. 4, no. 4, Aug. 1958, p. 197/232.

PHASE INTERCEPT DISTORTION IN FREQUENCY, PHASE, PULSE AMPLITUDE, AND PULSE TIME MODULATION SYSTEMS
C. May, et al., Dunham Lab., Yale U., Quarterly Progress Report No. 7 for the period ending 4 Sept. 1959, 26 p., AD 226 643.

The effects of a phase intercept angle upon the information that is conveyed by frequency, phase, pulse amplitude, and pulse time modulation systems are considered. See also AD 207 085.

TIME SERIES ANALYSIS
E. J. Hannan, New York, John Wiley & Sons, Inc., 1960, 152 p.

. . . an introduction to the statistical analysis of stationary second-order time series in discrete time. . . .

STATISTICAL EVALUATION OF DIGITAL—ANALOG SYSTEMS FOR FINITE OPERATING TIME
R. B. Northrop, et al., IRE Trans. Automatic Control, vol. AC-5, no. 2, June 1960, p. 118/128.

A frequency-domain mathematical model for comparing the performance of a linear sampled-data channel to a linear continuous channel is developed. . . .

EINFUHRUNG IN DIE THEORIE DER ABTASTSYSTEME (Introduction to the Theory of Sampled-Data Control Systems) (In German)
J. Tschauner, Munich, R. Oldenbourg, 1960, 185 p.

The mathematical theory of sampled-data control systems is dealt with in three main sections. The first of these deals with open-loop systems and the second with closed-loop systems and in each case some numerical examples and oscillograms of actual results are included. The third section is concerned with certain mathematical methods, namely, the Zeta-transform, the Taylor-transform and difference methods, and their application to sampled-data control systems. . . .

THE THEORY OF PULSE SYSTEMS
Y. Z. Tsypkin, Radio Engng: Transl. of Radiotekhnika, Moscow, Fizmatgiz, 1958, vol. 15, no. 3, 1960, p. 113/116.

ON THE PROBLEM OF TIME JITTER IN SAMPLING
A. V. Balakrishnan, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 226/236.

SOME EFFECTS OF BANDWIDTH LIMITATION ON P.S.M., P.L.M., AND P.P.M. SIGNALS
J. Das, Proc. Instn. Elect. Engrs., Lond., Part C, vol. 109, no. 16, Sept. 1962, p. 646/655, 23 refs.

A comparative study has been made of the effects of bandwidth reduction on such important parameters as sideband and harmonic distortions, crosstalk attenuation and message/noise ratios, in pulse-slope modulation, pulse-length modulation and pulse-position modulation systems. . . .

TIMING ERRORS IN A CHAIN OF REGENERATIVE REPEATERS, I
B. K. Kinariwala, Bell Syst. Tech. J., vol. 41, no. 6, Nov. 1962, p. 1769/1780.

The pulse displacements produced by timing errors in a chain of regenerative repeaters (using tuned-circuit timing filters) are represented by a linear transformation of the pulse displacements at the output of the first repeater. To facilitate the discussion of the general problem, the simpler case of periodic pulse trains is considered first. For this case it is shown that while the mean value tends to infinity, the central moments of the pulse displacements remain bounded as the number of repeaters approaches infinity. Further results are obtained which show that all the moments of the spacing jitter remain bounded for an indefinitely long string of repeaters. . . .

TIMING ERRORS IN A CHAIN OF REGENERATIVE REPEATERS, II
B. K. Kinariwala, Bell Syst. Tech. J., vol. 41, no. 6, Nov. 1962, p. 1781/1797.

The behavior of the timing jitter in a long chain of repeaters is shown to depend on the spectral properties of a linear operator which maps the space of bounded sequences into itself. As the number of repeaters increases indefinitely, so does the mean value of the jitter. The variation about this mean value remains bounded only for certain highly constrained pulse trains (e.g., periodic, finite, etc.), but it is otherwise unbounded.

THEORETICAL ANALYSIS OF A TYPICAL SAMPLED-DATA SYSTEM
H. R. McCarley, Army Missile Command, Redstone Arsenal, Huntsville, Ala., 21 Jan. 1962, 12 p. incl. illus., Rept. no. RG-TR-63-5, AD 296 863.

. . . The analysis of sampled data systems presents several features quite different from those found in continuous systems. . . . tendency to over correct for the accumulated error. . . . mathematical stability analysis of a typical sample data servo using the Z transform and root locus. The system was simulated on a Donner 3200 analog computer. . . .

CLASSIFICATION AND EVALUATION OF COHERENT SYNCHRONOUS SAMPLED-DATA TELEMETRY SYSTEM
A. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 1, March 1962, p. 12/23.

. . . various types of continuous wave and pulse modulation . . . perturbed by white Gaussian noise. Optimal coherent synchronous detection schemes for all the different modulation methods are shown to belong to one of two general classes: linear synchronous detection and correlation detection. The figures of merit, mean-square signal-to-error ratio and bandwidth occupancy, are determined for each system and compared.

A DETERMINISTIC STUDY OF DELTA MODULATION
C.A. Halijak, et al., IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 247/259.

. . . This paper views delta modulation as a hybrid PDM/PAM system. A nonlinear feedback model is constructed and subjected to digital computation on an IBM 650.

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge., 31 Jan. 1963, 101 p. (Technical rept. no. 399), AD 299 016.

Related Publications:

OPTIMUM FILTERING OF PERIODIC PULSE-MODULATED TIME SERIES
W.A. Janos, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 67/74.

. . . class of input time series in which the amplitude is modulated by uniformly-pulsed periodic functions. A uniform sampling of the output at a period equal to the pulsing period displays the property of time invariance.

DUAL-MODE FILTERING OF POLYNOMIAL SIGNALS IN NOISE
L.G. Shaw, (Western Electronic Show and Convention, San Francisco, Calif., Aug. 22-25, 1961), IEEE Trans. on Automatic Control, vol. AC-8, April 1963, p. 136/142.

. . . procedure for finding the best (minimum mean-square error) filter of a class of dual-mode (adaptive) filters when the input consists of a sample from an ensemble of fixed-order polynomials plus "almost white" noise.

ON THE DETERMINATION OF THE NUMBER OF SAMPLINGS AND THE APPROXIMATE FUNCTION FOR STATIONARY RANDOM PROCESSES
N. L. Sosenskiy, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 4/12.

By using the linear interpolation theory of stationary random processes, we will solve the problem of determination of the number of samplings that are necessary to approximate a stationary random process to a given degree of accuracy. . . .

DELAY OF TIME FUNCTIONS BY MEANS OF FREQUENCY DOMAIN SAMPLING
W.W. Wierwille, Commun. Electronics, vol. 80, no. 59, March 1962, p. 63/65.

It is possible to obtain delays of finite duration time functions by sampling in the frequency domain. The method is applicable when the delay time is greater than the waveform duration. The method is particularly amenable to analog computer techniques, and no special equipment is required. The holding feature of these machines makes it possible to delay functions several minutes. . . .

1.411: Mathematical Fundamentals of Time-Discrete Systems

Included: Z-transform; Sensitivity considerations; Interpolation of time functions; Prediction of time functions; Vector sequence concept; Time series analysis of sampled data transmission systems.

Not Included: Optimum linear filtering of time series (2).

Cross References: Least square error criterion (1.810); Sampling of statistical populations (1.119).

Principal Publications:

THEORETICAL FUNDAMENTALS OF PULSE TRANSMISSION
E.D. Sunde, Bell Syst. Tech. J., May 1954, p. 729.

STATISTICAL DESIGN THEORY FOR STRICTLY DIGITAL SAMPLED-DATA SYSTEMS
S.S.L. Chang, Commun. Electronics, Jan. 1958, p. 702/709.

. . . z-transform theory for the analysis and synthesis of sampled-data systems. Applicable when correlation functions concerning the input signals are the only known factors . . .

THE SAMPLED-DATA PROCESS, ITS BASIC TRANSFORM AND DERIVATIVE PROPERTIES
W.H. Shields, System Development Corp., Santa Monica, Calif., Rept. No. SP 45, Sept. 1958, 39 p, AD 209 511.

FREQUENCY DOMAIN APPLICATIONS TO DATA PROCESSING
M.A. Martin, IRE Trans. Space Electronics Telemetry, vol. SET-5, March 1959, p. 33/41.

. . . telemetered functions are not measured continuously. To permit time multiplexing, values of these functions are determined only at constant time intervals; it is said that they are sampled at a specified sampling frequency.

Smoothing, differentiation and integration of continuous signals are quite familiar. Mathematical tools have been developed which perform similar operations on digitized sampled functions; by analogy, these tools are called numerical filters, or simply filters.

ANALYSIS OF PULSE DURATION SAMPLED-DATA SYSTEMS WITH LINEAR ELEMENTS
R.E. Andeen, IRE Trans. Automatic Control, vol. AC-5, no. 4, Sept. 1960, p. 306/313.

. . . application of z-transform techniques to the analysis of sampled-data systems in which signals appear in pulse-duration modulated form. . . .

CONTRIBUTION TO THE MODIFIED Z-TRANSFORM THEORY
E. I. Jury, J. Franklin Inst. (USA), vol. 270, no. 2, Aug. 1960, p. 114/129.

Introduces a complex convolution theorem for the modified Z-transform . . . The theorem is fairly general and a number of special cases of wide interest are discussed, including relationship with Z-transform theory, evaluation of square error at sampling instants, analysis of integral square error and others of importance in conventional and multi-rate sampled-data systems. Examples are discussed and a short table of relevant transforms is given. Additional theorems include one enabling the solution of certain types of non-linear difference equations.

INTRODUCTION A L'ANALYSE DES SYSTEMES ASSERVIS A INFORMATION PULSEE (Introduction to the Analysis of Pulse Transmission Systems) (In French)
M. S. Thelliez, et al., Ann. Radioelect., vol. 16, no. 63, Jan. 1961, p. 9/68, 55 refs.

Having described the class of servo controlled systems examined in this article, the authors deal with the two main sampling and reconstitution operations on the information. They then present the Z transformation, the inverse transformation and their more interesting properties . . . helps to define the pulsed transfer functions of the principal structures encountered in practice, and this extension of the transfer function is the subject of the third chapter. The fourth chapter sets out . . . the analysis of the absolute stability of this family of systems the importance of which is demonstrated in the conclusion.

ANALYSE DES SYSTEMES A INFORMATIONS DISCRETE A L'AIDE DU CONCEPT DE VECTOR SEQUENCE CONCEPT (In French) (Discrete Information System Analysis Employing the Vector Sequence Concept)
R. J. Boudarel, et al., (Compagnie Européene d' Automatisme Electronique, Paris, France), Academie des Sciences (Paris), Comptes Rendus, vol. 256, no. 7, 11 Feb. 1963, p. 1465/1468, A63-17397.
Linear and nonlinear discrete information analysis based on a vector sequence analogy.

UTILISATION DE LA TRANSFORMATION EN Z POUR L'ETUDE DE LA POURSUITE AUTOMATIQUE DES INFORMATIONS RADAR (Application of the Z-Transform for the Study of Automatic Tracking in Radar Systems) (In French)
J. P. Gouyet, Ann. Radioelect. vol. 17, no. 67, Jan. 1962, p. 30/58.

. . . automatic detection and tracking of aircraft by means of search radars . . . article is concerned, in Part I, with the mathematical aspect of the problem of the reconstitution of aircraft tracks in the horizontal plane. It is shown that this problem is identical to that of filtering digital or sampled information. The sampling period is equal to the rotation of the search radar antennas used with the automatic tracking system. By using the mathematical operator, which is the Z transformation, as well as the evaluation criteria normally used in any sampling system, an analysis is given of absolute stability, relative stability and fluctuation filtering efficiency of the tracking system under examination.

SENSITIVITY CONSIDERATIONS IN CONTINUOUS AND SAMPLED-DATA CONTROL SYSTEMS
M. E. Gieseking, Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, Aug. 1963, 90p., AD 420 685.

Sensitivity is the percentage change in transmission function due to a percentage change in plant parameter. . . . The Bode diagram is used to investigate the sensitivity function in the frequency domain. . . . For frequencies approaching one-half the sampling frequency, the magnitude of the sensitivity functions of sampled-data systems is greater than one. As sampling frequency increases, the poles of a sampled-data system move toward z-1 on the z-plane root locus diagram.

CIRCUIT WAVEFORMS FOR PERIODIC WAVES
D. L. Waidelich, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 108/115.

. . . A method using steady-state transforms is described which indicates how the sum function of a Fourier series may be obtained. The method can be applied to problems arising from circuits containing concentrated circuit parameters, but is not quite so useful for those having distributed parameters. . . .

Related Publications:

DISCRETE ORTHONORMAL EXPONENTIALS
T. Y. Young, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 10/18.

. . . In this paper, we deal with digitizing the orthonormal exponentials with complex exponents. The z-transforms of continuous orthonormal exponentials are not themselves orthogonal in z-domain . . . For this reason, we introduce the Kautz process in the z-domain to define a set of discrete orthonormal exponentials. These discrete orthonormal exponentials approach the ordinary continuous orthonormal exponentials in the limit as the sampling interval T approaches zero.

*1.412: Sampling Theory

Included: Sampling theorems; Sampling errors; Band-pass sampling; Linear distortions due to sampling; Aliasing error; Optimum presampling filters; Sample-hold-resample processes; Truncation errors.

Not Included: Smoothing of sampled functions (2); Redundancy reduction through adaptive sampling (2).

Cross References: Theory of quantization (1.511); Sampling of statistical populations (1.119); Rotation sample design (1.418); Sampling processes (1.414).

Principal Publications:

ON SAMPLING THE ZEROS OF BANDWIDTH LIMITED SIGNALS
F. E. Bond, et al., IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 110/113.

SAMPLING THEOREMS FOR LINEAR TIME-VARIANT SYSTEMS
T. Kailath, Mass. Inst. Tech., Quarterly Progress Rept. Res. Lab. Electronics, July 1958, p. 128/133.

A SAMPLING THEOREM FOR STATIONARY RANDOM PROCESSES
D. W. Tufts, Mass. Inst. Tech., Quarterly Progress Rept., Res. Lab of Electronics, July 1958, p. 111/116.

SAMPLING OF SIGNALS WITHOUT D. C. COMPONENTS (Correspondence)
D. A. Bell, Electronic Radio Engr., vol. 36, May 1959, p. 193.

. . . the extension of the Sampling Theorem to bands not extending down to zero frequency was proved by Kohlenberg in 1953; and contrary to the conclusion reached by Dr. Billings, in the February issue, he was able to show that a mean sampling rate 2 Δf still suffices.

SAMPLING OF SIGNALS WITHOUT D. C. COMPONENTS
A. R. Billings, Electronics Radio Engr., vol. 36, Feb. 1959, p. 70/72.

SAMPLING OF SIGNALS WITHOUT D. C. COMPONENTS (Correspondence)
A. R. Billings, Electronic & Radio Engineer, vol. 36, July 1959, p. 275.

A DISCUSSION OF SAMPLING THEOREMS
D. A. Linden, Proc. IRE, vol. 47, July 1959, p. 1219/1226.

The convolution theorem of Fourier analysis is a convenient tool for the derivation of a number of sampling theorems. Second-order sampling of low-pass and band-pass functions, quadrature and Hilbert-transform sampling, sampling of periodic functions, and simultaneous sampling of a function and of one or more of its derivatives.

ON THE ACCURACY OF RESTORING A FUNCTION WITH A FINITE NUMBER OF TERMS OF A KOTEL'NIKOV SERIES
B. S. Tsybakov, et al., Radio Engrg. Electronics vol. 4, no. 3, 1959, p. 274/275.

A SAMPLING THEOREM FOR STATIONARY RANDOM PROCESSES
D. W. Tufts, Mass. Inst. of Tech. Res. Lab. Electronics, Progress Rept. no. 53, April 1959, p. 87/93.

A GENERALIZATION OF THE SAMPLING THEOREM
D. A. Linden, et al., Information Control, vol. 3, no. 1, March 1960, p. 26/31.

. . . sampling theorem for bandlimited functions allow one to reconstruct exactly a function containing no frequencies higher than W cps, given the values of the function at equispaced sampling points 1/2W sec apart. . . . values of the function and its first R derivatives at equispaced sampling points, (R+1) 2W sec apart. . . .

THEORETICAL BOUNDS ON THE PERFORMANCE OF SAMPLED DATA COMMUNICATIONS SYSTEMS
J. J. Spilker, Jr., IRE Trans. Circuit Theory, vol. CT-7, no. 3, Sept. 1960, p. 335/341.

. . . sampling at a rate two or more times the maximum message frequency. . . . In practical communications systems, the message spectrum is not strictly bandlimited, and noise is necessarily introduced into the sampled message by transmission. . . . message can be recovered with only small error by filtering the message before sampling and carefully choosing the smoothing filter.

DESIGN PROBLEMS IN PULSE TRANSMISSION
D. W. Tufts, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Doctoral thesis, 28 July 1960, 48 p. 24 refs., Technical rept. no. 368), AD 259 772.

. . . The results provide a generalization of the sampling principle.

LINEAR DISTORTIONS IN THE SAMPLING OF CONTINUOUS SIGNALS
V. A. Vol, Radio Engng: Transl. of Radiotekhnika vol. 15, no. 4, 1960, p. 61/69.

. . . distortions . . . when sampling time cannot be regarded as infinitely small, whilst the law governing the variation in the steepness of the converter is arbitrary. It is shown that the output voltage depends not only on the frequency of the corresponding component of the input signal but also on its phase when the form of the variation in the steepness of the converter is asymmetrical during the sampling period. These distortions can therefore only be regarded as phase-frequency distortions in the first approximation. . . .

SAMPLING THEOREMS AND BASES IN A HILBERT SPACE
F. J. Beutler, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 97/117.

A unified approach to sampling theorems for (wide sense) stationary random processes rests upon Hilbert space concepts. New results . . . along the following lines: recovery of the process x(t) from nonperiodic samples, or when any finite number of samples are deleted; conditions for obtaining x(t) when only the past is sampled; a criterion for restoring x(t) from a finite number of consecutive samples; and a minimum mean square error estimate of x(t) based on any (possibly nonperiodic) set of samples. . . .

INFORMATION BANDWIDTH PROBLEMS IN INSTRUMENTATION OF MISSILE FLIGHT TESTS
W. E. Mimmack, IRE Trans. Mil. Electronics, vol. MIL-5, no. 4, Oct. 1961, p. 272/278.

. . . It can be shown . . . that the rate of information acquisition of a sampled-data instrumentation system, when considered as a function of sampling interval, has a maximum . . .

THEORETICAL BASIS AND PRACTICAL IMPLICATIONS OF BAND-PASS SAMPLING
C. L. Ackerman, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 1/9.

If the Shannon sampling theorem is extended to the case of band-pass signals, the result is that a sampling rate between 2W and 4W samples per second suffices for a complete reconstitution of the signal. . . . In this paper, the effect of band-pass sampling is studied in a sampled-data correlation system using signal-to-noise processing gain as a performance measure. It is concluded that such alternatives as demodulation or quadrature sampling may be necessary to prevent degradation of system performance when band-pass sampling is employed.

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
D. G. Childers, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 267/283.

. . . to determine the effect of 1) data power spectrum, and 2) system design parameters on aliasing and data interpolation error. . . . Results are applicable to time-division multiplexed telemetry systems. In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM telemetry systems and PACM-FM. . . . The experimental test utilized a PAM-FM system to derive an accurate measurement of attainable performance and to indicate when other equipment factors begin to impose a limit on data recovery accuracy. . . . In most applications, especially when the interpolation error must be 1 per cent or better, a minimum samples per cycle of 3 or higher will be required. . . .

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING
G. Einarsson, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 15 March 1962, 76 p. Technical rept. no. 400, AD 416 605.

. . . A sampling theorem for linear bandpass filters is derived, and the results that can be expected when it is used to represent a single fluctuating path with Doppler shift are discussed.

TRUNCATION ERROR OF SAMPLING-THEOREM EXPANSIONS
H. D. Helms, et al., Proc. IRE, vol. 50, Feb. 1962, p. 179/184.

. . . arises in reconstituting a band-limited function by summing over only a finite number (instead of the requisite infinite number) of samples of this function in an appropriate sampling-theorem expansion. Upper bounds are given for the truncation errors of the Cardinal and Fogel sampling expansions and for "self-truncating" versions of these two sampling expansions.

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J. M. Kirshner, Conf., Proc. Natl. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

The concept of signal space allows one to apply geometric principles to waveforms used in communication. . . . 4. The Sampling Theorem and Separation of Channels. . . .

SAMPLING AND RECONSTRUCTION OF WAVE-NUMBER-LIMITED FUNCTIONS IN N-DIMENSIONAL EUCLIDEAN SPACES
D. P. Peterson, et al., Inform. Control, vol. 5, no. 4, Dec. 1962, p. 279/323.

. The well-known Whittaker-Kotel'nikov-Shannon sampling theorem for frequency-band-limited functions of time is extended to functions of multidimensional arguments. It is shown that a function whose spectrum is restricted to a finite region of wave-number space may be reconstructed from its samples taken over a periodic lattice having suitably small repetition vectors. The most efficient lattice (i.e., requiring minimum sampling points per unit hypervolume) is not in general rectangular, nor is a unique reconstruction function associated with a given sampling lattice. . . .

EXTRAPOLATION (PREDICTION) OF A FUNCTION WITH A LIMITED SPECTRUM FROM ITS DISCRETE VALUES (Translation)
I. G. Polliak, Telecommunications and Radio Engineering, Part II - Radio Engineering, vol. 17, Nov. 1962, p. 59/67, 12 refs., A63-16488.

. . . useful in the design and analysis of sampled-data systems in communications and remote control, as well as in numerical analysis.

PROBABILISTIC NETWORK STUDY - SYSTEM RELIABILITY
F. M. Reza, Syracuse U. Research Inst., N. Y., Final rept., Aug. 1962, 43 p. incl. illus. refs. (Rept. no. EE 747-6208FR), (AFCRL 62-724), AD 296 975.

. . . presents a note on a new sampling theorem using Bernstein's orthogonal polynominals. . . .

SAMPLING AND QUANTIZATION ERRORS IN A DIGITALLY MECHANIZED INERTIAL NAVIGATOR
N. A. Boehmer, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, Jan. 1963, p. 56/61.

. . . A constant altitude, meridian plane, pure Schuler tuned inertial navigator model on a nonrotating earth is used for analysis. Insofar as sampling and quantization effects are concerned, nothing significant is lost by this restriction since the cross-coupling effects are small, and the earth rotation vector components on the platform axes are slowly varying. . . . Time and frequency domain analysis of the sampled-data system is presented and the effects of quantization present at the digital computer input and output are evaluated. . . .

A NOTE ON 2 TW (Correspondence)
C. H. Dawson, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 2, June 1963, p. 61.

. . . block diagram shown, . . . If f_1 is too large, spectrum overlap occurs preventing perfect recovery while, if f_2 is too small, time domain overlap occurs again preventing perfect recovery.

NUMBER OF QUANTIZATION LEVELS AND INTERVALS REQUIRED FOR THE DISCRETE REPRESENTATION OF WEAK SIGNALS IN NOISE
L. I. Filippov, Radiotekhnika i Elektronika, vol. 8, March 1963, p. 497/499. In Russian. Radio Engineering and Electronic Physics, March 1963, p. 440-442. Translation, A64-10445.

. . . An interval in the time quantization can be determined by means of Kotel'nikov's theorem, which can only be applied to infinite waveforms. The error incurred when the theorem is applied to a finite waveform . . .

A NOTE ON OPTIMUM PRESAMPLING FILTERS (Correspondence)
D. Middleton, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 1, March 1963, p. 108/109.

. . . In a previous issue, Spilker derived an equation . . . for the error spectral density of a sampled-data system as a function of the presampling filter transfer function . . . the ideal presampling operation is to eliminate all power above the "Nyquist/Shannon" frequency band-limit. . . .

One might intuitively suspect that this result holds under less restrictive assumptions . . . a general proof applying to multi-dimensional stochastic processes has been obtained by the authors . . .

ALIASING EFFECTS FROM A SAMPLE-HOLD-RESAMPLE PROCESS
O. C. Myers, Jr., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 87/91.

STOCHASTIC SAMPLING OF A BINARY RANDOM PROCESS
S. J. Redman, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 1, March 1963, p. 3/24.

. . . When a binary random process is sampled by an independent random pulse process a new binary process is generated. Statistical properties of this new binary process are investigated in this paper. Two methods of sampling are considered, according as an even or odd number of zeros of the binary process being sampled occur between successive sampling pulses. . . . a brief description of an experimental sampling device and some results obtained with it, is given.

This paper is envisaged as the first of a series of three papers dealing with binary random processes and their application in the analysis of simple filters containing a randomly switched parameter.

DETERMINATION OF THE REQUIRED FREQUENCY OF PERIODIC MEASUREMENTS OF A CONTINUOUS SIGNAL
M. V. Rybashov, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 1963, AD 412 242.

THE REPRESENTATION OF STOCHASTIC PROCESSES BY ORTHOGONAL EXPANSIONS
J. B. Thomas, In: Joint Automatic Control Conference, 4th, University of Minnesota, Minneapolis, Minn., June 19-21, 1963, Preprints of Technical Papers. Conference sponsored by the American Institute of Chemical Engineers. New York, American Institute of Chemical Engineers, 1963, p. 287/291. A64-11196.

Review of types of series used to represent noises or random signals in problems of communications and control theory . . . considered are the Fourier series, the sampling theorem expansion, and the Karhunen-Loeve expansion.

ON THE SAMPLING PROPERTY OF THE DELTA FUNCTION
H. Urkowitz, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1057/1058.

The sampling property attributed to the delta function is usually expressed in. . . an integral expression . . . where f(t) is continuous at t = a. In a recent communication Urkowitz asserts an apparently more general result which for clarity we shall refer to as the sifting property; . . . in case f(t) has at worst an ordinary discontinuity at t = a. The main purpose of the present communication is to point out that these two properties are genuinely distinct and that the sifting property does not apply to the delta function at all. . . .

AMBIGUITIES IN TELEMETRY SAMPLING
R. E. Young, Electronic Engng, vol. 35, May 1963, p. 322/324. A63-24044.

. . . consideration of the "sampling theorem" and the two alternative proofs given by Shannon, and by Nichols and Rauch. Various design points are collated, and new techniques are suggested to give reduced bandwidth without an increase in sampling ambiguities.

PROGRAM 461 TELEMETRY ALIASING ERROR ANALYSIS
Lockheed Aircraft Corp., Sunnyvale, Calif., 10 June 1963, 1v. Rept. no. LMSC A324768, AD 409 887.

. . . Aliasing error may be reduced by faster sampling and/or better filtering. Since it is mandatory that a high degree of accuracy be attained with a minimum sampling rate, an optimization analysis is clearly necessary. To accomplish this, the telemetry system is described mathematically by the transfer functions of its significant blocks. . . . Three different interpolation filter types are compared; . . . The computation was performed on an IBM 7094 computer, with a program written so that system parameters could be easily varied.

Related Publications:

LIMITATIONS OF ANGULAR RADAR RESOLUTION
E. Eichler, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 4, June 1960, p. 249/252.

. . . The subject is linked to optical diffraction theory and to the resolution problem and the sampling theorem of communication. . . .

ON A NEW THEORY OF THE LIMITATION OF THE SIGNAL SPECTRUM (In French)
J. Oswald, Cables Transm., vol. 14, no. 4, Oct. 1960, p. 249/261.

. . . The basic idea of the present work is the substitution of a distributed function for the continuous functions (linear network operators) generally used for representing signals. This results naturally from the theory of sampling.

. . .

LINEAR RECONSTRUCTION OF QUANTIZED AND SAMPLED RANDOM SIGNALS
D. S. Ruchkin, IRE Trans. Commun. Syst., CS-9, no. 9, Dec. 1961, p. 350/355.

ON A SIMPLE PROCEDURE OF UNEQUAL PROBABILITY SAMPLING WITHOUT REPLACEMENT
J. N. K. Rao, et al., Iowa State U., Iowa City, 1962, 16 p. refs., (Technical rept. no. 1.2), (AROD rept. no. 2934.2), AD 298 881.

ASYMPTOTIC THEORY OF THREE UNEQUAL PROBABILITY SAMPLING PROCEDURES WITHOUT REPLACEMENT
J. N. K. Rao, Iowa State U., Iowa City, 1962, 16 p. incl. table, 4 refs. (Technical rept. no. 1.3), (AROD rept. no. 2934:3), AD 298 885.

SYNTHESIS OF OPTIMAL FILTERS FOR A FEEDBACK QUANTIZATION SYSTEM
E. G. Kimme, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 405/413.

. . . The feedback filter F is assumed to be a tapped delay line, whose top weights are obtained through a rapidly converging iterative procedure on an IBM 7090 automatic computer. . . . passive, lumped parameter predistortion and reconstruction filters are designed.

SOME RELATIONS BETWEEN DIGITIZING PARAMETERS AND CALCULATED STATISTICS OF A WAVEFORM
R. McAulay, Illinois Univ. Engineering Experiment Station, Urbana, 15 Aug. 1963, 35 p. Rept. nos. TR18, TR1, AD 419 905.

. . . to investigate the effect which the analog-to-digital converter has in perturbing the values of certain statistics from their true values. . . . the analog of the actual sampling and quantizing process is developed as a computer program. . . .

MULTIVARIATE POLYNOMIAL APPROXIMATION FOR EQUIDISTANT DATA
B. Mond, Mathematics of Computation, vol. 18, April 1964, p. 298/301, 5 refs., A64-16424.

Extension of the theory of polynomial approximation for evenly spaced point to multivariate approximation. It is shown that by approximately choosing the bivariate biorthogonal polynomials, available tables prepared for univariate approximation can be readily modified for use in the bivariate case. A straightforward extension to the multivariate case is presented.

FACTORS FOR ONE-SIDED TOLERANCE LIMITS AND FOR VARIABLES SAMPLING PLANS
D. B. Owen, Sandia Corp., Albuquerque, N. Mex., March 1963, 406 p., 82 refs., (SCR-607; supersedes SCR-13), N63-16782.

Tables are given of a quantity k which is used to define single-sample variables sampling plans and one-sided tolerance limits for a normal distribution. . . .

QUANTIZATION ERRORS IN DIGITAL CONTROL SYSTEMS
J. B. Slaughter, IEEE Trans. Automatic Control, vol. AC-9, Jan. 1964, p. 70/73; Discussion, Bernard Widros, p. 73, 74; Author's Reply, p. 74, 5 refs., A64-15915.

. . . For a third-order plant the error due to quantization was determined to be approximately ten times the value of the quantizing level, and was reduced to six times by increasing the sampling rate by a factor of two.

EXTENSIONS OF LINEAR, LEAST-SQUARES SAMPLING THEORY
D. W. Tufts, et al., Cruft Lab., Harvard U., Cambridge, Mass., 10 April 1963, 1v., TR 407, AD 411 848.

. . . some new results in the interpolation theory of random processes. . . . applied to the problem of reconstructing a random waveform from instantaneous samples. . . .

A NOTE ON BANDLIMITED FUNCTIONS (Correspondence)
F. Tung, IEEE Trans. Circuit. Theory, vol. CT-10, no. 2, June 1963, p. 275/276.

. . . a bandlimited function. . . . can be constructed from its sample values. . . . It is sometimes desirable to find expansions of f(t). . . . One may inquire into the possibility of finding functions $\psi_n(t)$ . . . We shall restrict ourselves to exploring functions that can be generated from second-order ordinary linear differential equations . . .

KVANTOVÂNIE NEPRERYVNYKH SOOBSHCHENII S MINIMAL'NOI SREDNE KVADRATICHNOI OSHIBKOI (Quantification of Continuous Information at Minimum Mean-Square Error) (In Russian)
A. I. Velichkin, Radiotekhnika, vol. 19, March 1964, p. 66/75, A64-17755.

Investigation of the conditions of minimum distortion in the quantification of continuous information with respect to time and levels. It is shown that the determination of the optimum parameters of the quantifier with respect to levels requires a two dimensional probability density distribution of the quantized information . . .

DEVELOPMENT AND EVALUATION OF PROCEDURES FOR QUANTIZING MULTIVARIATE DISTRIBUTIONS
P. Zador, Stanford U., Calif. 10 Dec. 1963, 64 p., Rept. no. TR-92, AD 426 677.

. . . approximation generated by a specific but arbitrary partion and a specific but arbitrary set of representation points is examined. A statistical measure of error is investigated. The size of the error is measured by some moment of the random variable. . . . The behavior of the minimum error when there is a large number of representation points is demonstrated. This extension takes into account the entropy rate of the discrete quantizing sequence.

1.413: Spectra of Pulse Trains

Included: Power spectra of pulse systems; Impulse-equivalent pulse trains; Correlation characteristics of pulse trains; Statistical characteristics of pulse trains.

Not Included: Spectrum analyzers.

Cross References: Spectra of analog modulated signals (1.210).

Principal Publications:

THE MEASUREMENT OF POWER SPECTRA FROM THE POINT OF VIEW OF COMMUNICATIONS ENGINEERING
R. B. Blackman, et al., Bell Systems Tech. J., vol. 37, Jan. 1958, p. 185/282; vol. 37, March 1958, p. 485/569.

ZUR MESSUNG DER WAHRESCHEINLICHKEITSDICHTE UND DES SPEKTRUMS VON STATIONAREN ZEITPROZESSEN (In German) On the Measurement of the Probability Density and the Spectrum of Stationary Time Processes.
P. Fey, Hochfreguenztech. Elek. Akust., vol. 66, March 1958, p. 141/142.

MEASUREMENT OF PEAK AND INSTANTANEOUS VALUES IN PERIODICALLY RECURRING CURRENT AND VOLTAGE WAVE FORMS
A. D. Kratirov, Telecommun., no. 2, 1958, p. 199/205.

A STATISTICAL DESCRIPTION OF COINCIDENCES AMONG RANDOM PULSE TRAINS
S. Stein, et al., Proc. IRE, vol. 46, May 1958, p. 827/830.

THE CORRELATION FUNCTIONS OF RANDOM SEQUENCES OF RECTANGULAR PULSES
I. N. Amiantov, et al., Radio Engrg., vol. 14, no. 4, 1959, p. 9/25.

THE ENERGY SPECTRA OF RANDOM SERIES OF OVERLAPPING PULSES
M. I. Dorman, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 71/74.

A study is made of the possibility of using Levin's method (1) to calculate the energy spectra of random series of overlapping pulses. Examples are given. . . .

PULSE SEQUENCE SPECTRA WITH TIME MODULATION
V. S. Fain, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 11, 1960, p. 28/32.

. . . study . . . of a simplified method of calculating pulse sequence spectra with time modulation. A formula is proposed and an actual example considered. . . .

PULSE SYSTEM THEORY APPLICATIONS, II
K. Ikrath, Army Signal Research and Development Lab., Fort Monmouth, 1 March 1960, ASRDL technical rept. 2099, AD 246 075.

The wave shapes of pulse train responses of various filter networks under different operating conditions are accurately formulated on the basis of mathematical methods which are documented in AD 149 511. A quantitative insight into the shortcomings of ordinary Laplace Transform and Fourier Transform approach to pulse systems problems is given on the basis of numerical examples whose practical implications are discussed.

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
J. W. Capps, et al., Aeronutronic, Newport Beach, Calif., Final rept., March-Sept. 1961, June 1962, 1v. incl. illus., 22 refs., (ASD TR 61-553), AD 278 515.

. . . applicable to time-division multiplexed telemetry systems. In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM telemetry systems. . . . to determine typical telemetry data spectra. . . .

SPECTRAL ANALYSIS OF A PULSE TRAIN
M. I. Finkel'shteyn, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 4, April 1962, p. 16/21.

The spectrum of a pulse train with symmetric envelope is determined and a method of estimating the degree to which the spectrum is concentrated around the "principal lobes" is given. The concept of the concentration coefficient is introduced, which has the order of magnitude of the cube of the number of pulses for a cosine-squared envelope. . . .

THE GENERATION OF IMPULSE-EQUIVALENT PULSE TRAINS
D. A. Huffman, IRE Trans. Inform. Th., Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. S10/16.

The necessary and sufficient conditions for a function to be the autocorrelation function of a waveform consisting of a finite length train of pulses of various amplitudes is derived. The number of pulse trains having a given realizable autocorrelation function is determined. An "impulse-equivalent" pulse train is defined as one that yields, as closely as is theoretically possible, the same autocorrelation function that a single pulse gives. . . . It is demonstrated that all impulse-equivalent pulse trains can be generated by exciting a linear digital filter with two input pulses that correspond in time to the initiation and to the termination of the desired output sequence. . . .

SPECTRA AND ANALYSIS (In Russian)
A. A. Kharkevich, Moscow, Fizmatgiz, 1962, 236 p.

The monograph deals with a selection of spectral representations used in the theory of oscillations, acoustics, and radio engineering . . . aims to widen the theoretical horizons of engineers working in the fields of radio and acoustics. . . .

KORRELATIONSELEKTRONIK. GRUNDLAGEN UND ANWENDUNG DER KORRELATIONS-ANALYSE IN DER MODERNEN NACHRICHTEN-, MeB- UND REGELUNGSTECHNIK; (2 Aufl.) (Correlation Electronics. Fundamentals and Applications of Correlation Analysis in Modern Communications and Control Technique) (In German)
F. H. Lange, Berlin, Verlag Technik, 1962, 381 p.

AUTOCORRELATION BY MAGNITUDE OF THE DIFFERENCE (Correspondence)
T. A. Martin, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2499.

For reasons of ease of implementation it is sometimes desirable to use functions other than the linear correlation function to examine data

for coherence. One such function is the "comparison correlation function" . . . The comparison autocorrelation function may be readily calculated for a random pulse train such as the one shown in Fig. 1. . . .

A NOTE ON THE CORRELATION FUNCTION OF NONINDEPENDENT, OVERLAPPING PULSE TRAINS
E. D. Banta, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 160/161.

Biorci and Mazzetti have found a general formula for the correlation function of non-independent, overlapping pulse trains; however, its application involves considerable mathematical difficulties in general. This paper shows how these difficulties can be avoided. . . .

COMPARISON OF POWER SPECTRAL DENSITY TECHNIQUES AS APPLIED TO DIGITALIZED DATA RECORDS OF NONSTATIONARY PROCESSES, PART I.
G. W. Evans, II, et al., Stanford Research Inst., Menio Park, Calif., Sept. 1963, 141 p., Technical rept. no. 14, AD 419 493.

. . . discussion of harmonic analysis, power spectral analysis, stationary and non-stationary stochastic processes, and a description of twenty-seven techniques for power spectral density (PSD) analysis. . . . Part II of this report . . . uses the preferred technique to analyze actual data from recordings of radar backscatter from missiles.

SPECTRUM OF PERIOD-MODULATED SINUSOIDAL OSCILLATIONS
L. Ya. Il'nitskiy, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 1/5.

. . . A comparison is made with the spectrum of a frequency-modulated signal. . . .

ENERGY SPECTRA OF GROUP SIGNALS IN MULTICHANNEL PULSE SYSTEMS (Translation)
B. R. Levin, et al., Telecommunications and Radio Engineering. Part I - Telecommunications, Feb. 1963, p. 1/9.

Extension of the theory of energy spectra for random pulse processes with a determinate time interval to include pulse group sequences . . . in a multichannel system with time division of channels . . . with pulse amplitude, pulse-time, or pulse-width modulations.

Related Publications:

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
D. G. Childers, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 267/283.

. . . to determine the effect of 1) data power spectrum, and 2) system design parameters on aliasing and data interpolation error . . .

SPECTRAL DENSITY DISTRIBUTIONS OF SIGNALS FOR BINARY DATA TRANSMISSION
H. J. Pushman, J. Brit. Instn. Radio Engrs., vol. 25, no. 2, Feb. 1963, p. 155/165.

CORRELATION FUNCTION AND SPECTRAL DENSITY OF A QUANTIZED PROCESS
A. I. Velichkin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July, 1962, p. 70/77.

THE EFFECTS OF NOISE THROUGH A RECTANGULAR-INTEGRATION PROCESS AND SOME SAMPLED SPECTRA-DENSITY METHODS
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 159/175.

. . . the effect of signal plus noise on the rectangular integration process that . . . a digital integrator might use. The arguments are case in the form taken by a digital differential analyzer (DDA) integrator. . . .

A DIGITAL FILTER FOR SEPARATING HIGH- AND LOW-FREQUENCY COMPONENTS OF A TRANSIENT SIGNAL
T. L. Geers, et al., David Taylor Model Basin, Washington, D. C., Jan. 1964, 39 p.

. . . separates a transient signal into high- and low-frequency portions and introduces no phase shifts or amplitude changes in either portion. A program written in FORTRAN for an IBM 7090 computer which will filter a sampled time-history record is presented. . . .

COMPUTER PROGRAMS FOR SPECTRAL ANALYSIS OF ECONOMIC TIME SERIES. ECONOMETRIC RESEARCH PROGRAM
H. F. Karreman, Princeton U., N. J., 15 July 1963, 100 p., AD 418 321.

. . . three programs. The first program computers power spectra of an arbitrary number of series. The second program computers power spectra of up to fourteen series and cross spectra of every combination of two series in the set. The third program computes, in addition to the power and cross-spectra, the multiple and partial correlation of these spectra of sets of up to six series. Of each of these three programs, there is a Tukey-Hanning and a Parzen-version . . . written in the Fortran-language for a computer of a little over thirty-two thousand memory locations . . . In the multiple and partial correlations subrouting of the third program use has been made of the facility to perform complex arithmetic operations on the IBM 7090 . . .

A METHOD OF CALCULATING COMPLEX SPECTRA OF IMPULSE FUNCTIONS BY MEANS OF AN AMPLITUDE ANALYZER
S.A. Kats, (Akademiia Nauk SSSR, Izvestiia, Seriia Geofizicheskaia, no. 10, 1963, p. 1544/1553.) In Russian., Academy of Sciences USSR, Bulletin, Geophysics Series, Oct. 1963, p. 932/937, Translation, A64-14817.

1.414: Sampling Processes

Included: Sampling procedures for sampling statistical populations; Adaptive sampling processes; Tuned sampling; Unequal probability sampling; Confidence criteria for probability sampling.

Not Included: Sampling of multiplex signals (2); Sampling equipment; Adaptive sampling for redundancy reduction (2); Statistical processing for information compaction (2); Signal conditioning equipment.

Cross References: Rotation sample design (1.418); Time-jitter in pulse communications systems (1.410); Sampling theory (1.412); Experimental evaluation of statistical populations (1.119).

Principal Publications:

A LOW-LEVEL HIGH-SPEED SAMPLING SYSTEM
J. P. Francis, IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, 1.3, April 1957, p. 1/9.

SAMPLE-AND-HOLD CIRCUITS FOR TIME CORRELATIONS OF ANALOG-VOLTAGE INFORMATION
W. T. Eddins, 1958, IRE WESCON Conv. Rec., pt. 5, 1958, p. 21/26.

ON THE ESTIMATION OF THE RELATIVE EFFICIENCY OF SAMPLING PROCEDURES
J. N. K. Rao, Iowa State U. of Science and Tech., Ames, 1958, 10 p. (Technical rept. no. 1.6), (AROD rept. no. 2934:8), AD 298 772.

OPTIMUM CONTROL THROUGH TUNED SAMPLING
J. T. Tou, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 290/298.

. . . A sampled-data control system contains one or more samplers which may operate with different sampling rates. The sampling rate may be either constant or variable. It is found that the control system exhibits optimum performance if the variable-rate sampler is properly "tuned." The system stability may be improved by selecting a suitable variable rate for the sampler. It is shown in this paper that when the cyclic-variable sampling rate is varied the stability boundary describes a curve which is concave downward, exhibiting a peak between two limiting values of the cyclic rate. Furthermore, when the system is subjected to a stochastic input, the mean-square error can be reduced to a minimum by "tuning" the variable-rate sampler to an optimum rate. The optimizing feature of tuned sampling may be utilized to achieve self-optimization of control systems.

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
J. W. Capps, et al., Aeronutronic, Newport Beach, Calif., Final rept., March-Sept. 1961, June 1962, 1v. incl. illus., 22 refs., (ASD TR 61-553), AD 278 515.

. . . applicable to time-division multiplexed telemetry systems. In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM telemetry systems. . . . to determine typical telemetry data spectra. . . .

ON A SIMPLE PROCEDURE OF UNEQUAL PROBABILITY SAMPLING WITHOUT REPLACEMENT
J. N. K. Rao, et al., Iowa State U., Iowa City, (Harvard U.), Tech. rept. 1.2, 1962, 16 p., N63-21695.

AN ADAPTIVE DATA SAMPLING SYSTEM
M. Berkowitz, Rec. Nat. Space Electronics Symp., 1963, no. 4.1.

. . . tests the change in signal level of each data channel, from one sample to the next, against a-priori, preprogrammed criteria, and . . . utilizes the result of this test to limit the system output to only significantly changed data. . . . resulting in varying amounts of time being liberated depending upon the properties of the signals being sampled. The time thus liberated can be utilized for the insertion of additional lower priority data . . . The usability of micro-electronic techniques to practically accomplish sophisticated operations of this type is illustrated by describing a newly designed microelectronic multiplexer. . . .

STUDIES IN RESEARCH METHODOLOGY VI. A SAMPLING STUDY OF THE CENTRAL LIMIT THEOREM AND THE ROBUSTNESS OF ONE SAMPLE PARAMETRIC TESTS
J. V. Bradley, Behavioral Sciences Lab., Aerospace Medical Div. Wright-Patterson Air Force Base, Ohio Final rept. March 1963, 305 p., AMRL TDR63 29, AD 411 439.

. . . the time to operate an instrument control is likely to have a distribution with a distinctive, extremely nonnormal shape . . . sampling study upon a population representing time scores for the operation of a push button. Ten thousand samples were drawn at each of the sample sizes, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, and were calculated. The sampling distributions of Z, t and X squared departed from their normal theory distributions to a degree which could only be described as iconoclastic. Even at N = 1024 these departures were quite appreciable at the testing tails, being greatest for X squared and least for Z, and becoming worse in all cases at increasingly extreme tail areas.

A SEQUENTIAL PROCEDURE FOR SUCCESSIVELY IMPROVING SAMPLING DISTORTIONS
C. E. Clark, System Development Corp., Santa Monica, Calif., 18 March 1963, 6 p., TM 94253, AD 402 663.

SELECTING SAMPLE RATES
L. W. Gardenhire, ISA Journal, vol. II, April 1964, p. 59/64, 7 refs., A64-17502.

Presentation of a method for selecting optimum sampling rates for data reduction systems, using realistic input data and actual filters. Various kinds of errors are investigated, such as step interpolation errors and errors of commission and omission; the values of these errors are predicted for several kinds of input data. Traditional methods of interpolating between samples are explained, and a method, called computer interpolation, which reduces the number of samples required, is presented. An experiment to determine the validity of the method developed for selecting the proper sampling rates is reviewed.

SINGLE SAMPLING INSPECTIONS PLANS WITH SPECIFIED ACCEPTANCE PROBABILITY AND MINIMUM COSTS
A. Hald, Copenhagen U. (Denmark), July 1963, 68 p., AD 416 800 and also AD 416 118.

To design an economical sampling plan it is necessary to know the costs of sampling inspection, the costs of wrong decisions, and the quality distribution of lots submitted for inspection, the prior distribution. Sometimes it is impossible to specify the prior distribution in detail but a vague knowledge is available which means that not enough is known to find the Bayes solution and on the other hand too much is known for the minimax solution to be satisfactory. The problem then is to choose a third principle leading to a reasonable solution . . .

THE USE OF SAMPLE RANGES AND QUASI-RANGES IN SETTING EXACT CONFIDENCE BOUNDS FOR THE POPULATION STANDARD DEVIATION. II. QUASI-RANGES OF SAMPLES FROM A NORMAL POPULATION-PROBABILITY INTEGRAL AND PERCENTAGE POINT: EXACT CONFIDENCE BOUNDS FOR SIGMA
H. L. Harter, Aeronautical Research Lab., Office of Aerospace Research, Wright-Patterson, AFB, Ohio, April 1963, 234 p., ARL 31, pt. 2, AD 412 352.

STOCHASTIC SAMPLING OF A BINARY RANDOM PROCESS
S. J. Redman, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 1, March 1963, p. 3/24.

. . . Two methods of sampling are considered, according as an even or odd number of zeros of the binary process being sampled occur between successive sampling pulses. . . . a brief description of an experimental sampling device and some results obtained with it, is given.
This paper is envisaged as the first of a series of three papers dealing with binary random processes and their application in the analysis of simple filters containing a randomly switched parameter.

THE COMBINED USE OF PULSE ATTRIBUTES IN PROTECTED CIRCULAR SIGNALS
Yu. Tomfel'd, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 19 Aug. 1963, 25 p., AD 419 226.

. . . To transmit information concerning the state of M two-position objects in one signal (i.e., for circular transmission in a group), it is necessary to have 2(M) signals, each of which corresponds to one of the combinations of states of the objects of the group. . . . Circular transmission may be accomplished with the aid of systematic codes by using a sampling method close to distributional. . . . protection from distortions may be realized both by the method of protective refusal and through error correction. . . . In the case of multi-position objects it is convenient to use incomplete combination elements.

Related Publications:

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 20 Aug. 1962, 38 p. incl. illus., 2 refs. (Trans. no. FTD-TT-62-32 from Nachrich-tentechnik, No. 3, p. 106/114, 1961), AD 292 315.

. . . companding values, instantly, of a time modulated signal which guarantees better utilization of the communication system without increasing the necessary frequency band requirements . . .

ON THE PROBLEM OF TIME JITTER IN SAMPLING
A. V. Balakrishnan, et al., IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 226/236.

A NEW PULSE MODULATED SPEECH COMMUNICATION SYSTEM HAVING A MINIMUM DUTY CYCLE
R. O. Eastman, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 114/118.

. . . deriving an optimum sampling rate from these signals. . . . two separate forms of information, amplitude and frequency . . . results of tests conducted through the system.

PROBABILITIES OF RANKINGS FOR TWO WIDELY SEPARATED NORMAL DISTRIBUTIONS
J. L. Hodges, Jr., et al., Statistical Lab., U. of Calif., Berkeley, 1962, 6 p., AD 414 647.

SOME SMALL SAMPLE PROPERTIES OF CERTAIN STRUCTURAL EQUATION ESTIMATORS
R. E. Quandt, Princeton U., N.J., 21 Dec. 1962, 69 p., (Research memo. no. 48), AD 299 553.

DISCRETE ORTHONORMAL EXPONENTIALS
T. Y. Young, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 10/18.

. . . transformation of orthonormal exponentials from the continuous form into the sampled data form, that is, the z-transformation. . . .
These discrete orthonormal exponentials approach the ordinary continuous orthonormal exponentials in the limit as the sampling interval T approaches zero.

HIGH SPEED SAMPLING AND DIGITIZING EQUIPMENT FOR PCM TELEMETRY
Nat. Telemetry Conf., May 1962, no. 7-2, p. 1/6.

ON THE NON PARAMETRIC ESTIMATION OF THE PROBABILITY DENSITY
M. R. Leadbetter, Research Triangle Inst., Durham, N.C., 24 May 1963, 96 p., Technical rept. no. 11, AD 415 764.

ALIASING EFFECTS FROM A SAMPLE-HOLD-RESAMPLE PROCESS
O. C. Myers, Jr., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 87/91.

SEMICONDUCTOR SAMPLE AND HOLD CIRCUITS
D. H. Rodgers, Weapons Research Establishment (Australia), Feb. 1963, 33 p., 4 refs., N63-17064.

. . . specification: sample time, 15 μ sec; hold time 50 μ sec; aperture time, < .1 μ sec; accuracy, 0.1% of 10 v. . . .

ON THE COMPARISON OF THE MEANS OF TWO POPULATIONS WITH UNKNOWN VARIANCES
Y. Yao, Carnegie Inst. of Tech., Pittsburgh, Pa., Final rept. Sept. 1961-June 1962., June 1963, 54 p., AD 415 002.

. . . using the method of "Approximate Degrees of Freedom." A modified version of the Welch method is given for the univariate situation, and an extension is given for the general multivariate situation. . . .

A DIGITAL FILTER FOR SEPARATING HIGH- AND LOW-FREQUENCY COMPONENTS OF A TRANSIENT SIGNAL
T. L. Geers, et al., David Taylor Model Basin, Washington, D.C., Jan. 1964, 39 p., AD432 277.

. . . separates a transient signal into high- and low-frequency portions and introduces no phase shifts or amplitude changes in either portion. A program written in FORTRAN for an IBM 7090 computer which will filter a sampled time-history record is presented. Simple formulas are given for estimating errors in the filter that are due to sampling and truncation of the continuous record. Application of the filter to signals produced by two or more physical sources is discussed.

1.418: Other Sampling Problems

Included: Nonlinear sampling modulation methods; Companding in time-discrete systems; Space-time sampling; Selective amplitude sampling; Rotation sample designs; Random sampling procedure.

Not Included: Nonlinear control systems; Redundancy reducing sampling methods (2).

Cross References: Nonlinear pulse code modulation methods (1.512).

Principal Publications:

A COMPARISON OF RANDOM AND PERIODIC DATA SAMPLING FOR THE DETECTION OF SIGNALS IN NOISE
D. Middleton, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 234/247.

SELECTIVE AMPLITUDE SAMPLING
L. R. Spogen, Jr., et al., Applied Research Lab., U. of Arizona, Tucson, Final rept., Jan. 1961, 30 p., (Supplement no. 1 to AD 210 550), (Supplement no. 1 to AEPG-SIG 960-73), AD 258 642.

. . . may be used in rf transmission in the form of pulse amplitude modulation, pulse duration modulation, or pulse position modulation. The techniques that may be used to obtain these modulation forms are discussed. A preliminary discussion of noise properties that will produce a degradation if intelligibility and quality of the signal in these basic forms is included.

ROTATION DESIGNS FOR SAMPLING ON REPEATED OCCASIONS. (Technical Rept. 2.1)
J.N.K. Rao, et al., Iowa State U. of Science and Tech., Ames, 1963, 24 p., 7 refs. N63-17385.

RECOVERY OF RANDOMLY SAMPLED TIME SEQUENCES (Correspondence)
C.S. Lorens, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 214/216.

. . . Normally, the sampling sequence is periodic . . . Yen points out that certain deviations can be made from the periodic structure without destroying the ability of perfect recovery.

In coded communication systems the times of channel availability are random. . . . This paper considers the noise and recovery problem associated with a random sampling of a continuous time sequence. . . .

TIME QUANTIZATION OF A SIGNAL OF FINITE AREA (Translation)
M. V. Rybashov, Telecommunications and Radio, Engineering. Part II - Radio Engineering, Dec. 1962, p. 11/14, A63-19202.

Derivation of an upper limit for the frequency of time quantization of a signal of limited area and spectrum . . .

A TWO-STATE MODULATION SYSTEM
A. G. Bose, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 1963, 10 p., AD 423 294.

A modulation system that converts a continuous signal into a two-state signal, and has the property that the modulating can be recovered by lowpass filtering . . . combines aspects of frequency and pulsewidth modulation in a manner that enables its realization in terms of a simple closed-loop system having a nonlinear forward path and a linear passive feedback path. . . . Applications to high-efficiency power amplification, nonlinear control, and low-frequency data recording are presented.

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div., Sept. 19, 1963, 39 p., 2 refs., (Transl. into English from Nachrichtentechnik, no. 3, 1961, p. 106/114) (FTD-TT-62-32/1+2), N63-23377, AD 420 608.

. . . A method is described for instantly companding the values of a time-modulated signal . . . Improvement of various communication system parameters are obtained by preemphasis on the transmitter side and an adequate distortion-correlation on the receiver side . . . The values of signal-to-noise ratio improvement, made available by the method described are derived . . .

GENERALIZED COMPOSITE AND MULTI-COMPONENT ESTIMATORS IN ROTATION SAMPLE DESIGNS (Technical Report 2.2.)
J.E. Graham, Iowa State U., Ames, 1963, 25 p., 10 refs., N63-19803.

A unified approach to the problem of sampling on successive occasions employing a fixed rotation design in a finite population has been previously developed by Rao and Graham (Technical Report 2.1 entitled "Rotation Designs for Sampling on Repeated Occasions.") In the present study a generalization is obtained for the composite estimator of the previous Rao and Graham study.

SPACE-TIME SAMPLING AND LIKELIHOOD RATIO PROCESSING IN ACOUSTIC PRESSURE FIELDS
P. L. Stocklin, J. Brit. Instn. Radio Engrs., vol. 26, no. 1, July 1963, p. 79/91.

. . . based on a three-dimensional Whitaker sampling function . . . Two examples are treated: the one-dimensional resolution problem for Gaussian signal in Gaussian noise, and the space-time likelihood ratio processor for signal known exactly in Gauss and Markov-Gauss noise. . . .

Related Publications:

STABILITY STUDY OF PULSE-WIDTH MODULATED AND NONLINEAR SAMPLED-DATA SYSTEMS
T. Nishimura, Electronics Research Lab., U. of Calif., Berkeley, 4 April 1961, 68 p., incl. illus., 33 refs., AD 273 858.

ANALYSE DES SYSTEMES A INFORMATIONS DISCRETES A L'AIDE DU CONCEPT DE VECTEUR SEQUENCE (Discrete Information System Analysis Employing the Vector Sequence Concept) (In French)
R. J. Boudarel, et al., Academie des Sciences (Paris), Comptes Rendus, vol. 256, no. 7, 11 Feb. 1963, p. 1465/1468, A63-17397.

Linear and nonlinear discrete information analysis based on a vector sequence analogy.

ROTATIONAL TRANSFORMATION OF SIGNALS
G.R. Lang, IEEE Trans. Inform. Th., vol. IT-9 no. 3, July 1963, p. 191/198.

A coding procedure based on a rotational transformation is applied to reduce the effect of non-Gaussian impulse noise in sampled data communication systems.

STOCHASTIC LINEAR EQUIVALENTS OF CLOSED LOOP SYSTEMS
J.A. Warshauer, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., 15 May 1963, 72 p., Research rept. no. PIBMRI-1167 63, AD 411 316.

. . . The area of study is restricted to a class of m-th order discrete time nonlinear systems with white Gaussian zero mean stochastic inputs.

ABSOLIUTNAIA USTOICHIVOST' POLOZHENIA RAVNOVESIIA I PROTSESSOV V NELINEINYKH IMPUL'SNYKH AVTOMATICHESKIKH SISTEMAKH (Absolute Stability of the State of Equilibrium and Processes in Automatic Nonlinear Sampled-Data Systems) (In Russian)
Ia. Z. Tsypkin, Avtomatika i Telemekhanika, vol 24, Dec. 1963, p. 1601/1615, 14 refs., A64-13117.

Generalization of a previously derived criterion . . . extended to cover systems having a nonsteady characteristic of the nonlinear element and a steady or unsteady linear pulse unit . . . applied to several examples.

Section 1.42
Pulse Amplitude Modulation

This method is one of the oldest telemetry methods for time-shared, mechanically commutated telemetry systems. Most publications dated prior to 1958 are not included. Time division multiplexing as such will be discussed in volume 2 of this series. The fundamentals of amplitude modulation are included in section 1.22 in this volume. Equipment descriptions of PAM space telemetry systems are not the subject of this bibliography, but some selected references are included below under "related publications".

We consider multi-level pulse amplitude modulation as a digital data system and not as a sampled modulation system. It is placed in 1.325 and in 1.518 as a multi-level PCM system.

1.420: Pulse Amplitude Modulation Methods (PAM)

Included: Intersymbol interference in PAM systems; Resolution and telemetry accuracy in PAM.

Not Included: PAM telemetry equipment; PACM hybrid multiplex telemetry systems (2); PAM-PDM modulation converters; Time division multiplex systems in general (2).

Cross References: Multi-level AM data systems (1.325); Multi-level PCM systems (1.518); PAM-FM systems (1.933); PAM-FM-AM systems (1.950).

Principal Publications:

SOME METHODS OF ERROR SIGNAL DETECTION IN PAM-SYSTEMS FOR MULTIPLEX TRANSMISSION OF SYNCHRO DATA
O. Carlstedt, IRE Trans. Telemetry Remote Control, vol. TRC-2, no. 1, March 1956, p. 2-4.

. . . to transmit synchro data over a two-wire line or radio link . . . using time division multiplex . . . transmitted as pulse trains representing the sine and cosine of the shaft angles of the synchro transmitters. This paper discusses various methods of producing the servo error signals from the information in the received pulse trains.

EFFICIENCY AND RECIPROCITY IN PULSE-AMPLITUDE MODULATION: PART I, PRINCIPLES
K. W. Cattermole, Proc. Instn. Elect. Engrs. (GB), Part B, vol. 105, Sept. 1958, p. 449/462

EFFICIENCY AND RECIPROCITY IN PULSE-AMPLITUDE MODULATION: PART 2, TESTING AND APPLICATIONS
J. C. Price, Proc. Instn. Elect. Engrs. (GB), Part B, vol. 105, Sept. 1958, p. 463/470.

UBER DIE ERREICHBARE GENAUIGKEIT BEI PULSAMPLITUDENMOFULATION UND PULSLÄNGENMODULATION MIT TRANSISTOREN (On the Accuracy in PAM and PWM When Applying Transistors) (In German)
E. Schenck, Nachrichtentech. Zeitsch., vol. 11, April 1958, p. 191/196.

ENERGY OPTIMAL CONTROL FOR PULSE AMPLITUDE MODULATED LINEAR TIME-INVARIANT SAMPLED-DATA SYSTEM
C. Lee, et al., Electronics Research Lab., U. of Calif., Berkley, 27 April 1962, 24 p., Series 60, Issue 447, AD 418 236

DEPENDENCY OF CROSSTALK ON UPPER AND LOWER CUTOFF FREQUENCIES IN PAM TIME-MULTIPLEXED TRANSMISSION PATHS
H. M. Straube, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 268/276.

CERTAIN RESULTS IN PULSE TRANSMISSION THEORY
D. W. Tufts, Cruft Lab., Harvard U., Cambridge, Mass., 5 Feb. 1962, 43 p. incl. illus., 26 refs., (Technical rept. no. 355) AD 275 564.

. . . problem of controlling intersymbol interference and additive noise interference in a certain type of pulse transmission system . . . amplitude modulated, periodic pulse train . . . At the receiver, the amplitude of each transmitted pulse is estimated by performing a weighted integration of the received waveform. A pulse code modulation link is a special case of such a system. . . .

METODY RASCHETA I SINTEZA IMPUL'SNYKH AVTOMATICHESKIKH SISTEM. II (Methods of Calculation and Synthesis for Automatic Sampled-Data Systems. II) (In Russian)
E. G. Gol'shtein, et al., Avtomatika i Telemekhanika, vol. 24, Dec. 1963, p. 1643/1659, A64-13118.

Application of mathematical programming methods to the calculation and synthesis of PAM automatic sampled-data systems. The analysis is limited to the case where the limiting conditions apply only to the upper and lower bounds of each control response. A solution is obtained by a method due to Beale, in which the variables that do not have their limit values are expressed through the remaining variables and certain parameters. . . .

Related Publications:

A PAM/PDM DECOMMUTATOR WITH IMPROVED SYNCHRONIZATION IN PRESENCE OF NOISE
E. D. Heberling, et al., IRE WESCON Conv. Rec., no. 5, Aug. 1958, p. 5/13.

NOLC PAM/PDM DECOMMUTATOR
M. G. Pawley, Naval Ordnance Lab., Corona, Calif., NOLC Tech. Memo No. 73 27, Sept. 1958, p. 1/6, AD 208 449.

A HIGH CAPACITY PAM-FM-FM TELEMETERING SYSTEM FOR THE SATURN BOOSTER
O. B. King, Nat. Symp. Space Electronics Telemetry, no. 7.1, Sept. 1959, p. 1/10.

A S/N IMPROVEMENT FACTOR ON PAM-FM WHOSE RECEIVED PULSE IS COSINE-SQUARED (Correspondence)
A. Watanabe, Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 257/258.

ANALYSE VON LINEAREN NETZWERKEN MIT HAARD-SVALA-SCHALTERN (RESONANZUBERTRAGUNG) (Analysis of Linear Networks with HAARD-SVALA Switches (Resonance Transfer)) (In German)
G. Kraus, Arch. Elekt. Uebertragung, vol. 16, Dec. 1962, p. 611/626.

Referring to publications of Cattermole and Desoer the author works out general fundamentals for the analysis of linear networks with Haard-Svala gates under the assumption that all gates are operated at the same on/off rate and with a vanishing on/off ratio. Examples explain the application of the method. The analysis starts from the behavior of linear networks with respect to amplitude-modulated pulse trains. The well-known forms of a mathematical statement of the behavior are intercompared and brought to agreement in order to facilitate the transition from one to the other. . . .

PRACTICAL DESIGN OF PACM TELEMETRY EQUIPMENT
G. J. Pastor, Nat. Telem. Conf., no. 13-4, May 1962, p. 1/13.

. . . hybrid Pulse Amplitude and Pulse Code Modulation . . . Feasibility Model . . .

A DETERMINISTIC STUDY OF DELTA MODULATION
C. A. Halijak, et al., IEEE Intern. Conv. Rec. Pt. 8, vol. 11, March 1963, p. 247/259.

. . . This paper views delta modulation as a hybrid PDM/PAM system. A nonlinear feedback model is constructed and subjected to digital computation on an IBM 650. . . .

DATA TRANSMISSION AND TRAJECTORY DETERMINING DEVICES FOR RESEARCH ROCKETS AND SATELLITES. (VOLUME I)
I. S. Rochefort, et al., Northeastern U., Boston, Mass., Electronics Research Lab., June 30, 1963, 76 p., 7 refs., Final Report, (AFCRL-63-821 (1)), N63-21719.

. . . a duel triggered parallel-read commutator for an aspect system; the development of a PAM/FM system; a reentry physics program concerned with using Trailblazer vehicles to measure the effects of the plasma sheath on communications . . . program for the evaluation of commercial airborne telemetry system equipments . . . test procedures and equipment tested.

TIME-DIVISION-MULTIPLEX ELECTRONIC TELEPHONE EXCHANGE SYSTEM FOR SMALL PAX
K. Toyoda, et al., IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 455/464.

. . . An experimental time-division-multiplex electronic telephone exchange on a 200-line 4-wire PAM (pulse amplitude modulation) system is described. . . . For reliable operation, common and multiplexed circuits are duplicated, and fault detection and change-over operation are explained.

Section 1.43
Sampled Frequency Modulation Methods

There are basically two frequencies in pulsed carrier systems which can be continuously modulated, the carrier (or subcarrier) frequency of the sinusoidal wave and the pulse repetition frequency (PRF) of the time discrete pulse trains. The first alternative has gained importance as PFM in space telemetry (1.432). Many of its problems are closely related to corresponding FM problems. The second alternative is often used in certain radar applications and key publications in this area date back to the time prior to 1958. Nevertheless a special subdivision has been established to document the fundamentally different characters of these two methods. PRF modulation is also closely related but is still different from pulse interval modulation (PIM) (see 1.444).

1.432: Pulse Frequency Modulation (PFM)

Included: Two state modulation system PWM-PFM; Pulse.

Cross References: Binary frequency shift keying methods (1.332); Fundamentals of frequency modulation (1.232); Pulse delay modulation (1.433); PFM/AM systems (1.950); FSM = frequency slope modulation (1.920).

Principal Publications:

CONCERNING THE NOISE STABILITY OF PULSE-FREQUENCY TELEMETRY
N. V. Pozin, Automation Remote Control, vol. 19, Oct. 1958, p. 948/957.

A STATIC TRANSMITTER UNIT FOR PULSE-FREQUENCY TELEMETERING SYSTEMS
A. M. Pschenichnikov, Automation Remote Control, April 1958, p. 485/489.

CHOICE OF FREQUENCY RANGE FOR INDUSTRIAL PULSE-FREQUENCY TELEMETRY SYSTEM DEVICES. (In Russian)
A. M. Pshenichnikov, Avtomat i Telemekh. (USSR) vol. 21, no. 4, April 1960, p. 525/529.

Considers the effect of frequency range of pulse-frequency telemetry system devices on the errors and noise resistance of transmission, speed of action, and receiver dynamics.

AN ACCURATE DISCRIMINATOR FOR DEMODULATION NOISY PFM TELEMETRY SIGNALS
B. Harris, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 3.3.

. . . consists of a band of relatively closely spaced bandpass filters, each of which is followed by an envelope detector. By means of decision circuitry, the center frequency of the filter-detector combination having the greatest output is selected as the frequency of the PFM pulse. . . . little attention has been given to designing the discriminator for optimum performance when the input signal is masked by noise. When doing so, three parameters must be considered:
1. Number of filters
2. Type of each filter
3. Bandwidth of each filter
A technique is given for the design of an optimum filter bank with respect to detected signal-to-noise ratio and resolution. . . .

THE USE OF PULSE-FREQUENCY MODULATION FOR ADAPTIVE CONTROL
G. J. Murphy, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 271/278.

PULSE-FREQUENCY MODULATION
R. W. Rochelle, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 107/111.

Pulse-frequency modulation (PFM) has been successfully employed as the encoding technique in a number of small U. S. Earth satellites where reduction of power and weight are prime considerations. This paper is concerned with the introduction of some of the more basic principles of PFM. Rather than presenting a rigorous proof on the orthogonality of this type of modulation, a comparison is made to the better-known characteristics of coded binary sequences. It is shown that PFM with quantized frequencies has the same communication efficiency in the presence of additive white Gaussian noise as a corresponding set of coded binary sequences with an equal number of quantized levels. . . . Vanguard III. . .carrying a combination of pulse-duration modulation and PFM. Similar systems were carrier by Explorer VII. . .and by Explorer X. . .Explorer XII carried the first truly PFM system into a highly elliptical orbit with an apogee of 50,000 miles. . . .

PFM SIGNAL PROCESSING
C. M. Stout, Proc. Nat. Telem. Conf., vol. 2, May 1962, no. 3-5.

. . . problems presented to the ground processing system through the use of several variations of the basic PFM system. . . Since this particular type of modulation is relatively new, off the shelf items were not available. . . Ground Processing of Explorer XII Signals. . .

CONSIDERATIONS ON THE DESIGN OF PFM TELEMETRY ENCODERS
H. D. White, Jr., Proc. Nat. Telem. Conf., no. 3-4, May 1962, p. 1/24.

. . . Pulse Frequency Modulation (PFM) is a time-division-multiplex telemetry system. . . Several encoders will be discussed (e.g., Explorer XII, the UK-1, and a general purpose digital data processor).

A TWO-STATE MODULATION SYSTEM
A. G. Bose, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 1963, 10p., AD 423 294

. . . combines aspects of frequency and pulse-width modulation in a manner that enables its realization in terms of a simple closed-loop system having a non-linear forward path and a linear passive feedback path. . .

PFM SIMULATOR
H. Levy, et al., NASA Goddard Space Flight Center, Greenbelt, Md., Sept. 1963, 41 p., N64-12946.

A pulse Frequency Modulation (PFM) simulator, constructed to assist in the design and checkout of PBM equipment, is described. . .

A MAGNETIC CORE VOLTAGE-TO-FREQUENCY CONVERTER
S. Paull, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 12/18.

In a Pulse Frequency Modulation (PFM) telemetering system, there is a need for a subcarrier oscillator with. . .square wave output with constant amplitude over the entire frequency range, . . . This paper describes a method for controlling the frequency of a square-loop magnetic core oscillator by means of a dc voltage to give a voltage-to-frequency converter with the above characteristics. . . . a voltage controlled oscillator that operates from 15 to 5 kc as the input control voltage varies from 0 to +5 volts is used as the design example. . . . Design experience with this device has been chiefly in connection with. . .Explorer VIII, . . .Explorer X. . . Explorer XII, and the first International Satellite UK-1. . . .

PULSE-FREQUENCY MODULATION TELEMETRY
R. W. Rochelle, Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 438/446, Also N63-12695.

. . . an information encoding technique which has found use in a number of spacecraft. The primary advantages have been its noise-immunity characteristics combined with its ease of generation. A description of the present method of formatting and synchronization is presented to illustrate the convenient handling of both analog and digital data. In the detection process for PFM signals, a set of contiguous unmatched filters is used to enhance the signal/noise ratio. To examine the effects of Rayleigh noise on the output of these filters, the word-error probability is derived as a function of the energy per bit, the noise power density, and the degree of coding. . . .

THE PROBABILITY OF ERROR FOR LARGEST-OF-SELECTION BY NUMERICAL INTEGRATION (Correspondence)
R. C. Sommer, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 236.

An article by Ward. . .was recently published. It may be of interest that a similar analysis had been performed at New York University for evaluating various PFM (pulse-frequency modulation) space telemetry schemes. . . .

Related Publications:

A PULSE MODULATOR THAT CAN BE USED AS AN AMPLIFIER, A MULTIPLIER, OR A DIVIDER
J. A. Rosenthal, IEEE Trans. Instrumentation and Measurement, vol. IM-12, Dec. 1963, p. 125/134, A64-17346.

. . . operates by continuously sampling the input signal. The output of the modulator is a pulse train whose frequency and pulse duration vary with the input signal. The modulator can respond instantaneously to a change in the input signal. It is capable of both proportional and on-off control and may be used as an amplifier, a multiplier, or a divider, or any combination of these three. . .

1.433: Pulse Repetition Rate Modulation

Included: Pulse delay modulation; Pulse period modulation; Pulse repetition frequency modulation; Pulse number modulation.

Not Included: PRF radar problems.

Cross References: Delta modulation (Sect. 1.53); Pulse interval modulation (1.444); Pulse position modulation (1.442).

Principal Publications:

A NEW METHOD FOR DELAY-MODULATING A PULSE TRAIN
L. I. Bluestein, Lincoln Lab., Mass. Inst. of Tech., Lexington, 28 May 1963, 12 p., AFESD TDR63 64, AD 406 108.

A new circuit for obtaining pulse frequency modulation (which is equivalent to pulse delay modulation) is derived. . . A practical implementation of the circuit is shown. . .

SPECTRUM OF PERIOD-MODULATED SINUSOIDAL OSCILLATIONS
L. Y. Il'nitskiy, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, 1963, p. 1/5.

. . . A comparison is made with the spectrum of a frequency-modulated signal. For RC oscillators there exists a linear relationship between the oscillation period T and the values of the circuit elements the magnitude of which determines the period . . . The linear relationship between the period and the parameters, the magnitude of which can be varied by means of the modulating voltage implies that for period-modulation it is possible to have a large depth of modulation without any nonlinear distortions. . . .

Related Publications:

THE ACCUMULATION OF PULSE SIGNALS THE REPETITION FREQUENCY BEING UNSTABLE
M.I. Finkel'Shtein, Radio Engrg., vol. 15, no. 2, 1960, p. 67/72.

Section 1.44
Pulse Time Modulation Methods

This section comprises pulse modulation methods which, to some extent, may be called the pulse versions of phase modulation methods. Their common aspect is the continuous modulation of some parameter in the time domain.

If one uses a rectangular envelope of a sinusoidal carrier as an ideal model for a pulse communications system, it is easy to see that there are a number of time domain parameters which may be continuously modulated.

Most characteristic is the"epoch" of the pulse, i.e., its position on an absolute time scale. This is normally characterized by the appearance of the pulse energy at a particular time instant. This can be measured as the occurrence of the pulse peak power with respect to a local time response. In Europe, methods with these characteristics are also called pulse phase modulation. We discuss them in subdivision 1.442.

Another time domain parameter is the length (duration or width) of the rectangular pulse leading to PWM systems (1.443).

If two or more pulses form a pulse group, it is easy to see how the intervals between pairs of pulses can be used to carry modulation (1.444).

In all the above methods, it is assumed that the amplitude of the rectangular pulse is constant and does not carry any modulation. If this assumption is dropped one may arrive at hybrid modulation systems, some of which are included in division 1.9.

Additional pulse time modulation systems are conceivable when using a tone modulation of the envelope of the rectangular pulse. This leads to tone-burst signals, or ac-pulses. The phase of the tone signal with respect to the epoch of the pulse is a new parameter which can be modulated in such cases. No special publications in this area have yet come to our attention.

1.440: Pulse Time Modulation in General

Included: Companding methods in PTM systems; Analysis of disturbances common to all PTM methods.

Not Included: Synchronization problems in PTM.

Principal Publications

CONCERNING THE MULTIPLEXING OF RADIO LINKS WITH PULSE TIME MODULATION AND FREQUENCY MODULATION OF THE RF CARRIER (In German)
R. Eberman, Nachrichtentech., vol. 10, March 1960, p. 95/103.

DIE BEEINFLUSSUNG DER PULSZEIT-MODULATION DURCH EINE FREQUENZMODULATION DES HOCHFREQUENTEN TRAGERS (The Effect of Frequency Modulation of the RF-Carrier on the Performance of a Pulse Time Modulation Signal)(In German)
R. Ebermann, Hockfrequenz. Techn. Elek. Akust, vol. 67, Sept. 1958, p. 48/59.

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 20 Aug. 1962, 38 p. incl. illus., 2 refs. (Trans. no. FTD-TT-62-32 from Nachrichtentechnik, No. 3, p. 106/114, 1961), AD 292 315.

. . . companding values, instantly, of a time modulated signal which guarantees better utilization of the communication system without increasing the necessary frequency band requirements. . . .

NOISE IMMUNITY OF PULSE-TIME MODULATION IN THE PRESENCE OF INTENSE FLUCTUATION NOISE
O.A. Polyakov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 36/43.

. . . for two methods of reception under conditions of intense fluctuation noise for a given transmission rate and accuracy. It is shown that the use of a receiver with instantaneous limiting threshold gives an improvement by a factor of 1.15-1.7, depending on the bandwidth occupied by the signal. . . .

HYBRID DIGITAL ANALOG PULSE-TIME TECHNIQUES FOR FLIGHT CONTROL SYSTEM COMPUTERS
W.R. Seegmiller, IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 498/503.

Related Publications:

A NEW PULSE MODULATED SPEECH COMMUNICATION SYSTEM HAVING A MINIMUM DUTY CYCLE
R.O. Eastman, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 114/118.

. . . The system provides adequate naturalness of speech while maintaining a quantized sampling rate which is proportional to the information bandwidth. . . . generating infinitely clipped signals . . . deriving an optimum sampling rate from these signals. . . . two separate forms of information, amplitude and frequency, are conveyed by a time modulated pulse. . . . results of tests conducted through the system. . . .

1.442: Pulse Position Modulation (PPM)

Included: Autocorrelation of PPM signals; PPM vernier on PCM systems; Bandwidth limitations for PPM; Pulse phase modulation methods.

Cross References: Pulse interval modulation (1.444).

Principal Publications:

A STUDY OF THE PULSE-PHASE-MODULATION INSTALLATION
R. Kaenel, et al., Tech. Mitt. PTT, vol. 36, Jan. 1958, p. 1/12.

A comparison of the PPM system with other modulation systems, and a description of a model installation for four telephony channels.

COMPARISON OF PCM AND PPM FOR RADAR COMMAND
S. Kazel, Proc. Nat. Symp. Telemetry, no. 9.3, Sept. 1958, p. 1/12.

. . . For PCM, it is shown that when the effects of both quantization noise and noise breaking through the receiver threshold are considered, there is optimum number of pulses which results in maximum S/N improvement. For PPM, it is shown that when both edge-shift noise and noise breakthrough are considered, there is an optimum deviation that maximizes the output S/N ratio. . . . under the assumed system limitations, PPM is superior to PCM in regard to maximum reliable range, S/N improvements, and minimum required bandwidth. . . .

A PULSE POSITION TELEMETRY SYSTEM
L. Weisman, et al., IRE Nat. Conv. Rec., vol. 6, pt. 5, March 1958, p. 11/20; Proc. Nat. Aeron. Electronics Conf., vol. 7, May 1959, p. 218/227.

PULSE PHASE MODULATED RADIO LINK EQUIPMENT RVG 934
L. Janke, Nachrichtentech., vol. 10, March 1960, p. 103/108.

ANALYSIS OF A PCM SYSTEM EMPLOYING A PPM VERNIER
W.H. Lob, IRE Trans. Commun. Syst. vol. CS-9, no. 9, Dec. 1961, p. 343/349.

The upper limit to the output SNR of sampled-data PCM systems is set by the quantization noise. The present study. . . . overcoming this limitation by employing time shifting of the PCM pulse groups so as to constitute an analog encoding of the difference between the sample amplitude and the nearest quantization level.

A MULTI-CHANNEL PERSONAL TELEMETRY SYSTEM USING PULSE POSITION MODULATIONS
Proc. Nat. Telemetering Conf., May 1961, p. 12-13/12-27,

SOME EFFECTS OF BANDWIDTH LIMITATION ON P.S.M., P.L.M., AND P.P.M. SIGNALS
J. Das, Proc. Instn. Elect. Engrs. Lond. (Part C), vol. 109, no. 16, Sept. 1962, p. 646/655, 23 refs.

A comparative study has been made of the effects of bandwidth reduction on such important parameters as sideband and harmonic distortions, crosstalk attenuation and message/noise ratios, in pulse-slope modulation, pulse-length modulation and pulse-position modulation systems. . . .

AUTOCORRELATION OF PULSE POSITION MODULATED SIGNALS
N.G. Gionis, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, Masters thesis, Dec. 1962, 65 p. incl. illus. tables, 10 refs. (Rept. no. GE/EE/62-7), AD 294 922.

ASYMMETRICAL SIDEBAND TRANSMISSION OF POSITION MODULATED PULSES
G.I. Lukatela, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 102/108.

. . . It is shown that the synchronously detected component of the envelope of an asymmetrically transmitted impulse can possess a steeper slope than the envelope itself and that over-all transient time of this component may be reduced. . . . The effect of various degrees of transmission asymmetry is calculated for "squared cosine" type transmission-frequency characteristics. The conclusion is reached that for a given channel capacity an asymmetrical sideband transmission in PPM systems should be distinctly superior to a symmetrical one. . . .

RESEARCH AND DEVELOPMENT ON PULSE-MODULATED, PERSONAL-TELEMETRY SYSTEMS (Report Period, Jan. 1961-July 1963.)
A.R. Marko, et al., Aerospace Medical Div. Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio, Oct. 1963, 23 p., refs., (AMRL-TDR-63-96), AD 425 574, N64-13804.

. . . pulse-position and pulse-duration modulation for application in personal telemetry systems . . . an improved three-channel pulse-position amplitude-modulation-telemetry system with frequency modulation in the FM band. Further experimentation resulted in a seven-channel laboratory mode using pulse-duration modulation . . . New microelectronic components make it feasible to reduce the size of the seven-channel transmitting unit to 3 1/2 by 2 1/4 by 1 inch, and the weight to about 200 g, without sacrificing performance.

Related Publications:

A 45 CHANNEL PPM SYSTEM
S. Schreiner, et al., IRE Nat. Conv. Rec., vol. 6, March 1958, p. 225/229.

MODULATIONSEINRICHTUNG PPM 24 MIT KENNTON-SYNCHRONISATION (Modulator Equipment PPM 24 with Pilot Tone Synchronization) (In German)
H.M. Christiansen, et al., Frequenz, vol. 13, Feb. 1959, p. 44/52.

PORTABLE MULTIPLEXER FOR TELEPHONE COMMUNICATIONS
P.W. Kiesling, Jr., Electronics, vol. 32, no. 9, Jan. 1959, p. 60/62.

. . . four channel PPM multiplex. Amplitude modulation of a microwave radio system.

BEACON TELEMETERING SYSTEM
R.C. Pegg, Stavid Engineering, Inc., Plainfield, N.J., Final rept. 1 June 1954-1 June 1959. AD 228 017.

. . . a pulse-position modulation system that relays specified information from an in-flight missile to ground receiver equipment.

PPM 60--A TRANSISTORIZED PPM SYSTEM FOR 60 CHANNELS (In German)
H.M. Christiansen, et al., Nachrichtentech. Zeitsch., vol. 13, Aug. 1960, p. 392/399.

MICROMINIATURE MULTICHANNEL PULSE-POSITION-MODULATION SYSTEM INCORPORATING TRANSISTOR-MAGNETIC-CORE CIRCUITRY
H. Kihn, et al., RCA Rev., vol. 21, no. 2, June 1960, p. 199/227.

An experimental five-channel time-division multiplex system . . . incorporating a micro-miniature transistor-core ring counter for both the transmitter modulator and receiver sampler . . . The sampling rate used in the system is 15 kilocycles with an upper limit set only by the transistor and core high-frequency cutoff. Channel cross talk as low as -40 decibels may be obtained by suitable adjustment of operating parameters. . . . Power consumption is approximately 200 milliwatts at the 15-kilocycle rate. Linearity is adequate . . . for voice communication . . .

A PULSE-POSITION MODULATOR-TYPE MAGNETOMETER
S. Stricker, et al., Commun. Electronics, vol. 80, no. 55, July 1961, p. 253/258.

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS - COMMUNICATION TYPE
R.N. Bailey, et al., Georgia Inst. of Tech., Engineering Experiment Station, Atlanta, 15 Feb. 1963, 134p., AD 401 132.

. Band-width and crosstalk tests and test procedures developed for the pulse-position modulated, time-division multiplexer AN/TCC-13 . . . The system error rate test is presented in detail . . . results of mixer studies . . . spurious response bandwidth is found to be inversely proportional to the integer 'q' in the spurious response equation.

PULSE POSITION MODULATION CODE FOR THE IMPROVEMENT OF DOPPLER SHIFT MEASUREMENT
L.A. Wan, IEEE Trans. Inform. Th., vol. 10, no. 3, July 1964, p. 192/195.

. . . for improving Doppler measurement by pulsed radar with respect to Woodward's expression of Doppler ambiguity . . . The code of pulse positions is shown to be analytically obtained from the difference between the required ambiguity expression and that of a constant pulse-repetition frequency signal. . . .

1.443: Pulse Width Modulation

Included: Pulse length modulation; Pulse duration modulation (PDM).

Not Included: Complete telemetry systems.

Cross References: Pulse interval modulation (1.444); PDM/FM or PWM/FM systems (1.933); PDM/AM or PWM/AM systems (1.950).

Principal Publications:

THE TRANSMISSION OF PULSE WIDTH MODULATED SIGNALS OVER RESTRICTED BANDWIDTH SYSTEMS
H.J. Heffernan, IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, April 1957, no. 2.3, p. 1/4.

A SOLID-STATE PULSE-WIDTH MODUALTOR
H. Kaplan, et al., IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, April 1957, no. 3.3, p. 1/8, (Addendum).

A TRANSISTORIZED PULSE WIDTH KEYER
J.A. Riedel, Jr., IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, April 1957, no. 6.5, p. 1/6.

PDM BANDWIDTH REQUIREMENTS
F.E. Rock, IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, April 1957, no. 7.2, p. 1/6.

DIE BEEINFLUSSUNG DER PULSZEIT-MODULATION DURCH EINE FREQUENZ-MODULATION DES HOCHFREQUENTEN TRAGERS (The Effect of a Frequency Modulated RF Carrier on a Pulse Time Modulated Signal) (In German)
R. Ebermann, Hochfrequenztech. Elek. Akust., vol. 67, Sept. 1958, p. 48/59.

TRANSISTOR PULSE WIDTH CONTROL AMPLIFIER WITH REACTIVE LOAD
G.T. Flesher, Proc. Nat. Electronics Conf. vol. 14, Oct. 1958, p. 454/463.

Transistors can control a d-c power output of 30 to 50 times their internal dissipation rating when used as pulse width controlled switches. Switch operation carries the transistor rapidly from a low dissipation "on" state to a low dissipation "off" state which results in low transistor heating but large d-c output depending on the duty cycle of the on-off condition. Excellent operation is achieved with resistive loads, but reactive loads slow the switching speed and the transistor dissipation increases. . . .

A PAM/PDM DECOMMUTATOR WITH IMPROVED SYNCHRONIZATION IN PRESENCE OF NOISE
E.D. Heberling, et al., IRE WESCON Conv. Rec., no. 5, Aug. 1958, p. 5/13.

A SOLID STATE COMMUTATING AND PULSE WIDTH ENCODING CIRCUIT
W.H. Lucke, Naval Res. Lab., Washington, D.C., NRL Rept. No. 5082, March 1958, 18 p., AD 157 309.

NEW PRINCIPLES OF CONSTRUCTING TELEMETRY SYSTEMS WITH PULSE-TIME AND PULSE-WIDTH MODULATION
A.I. Novikov, et al., Automation & Remote Control, vol. 19, Aug. 1958, p. 741/746.

A CONDUCTIVITY-STORAGE TRANSISTOR PULSE-WIDTH MODULATOR
J.C. Price, Electronic Engng., vol. 30, Feb. 1958, p. 88/90.

A TRANSISTORIZED ALL ELECTRONIC LOW LEVEL PULSE WIDTH MULTICODER
J.A. Riedel, Jr., Proc. Nat. Telemetering Symp., Sept. 1958. no. 12.4.

UBER DIE ERREICHBARE GENAUIGKEIT BEI PULSAMPLITUDENMODULATION UND PULSLANGENMODULATION MIT TRANSISTOREN (On the Precision of PAM and PWM Systems when Operating with Transistors) (In German)
E. Schenck, Nachrichtentech. Zeitsch., vol. 11, April 1958, p. 191/196.

DIRECT DIGITAL CONVERSION OF PULSE-WIDTH MULTIPLEXED DATA
F.T. Chambers, Electronic Equipment Engrg., vol. 7, Nov. 1959, p. 55/58.

A MAGNETIC-AMPLIFIER COMMUTATING AND PULSE-WIDTH ENCODING CIRCUIT
W.H. Lucke, Commun. Electronics, Jan. 1959, p. 884/892.

PULSE WIDTH MODULATED RELAY CONTROL OF SYSTEMS SUBJECT TO SAMPLED DATA
W.L. Nelson, Electronic Res. Lab., Columbia University, N.Y., Rept. No. AFOSR RN-59-282, July 1959, 68 p., AD 212 915.

An investigation was conducted on the application of pulse width modulation as a control method for relay controlled systems with sampling. The limit cycles which occur in relay control systems with sampling are discussed and two methods of design employing pulse width control which eliminates these limit cycles are developed. Experimental results are presented for a second order system. Application and extension of the results are discussed.

PULSE WIDTH CONTROL OF SAMPLED DATA SYSTEMS
W.L. Nelson, Electronics Research Lab., Columbia U., New York, July 1959, Report No. CU-55-59-AD-677-EE, Technical Report No. T-35/B; (AFOSR TN-59-609), AD 217 396.

NOISE STABILITY IN PULSE-WIDTH & PULSE-TIME TELEMETRY SUBJECT TO STRONG FLUCTUATION NOISE
N.V. Pozin, Automation & Remote Control, vol. 20, Feb. 1959, p. 227/235.

AN IMPROVED TRANSISTORIZED PDM KEYER FOR THE MULTI-CHANNEL DATA ACQUISITION SYSTEM
B. Stefanov, Nat. Symp. Space Electronics Telemetry, Sept. 1959, no. 4.3, p. 1/7.

ANALYSIS OF PULSE DURATION SAMPLED-DATA SYSTEMS WITH LINEAR ELEMENTS
R.E. Andeen, IRE Trans. Automatic Control, vol. AC-5, no. 4, Sept. 1960, p. 306/313.

Deals with the application of z-transform techniques to the analysis of sampled-data systems in which signals appear in pulse-duration modulated form. The characteristics of pulse-duration sampled data are first briefly described. . . . a comparison is shown of analytical results with tests on several representative experimental systems. . . . relative advantages and disadvantages of p.d.m. in control systems . . .

PDM THERMOCOUPLE SUBCOMMUTATION SYSTEM
A. Ferkovich, Jr., Proc. Nat. Telemetering Conf., May 1961, p. 4-53/4-71.

STABILITY STUDY OF PULSE-WIDTH MODULATED AND NONLINEAR SAMPLED-DATA SYSTEMS
T. Nishimura, Electronics Research Lab., U. of Calif., Berkeley, 4 April 1961, 68 p. incl. illus., 33 refs., AD 273 858.

ON THE POSSIBILITY OF PULSE MODULATION BY SATURABLE REACTORS
J.K. Sen, Journal of Technology, vol. 6, June 1961, p. 1-9, A63-20435.

Presentation of a method for obtaining pulse-width and pulse-time modulation by using saturable reactors (magnetic amplifiers). . . .

SOME EFFECTS BANDWIDTH LIMITATION ON P.S.M., P.L.M., AND P.P.M. SIGNALS
J. Das, Proc. Instn. Elect. Engrs. Lond. (Part C), vol. 109, no. 16, Sept. 1962, p. 646/655, 23 refs.

A comparative study has been made of the effects of bandwidth reduction on such important parameters as sideband and harmonic distortion, crosstalk attenuation and message/noise ratios, in pulse-slope modulation, pulse-length mod- and pulse-position modulation systems. . . .

ON THE DYNAMIC RANGE OF A MAGNETIC RECORDING CHANNEL
M.V. Gitlits, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 4, April 1962, p. 65/75.

The effect of irregularities in efficiency of ferromagnetic recording media and of tape-transport flutter on the dynamic range of a channel during direct magnetic recording of signals is analyzed as is the use of amplitude, frequency and pulse-width modulation. . . .

PROJECT RELAY DIGITAL COMMAND SYSTEM
S.H. Roth, et al., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 100/103.

. . . (NASA) has developed a coded message sequence consisting of discrete, pulse-duration-modulated (PDM) tone bursts for commanding satellites. The message consists of a sync pulse followed by some combination of six pulses, three each of zeros and ones. This code allows for 20 commands (the combination of six things taken three at a time). . . . equipment developed for the Relay satellite program which demodulates the tone bursts, converts the pulse-duration modulation into a binary code, and then decodes the message into twenty discrete commands. . . .
The subcarrier tone amplitude-modulates a VHF carrier for transmission to the vehicle. . . .

A TWO-STAGE MODULATION SYSTEM
A.G. Bose, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge. 1963, 10 p., AD 423 294.

. A modulation system that converts a continuous signal into a two-state signal, and has the property that the modulating signal can be recovered by lowpass filtering . . . combines aspects of frequency and pulsewidth modulation in a manner that enables its realization in terms of a simple closed-loop system having a nonlinear forward path. . . . Applications to high-efficiency power amplification, nonlinear control, and low-frequency data recording are presented.

PASSAGE OF A PULSE-WIDTH-MODULATED SIGNAL THROUGH A MAGNETIC RECORDING CHANNEL

M.V. Gitlits, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1963, p. 37/46.

The distortions of a pulse signal as it passes through a magnetic recording channel are determined. Various methods of shaping the pulses of the playback signal in a system with pulse-width modulation are considered from the viewpoint of the efficient utilization of the bandwidth of the recording channel and allowing for the effect of multiplicative and additive noise. A pulse-shaping method "according to the zero of the derivative" is considered. . . .

STABILITY STUDY OF PWM FEEDBACK SYSTEMS

E.I. Jury, et al., (American Society of Mechanical Engineers, Joint Automatic Control Conference, Minneapolis, Minn., June 19-21, 1963.) ASME, Transactions, Series D - Journal of Basic Engineering, vol. 86, March 1964, p. 80/86, 22 refs., A64-15437.

Derivation of a fundamental equation which yields the limit-cycle feature of PWM feedback system. The application of this equation to obtain the response of the autonomous as well as the forced PWM system is indicated. The application of this fundamental equation to other types of nonlinear sampled-data feedback systems is also demonstrated. . . .

AN OPTIMIZATION TECHNIQUE FOR PULSE WIDTH MODULATED SYSTEMS

R.W. Kafka, Illinois U. Coordinated Science Lab., Urbana, May 1963, 97 p., 37 refs. N63-17090, AD 406 078.

. . . design of a controller to optimize a certain class of pulse-width modulated systems . . . The process to be controlled is time-invariant, of arbitrary order, and excited by a sequence of pulse generated from information available at arbitrary sampling instants. Input information to the system is quite general and includes random and deterministic phenomena. . . . The controller is not adaptive in the sense of redesign occuring as new information becomes available from the estimator. It does, however, accomplish the goal of optimization by deciding the form of the pulse-width actuating signal utilizing the future erros of the system.

RESEARCH AND DEVELOPMENT ON PULSE-MODULATED, PERSONAL-TELEMETRY SYSTEMS

A.R. Marko, et al., Acrospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio, (Report Period, Jan. 1961-July 1963), Oct. 1963, 23 p., refs., (AMRL-TDR-63-96), AD 425 574, N64-13804.

. . . pulse-position and pulse-duration modulation for application in personal telemetry systems . . . an improved three-channel pulse-position amplitude-modulation-telemetry system with frequency modulation in the FM band. Further experimentation resulted in a seven-channel laboratory mode using pulse-duration modulation . . . New microelectronic components make it feasible to reduce the size of the seven-channel transmitting unit to 3 1/2 by 2 1/4 by 1 inch, and the weight to about 200 g, without sacrificing performance.

OPTIMAL SYNTHESIS OF LINEAR PULSE-WIDTH-MODULATED COMPUTER-CONTROLLED SYSTEMS.

G.J. Murphy, et al., Franklin Institute, Journal, vol. 277, Feb. 1964, p. 128/139, 13 refs., A64-15308.

. . . optimal synthesis of linear control systems with pulse-width modulation. The criterion of system performance is a quadratic index . . . The technique, which is based on the state-variable concept and on dynamic programming, leads to the determination of a computer program for calculating the optimum sequence of signals to be applied to the input of the pulse-width modulator.

A SIMPLE SUPERVISORY ENCODER USING PULSE-LENGTH MODULATION

P.N. Sargeaunt, Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 369/374.

. . . A method of encoding eight binary signals in a form which enables either visual (oscilloscope) or automatic readout to be employed at a remote station is described. . . . A time division multiplex method is used, individual channel information being impressed by pulse width modulation. . . .

SUPPRESSION OF NOISE EFFECTS IN PULSE WIDTH MODULATED SYSTEMS

H.J. Stein, Coordinated Science Lab., Univ. of Illinois, Urbana, Jan. 1964, 55 p., Rept. no. R190, AD 437 495.

. . . sampled data feedback system, consisting of a lead type pulse width modulator, a general (n-th order), linear, time-invariant plant, and unity feedback. The closed loop system is assumed to be stable, and it is assumed that plant time constants are of the order of, or shorter than, the pulsing period. The modulator is assumed to be imperfect (noisy). . . .

DESIGN OF A PULSE WIDTH MODULATOR FOR USE IN SILICON INTEGRATED CIRCUITS
A.J. Wall, Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, Aug. 1963, 45 p., AD 421 032.

. . . to demonstrate that such a modulation function can be realized within a 250 by 30 mil silicon integrated semiconductor structure. . . . Three active and seven passive components are used. The modulator utilizes trailing edge modulation and samples a single audio input signal at 20 kc. . . .

Related Publications:

PDM/FM/FM ON LOWER SUB-CARRIER FREQUENCIES
F.E. Rock, Proc. Nat. Symp. Telemetering, Sept. 1958, no. 12.2.

CROSSTALK IN TIME SHARED SYSTEMS AS AFFECTED BY DISCRIMINATOR CHARACTERISTICS
O.J. Ott, Nat. Symp. Space Electronics & Telemetering, Sept. 1959, no. 8.3, p. 1/6.

A commonly used method for increasing the number of channels in an FM-FM system is to commutate a group of low frequency inputs and transmit the time shared waveform as PAM or PDM information on one of the subcarrier channels.

A DETERMINISTIC STUDY OF DELTA MODULATION
C.A. Halijak, et al., IEEE Intern Conv Rec. Pt. 8, vol. 11, March 1963, p. 247/259.

. . . Delta modulation has often been viewed as a type of PCM and has been analyzed by probabilistic methods. This paper views data modulation as a hybrid PDM/PAM system. A nonlinear feedback model is constructed and subjected to digital computation on an IBM 650. Computation is enabled by trapezoidal convulution, an approximate Z-transform method for solving dynamical systems. . . .

A PULSE MODULATOR THAT CAN BE USED AS AN AMPLIFIER, A MULTIPLIER, OR A DIVIDER
J. A. Rosenthal, IEEE Trans. Instrumentation and Measurement, vol. IM-12, Dec. 1963, p. 125/134, A64-17346.

. . . operates by continuously sampling the input signal. The output of the modulator is a pulse train whose frequency and pulse duration vary with the input signal. The modulator can respond instantaneously to a change in the input signal. It is capable of both proportional and on-off control and may be used as an amplifier, a multiplier, or a divider, or any combination of these three . . .

1.444: Pulse Interval Modulation

Included: Time interval modulation methods.

Cross References: Pulse position modulation (1.442).

Principal Publications:

TIME INTERVAL TELEMETERING SYSTEM
N. Wilde, IRE Trans. Telemetry Remote Control, vol. TRC-3, no. 1, April 1957, no. 8.3, p. 1/7, (Addendum).

Random nonrepetitive pulses space from 0.5 to several hundred microseconds apart originate in a moving source. These time intervals are to be measured and immediately displayed in digital form at a remote point located 10 to 20 miles from the vehicle.

INFLUENCE OF NOISE FLUCTUATIONS ON A DECODING UNIT DURING THE INTERVALS SEPARATING THE PULSES IN A CODE GROUP
L.P. Kuklev, Radio Engrg. Electronics, vol. 4, no. 3, 1959, p. 31/39.

. . . we investigate the problem of the effect of noise fluctuations in radionavigation systems with pulse interval coding. . . . comprises the transmission of n pulses identical in form and duration with a certain definite position of the pulses relative to each other. Decoding of such signals is often carried out with the help of delay lines and coincidence stages by comparing the code intervals in the signal with the delay intervals in the lines which are adjusted for the reception of codes fixed in advance.

A METHOD OF RADIO COMMUNICATION USING THE MOON
N.A. Kalashnikov, et al., Foreign Tech. Div. Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 4 June 1962, 4 p. incl. illus., (Trans. no. FTD-TT-62-rri from Sovient Patent no. 132680 (652243/26) 28 Jan. 1960, AD 281 510.

A broad-band communications system is proposed. . . . each discrete communication being transmitted using two pulses, shifted with respect to one other; they are modulated by different frequences such that at the reception point the output pulse is determined by the difference in the envelopes of these two pulses; this makes it possible to decrease the mutual influence of the pulses of neighboring channels.

Section 1.47
Sampling Modulation Methods in Control Systems

Sampled data systems are an increasingly important class of control systems. This section contains references which may indicate the close relation of the number of problems and techniques between the respective branches of communications engineering and control engineering to the space communications engineer.

This selection is, by necessity, somewhat subjective and the reader is advised to consult specialized control techniques literature for further details.

1.470: Sampled Data Systems

Included: Modulation problems of sampled data systems; Signal distortions in sampled data system; Tuned variable rate samples; Fundamentals of multivariable sampled data systems; State transition flow graphs.

Not Included: Design of control systems.

Cross References: Time series analysis of sampled data systems (1.411).

Principal Publications:

ANALOG SIMULATION OF SAMPLED-DATA SYSTEMS
R. C. Klein, IRE Trans. Telemetry Remote Control, vol. TRC-1, no. 2, May 1955, p. 2/7.

STATISTICAL DESIGN THEORY FOR STRICTLY DIGITAL SAMPLED-DATA SYSTEMS
S. S. L. Chang, Commun. Electronics, Jan. 1958, p. 702/709.

. . . z-transform theory for the analysis and synthesis of sampled-data systems. Applicable when correlation functions concerning the input signals are the only known factors.

CONCERNING A METHOD FOR ANALYZING SAMPLED-DATA SYSTEMS
F. Chun-Wui, Automation Remote Control, vol. 19, April 1958, p. 288/298.

A WAY OF FORMING TRANSFER FUNCTIONS OF SAMPLED-DATA CONTROL SYSTEMS WITH EXTRAPOLATING DEVICES
S. S. Ermakov, et al., Automation Remote Control, vol. 19, May 1958, p. 395/402.

AN APPROXIMATION TO SIMPLIFY THE ANALYSIS OF CLOSED-LOOP SAMPLED-DATA SYSTEMS WITH NON-NEGLIGIBLE PULSE WIDTH
G. J. Murphy, Proc. Nat. Elect. Conf., vol. 14, Oct. 1958, p. 65/75.

CONCERNING THE EQUIVALENCE OF PULSE AND CONTINUOUS-DATA CONTROL SYSTEMS
V. A. Rubtsov, Automation Remote Control, vol. 19, Oct. 1958, p. 926/933.

SAMPLED-DATA SYSTEMS WITH EXTRAPOLATING DEVICES
I. Tsypkin, Automation Remote Control, vol. 19, May 1958, p. 383/394.

STATISTICAL INVARIANCE OF NOISE IN SAMPLED-DATA SYSTEMS
S. A. Zadoff, IRE WESCON Conv. Rec., no. 4, Aug., 1958, p. 173/176.

OPTIMUM CONTROL THROUGH TUNED SAMPLING
J. T. Tou, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 290/298.

. . . A sampled-data control system contains one or more samplers which may operate with different sampling rates. The sampling rate may be either constant or variable. It is found that the control system exhibits optimum performance if the variable-rate sampler is properly "tuned." The system stability may be improved by selecting a suitable variable rate for the sampler. It is shown in this paper that when the cyclic-variable sampling rate is varied the stability boundary describes a curve which is concave downward, exhibiting a peak between two limiting values of the cyclic rate. Furthermore, when the system is subjected to a stochastic input, the mean-square error can be reduced to a minimum by "tuning" the variable-rate sampler to an optimum rate. The optimizing feature of tuned sampling may be utilized to achieve self-optimization of control systems.

ANALYSIS OF PULSE DURATION SAMPLED-DATA SYSTEMS WITH LINEAR ELEMENTS
R. E. Andeen, IRE Trans. Automatic Control, vol. AC-5, no. 4, Sept. 1960, p. 306/313.

Deals with the application of z-transform techniques to the analysis of sampled-data systems in which signals appear in pulse-duration modulated form. The characteristics of pulse-duration sampled data are first briefly described. . . . a comparison is shown of analytical results with tests on several representative experimental systems. . . . relative advantages and disadvantages of p.d.m. in control systems. . .

CONTRIBUTION TO THE MODIFIED Z-TRANSFORM THEORY
E. I. Jury, J. Franklin Inst., vol. 270, no. 2, Aug. 1960, p. 114/129.

Introduces a complex convolution theorem for the modified Z-transform. . . The theorem is fairly general and a number of special cases of wide interest are discussed, including relationship with Z-transform theory, evaluation of square error at sampling instants, analysis of integral square error and others of importance in conventional and multi-rate sampled-data systems. Examples are discussed and a short table of relevant transforms is given. Additional theorems include one enabling the solution of certain types of non-linear difference equations.

UBER DIE NACHBILDUNG UND UNTERSUCHUNG VON ABTASTSYSTEMEN AUF EINEN ELEKTRISCHEN ANALOGRECHNER (Synthesizing and Investigation of Sampled-Data Systems by means of an Analog Computer) (In German)
G. Schneider, Elektron Rechenanlagen, vol. 1, Feb. 1960, p. 31/37.

STUDY OF SAMPLED-DATA CONTROL SYSTEMS BY MEANS OF DISCRETE FREQUENCY RESPONSE ANALYSIS
H. C. Torng, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 96/102.

. . . a discrete frequency response analysis is proposed. It is needed because the conventional frequency response approach, which is so useful in the study of continuous control systems, fails to yield the same effect when it is used to study sampled-data control systems. . . . Sampled-data control systems have been intensively investigated in the past decade. Three books 1, 2, 3 and numerous articles 4, 5 have been published in this area. . . . The L-transform approach for convenient systems finds its counterpart for discrete control systems in the Z-transform technique. . . .yields the key to adopting the block-diagram approach and many other useful techniques for continuous systems to studies of sampled-data control systems. The frequency response analysis of discrete control systems is however not so fortunate. In attempting to plot the Nyquist Diagram, Bode diagram, and Nichols Chart for a discrete control system, the investigator encounters a formidable task. . .

EINFUHRUNG IN DIE THEORIE DER ABTASTSYSTEME (Introduction to the Theory of Sampled-Data Control Systems) (In German)
J. Tschauner, Munich: R. Oldenbourg, 1960, 185p.

The mathematical theory of sampled-data control systems is dealt with in three main sections. The first of these deals with open-loop systems and the second with closed-loop systems and in each case some numerical examples and oscillograms of actual results are included. The third section is concerned with certain mathematical methods, namely, the Zeta-transform, the Taylor-transform and difference methods, and their application to sampled-data control systems. . . .

THE CALCULATION OF PULSED SYSTEMS WITH DIFFERENT INPUTS (In German)
J. Tschauner, Nachrichtentech; vol. 13, no. 6, June 1960, p. 271/274.

Transfer functions are derived for systems in which the error is sampled. Three cases are discussed; an error signal, determined immediately before the beginning of an active control period, . . .a constant error signal, acting over the sampling period; very narrow pulses (δ functions) of varying amplitude; acting over a very short interval of time. Oscillograms are given which confirm the expected behavior for various parameters. . . .

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF NOISE SUPPRESSIONS IN THE SAMPLED DATA METHOD OF AMPLIFICATION
G. S. Anufriyev, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 9, 1961, p. 10/18.

. . . feasibility of recording weak periodic signals in the stroboscopic method of amplification. An experimental system was realized, which boosts the voltage signal-to-noise ratio by a factor of approximately 10^3. . . . Periodic signals with a voltage of 4.10^{-7} with an upper limit of the frequency spectrum equal to 5 Mc were definitely observed. . . . employ various systems in which methods of storage filter discrimination, compensation and positive feedback stores are used. . . . the stroboscopic method of conversion can be recommended in the following cases:
1. To register periodic pulse signals with a low signal-to-noise ratio at the input of the receiver (for the reception of radar signals in certain special cases. . . .)
2. In the measuring technique for obtaining large signal-to-noise ratios, which in a number of cases may ensure a sufficiently accurate measurement of the signal parameters.
3. For physical experiments, for example, in pulse mass-spectrometers . . .

OPTIMUM PREFILTERING OF SAMPLED DATA (Correspondence)
W. M. Brown, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 269/270.

Let f denote a stochastic signal and n denote additive noise; consider a prefilter which prepares f + n for sampling. The sampled data is interpolated to recover an estimate of f. . . .

THE RELATION BETWEEN DISCRETE PERIODIC INPUTS, THE TRANSFER FUNCTION AND THE TRANSIENT RESPONSE OF A SYSTEM
T. Glucharoff, Proc. Instn. Elect. Engrs. (GB), Monogr. 452. To be republished in Part C., June 1961, 7 p.

Sampled-data systems are characterized by the presence of discrete signals at some point of the system, but the overall output is usually a continuous function of time. It is shown that the pulse sequence of discrete periodic signals, which result in a finite-settling-time response when applied to the input of a system, can be determined directly from the system transient response. . . .

OPTIMUM SAMPLED-DATA CONTROL
R. Jackson, Proc. Instn. Elect. Engrs., (GB), Part C, vol. 108, no. 14, Sept. 1961, p. 309/316.

A method of rendering feedback control systems amenable to treatment by the Wiener theory is applied to the case in which the controller operates on a sampled measurement. An explicity expression is obtained for the minimum attainable mean-square error for certain classes of system transfer functions and disturbance power spectra, and the form of the optimum controller is derived. . . .

ON THE EXACT ANALYSIS OF SAMPLED-DATA FEEDBACK SYSTEMS WITH APPRECIABLE PULSE WIDTH
G. J. Murphy, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 214.

A GENERAL SOLUTION FOR LINEAR, SAMPLED-DATA CONTROL
T. L. Gunckel, II, et al., American Society of Mechanical Engineers, Joint Automatic Control Conference, New York, N.Y., June 27-29, 1962, Paper 62 - JACC-11, ASME, Transactions, Series D, Journal of Basic Engineering, vol. 85, June 1963, p. 197/201; Discussion, p. 201/203; Authors' Closure, p. 203. 10 refs., A63-22309.

Demonstration that if linear, sampled-data control-system performance can be adequately measured by a quadratic function of the error, it is possible to develop single optimum-design procedure that encompasses almost all linear sampled-data control problems of interest. . . .

APERIODICITY CRITERIA FOR LINEAR DISCRETE SYSTEMS (Correspondence)
E. I. Jury, et al., IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 431/434.

. . . Aperiodicity conditions in continuous systems are obtained when all the roots of the system characteristic equation lie on the negative real axis in the s plane, . . . The criteria for obtaining these conditions have been investigated extensively abroad, in particular in Russia. . . and England. Comparatively little or nothing on this problem has been published in this country. . . .

In analogy to the continuous case, we define aperiodicity conditions in sampled-data or discrete systems. . .

ANALYSIS AND DESIGN OF SAMPLED-DATA SYSTEMS VIA STATE TRANSITION FLOW GRAPHS
B. C. Kuo, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 28/39.

The state transition method of analyzing linear dynamic systems is reviewed. The state transition flow graphs of continuous-data and sampled-data dynamic systems are defined. . . The state transition equations of the system may be determined directly from the state transition flow graph by applying Mason's gain formula and taking the inverse Laplace transform. The state transition flow graph technique is particularly useful for the study of multirate sampling, multi-sampler, cyclic-sampling, and non-synchronized sampling systems. Examples are given illustrating the application of the technique. . .

ENERGY OPTIMAL CONTROL FOR PULSE AMPLITUDE MODULATED LINEAR TIME-INVARIANT SAMPLED-DATA SYSTEM
C. Lee, et al., Electronics Research Lab., U. of Calif. Berkeley, 27 April 1962, 24 p., AD 418 236.

The problem under consideration is an idealization of the attitude control problem of space vehicles. In the case where a space vehicle is to have a rather long life it is important to keep the fuel consumption at a minimum so that possibly the useful life of the satellite may be limited by considerations other than the amount of fuel it carries at the start of the trip. . .

OPTIMIZATION OF MULTIVARIABLE SAMPLED-DATA CONTROL SYSTEMS
J. Lieutaud, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., Sept 1962, 50 p. incl. illus., 6 refs. (Research rept. no. PIBMRI-1078-62), AD 297 251.

A squared error performance criterion is chosen and the effects of controllability and observability are studied.

DIGITAL PROCESSES FOR SAMPLED DATA SYSTEMS
A. J. Monroe, New York, John Wiley and Sons, Inc., 1962, 490 p.

. . . to be used as a self teaching aid. . . . concerned with the use of a digital computer as a data processing device, and presents analytical methods for constructing digital programs and digital to analogue converter weighting functions. It also features a composite design criterion that weds transient behavior design and noise-conscious design. . . .
Several features unify the material. . . .

A SIMPLE APPROXIMATE FORMULA FOR PROCESSES IN SAMPLED-DATA CONTROL SYSTEMS. (In German)
A. Papoulis, Regelungstechnik, vol. 10, no. 3, March 1962, p. 105/107.

GAIN OF MULTISAMPLER SYSTEMS (Correspondence)
G. C. Reis, Proc. IRE, vol. 50, no. 8, Aug. 1962, p. 1843.

DESIGN OF AN ACCURATE SIMULATOR FOR SAMPLED-DATA SYSTEMS
M. J. Somerville, et al., Proc. Instn. Elec. Engrs. London (Part B), vol. 109, no. 43, Jan. 1962, p. 67/76.

. . . detailed consideration. . . certain specialized units by means of which an analogue machine, normally used for simulation of continuous systems, may be adapted to allow also simulation of sampled-data systems. . . .

ON PERIODIC MODES OF SATURATING DISCRETE CONTROL SYSTEMS
H. C. Torng, J. Franklin Inst., vol. 274. no. 5, Nov. 1962, p. 358/368.

A discrete sequence method is presented in this paper to identify possible limit cycles in saturating discrete control systems. This method produces explicit relationships between self-sustained oscillations and relevant system parameters. No approximation is made. There is no restriction with respect to the order of the linear plant to be controlled. Experimental verification is also provided.

A SURVEY OF CONTROL RESEARCH IN U.S. ENGINEERING SCHOOLS
J. E. Ward, IRE Trans. Automatic Control, vol. AC-7, no. 5, Oct. 1962, p. 126/129.

The American Automatic Control Council set up the Control Advisory Committee (CAC) for assessing the present U. S. effort in control research. The CAC surveyed only university groups, since the assessment of industrial control-research activities would have been beyond its capabilities. . . . The data obtained show that a substantial effort in control research is made at U.S. universities (about 6 1/2 million dollars spent, about 1000 people employed, about 800 theses per year). The author discusses the limitations of the survey and arrives at the conclusion that this survey is an indication of the fairly substantial U. S. effort in control research and education, but that it is no more than an indication.

SAMPLING AND QUANTIZATION ERRORS IN A DIGITALLY MECHANIZED INERTIAL NAVIGATOR
N. A. Boehmer, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 1, Jan. 1963, p. 56/61.

. . . A constant altitude, meridian plane, pure Schuler tuned inertial navigator model on a nonrotating earth is used for analysis. Insofar as sampling and quantization effects are concerned, nothing significant is lost by this restriction since the cross-coupling effects are small, and the earth rotation vector components on the platform axes are slowly varying. . . . Time and frequency domain analysis of the sampled-data system is presented and the effects of quantization present at the digital computer input and output are evaluated. . . .

METODY RASCHETA I SINTEZA IMPUL'-SNYKH AVTOMATICHESKIKH SISTEM. II. (Methods of Calculation and Synthesis for Automatic Sampled-Data Systems. II) (In Russian)
E. G. Gol'shtein, et al., Avtomatika i Telemekhanika, vol. 24, Dec. 1963, p. 1643/1659, A64-13118.

Application of mathematical programming methods to the calculation and synthesis of PAM automatic sampled-data systems. The analysis is limited to the case where the limiting conditions apply only to the upper and lower bounds of each control response. A solution is obtained by a method due to Beale, in which the variables that do not have their limit values are expressed through the remaining variables and certain parameters. . . .

AN ON LINE SOLUTION TO SAMPLED-DATA TIME OPTIMAL CONTROL
J. H. Eaton, Repr. from J. of Electron. Control, v. 15, no. 4, Oct. 1963, p. 333/341, refs., N64-18109.

The problem considered is that of designing a special purpose computer that is rapid enough to provide an on-line solution to the sampled-data time optimal control problem in which the inputs are subjected to amplitude constraints. . . The time optimal control problem is solved by increasing the number of sampling periods until the specified terminal state is reachable. Preliminary results with a fourth-order system indicate that computer settling times of a few milliseconds can be obtained.

ADAPTIVE GAIN AND ADAPTIVE SAMPLING SAMPLED-DATA CONTROL SYSTEMS
S.C. Gupta, IEEE Paper no. 63-130, Feb. 1963, 7 p.

AN ITERATIVE PROCEDURE FOR OPTIMAL CONTROL OF A SYSTEM BY SAMPLED INPUT
L. Hasdorff, et al., Journal of Electronics and Control, 1st Series, vol. 16, Feb. 1964, p. 177/188. 16 refs., A64-14913.

Study of the problem of optimal control of any given nonlinear, time varying system by sampled input. The procedure used is a numerical iterative technique developed primarily by Kelly, Bryson and Denham, and Bryson et al. A real value criterion function of the final state is assumed and is minimized, at the end of which the input is in the required form of amplitude varying pulses over a given period. . . .

AN EXTREME VALUE PROBLEM IN A LINEAR SAMPLED-DATA FEEDBACK SYSTEM
J. B. Knowles, IEEE Trans. on Automatic Control, vol. AC-8, July 1963, p. 235/239, A63-22503.

Consideration of a linear sampled-data feedback system with an uncorrelated, wide-band Markov noise process contaminating the input signal. . . .

GAIN OF MULTISAMPLER SYSTEMS (Correspondence)
G.G. Lendaris, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 395/396.

. . . recent correspondence . . . G.C. Reis . . . several available methods . . . a few comments concerning the one proposed by Reis. . . .

OPTIMUM SAMPLED-DATA SYSTEMS WITH QUANTIZED CONTROL SIGNALS
J.B. Lewis, et al., (American Institute of Electrical Engineers, Winter General Meeting, New York, N.Y., Jan. 27-Feb. 1, 1963), IEEE Trans. on Applications and Industry, July 1963, p. 229/233; Discussion, p. 233, 15 refs., A63-21784.

. . . design of a class of nonlinear sampled-data systems where the control signal is quantized, so that its value at any instant is chosen from a set of 2L+1 levels. A design compromise between the extremes of proportional control systems (no quanitizing or bounding on control signal) and relay control systems (coarse quantization) can be achieved. . . . Dynamic programming techniques are used in carrying out the optimum design. Both minimum summed-square-error systems and minimum - N systems are discussed and illustrated for dynamic performance.

USE OF A COORDINATE TRANSFORMATION IN THE INCREMENTAL PHASE PLANE
D. P. Lindorff, IEEE Trans. on Automatic Control, vol. AC-9, Jan. 1964, p. 110/113, A64-15920.

. . . to facilitate the design of sampled-data control systems in which there is a simple nonlinearity. Use of the transformed coordinates permits the slope of a boundary specified by the nonlinearity to be directly related to a simple gain term in the transformed system. . . . By using the transformed coordinates it is possible to identify intersample oscillations which are undetectable in the original coordinate system. . . .

OPTIMUM SYNTHESIS OF SAMPLED-DATA SYSTEMS WITH NON-STATIONARY RANDOM UNITS
R.H. McCamish, Master's thesis, Kansas U., Lawrence, Feb. 1963, 43 p. incl. illus., 16 refs., AD 401 817.

. . . presents a mean amplitude-set-time weighted error optimization criterion for use in synthesizing an optimum sampled-data system whose input is a non-stationary random signal corrupted by additive noise.

A TRANSFORM TECHNIQUE FOR MULTIVARIABLE, TIME VARYING, DISCRETE-TIME, LINEAR SYSTEMS
A.W. Naylor, Cooley Electronics Lab., U. of Michigan, Ann Arbor, Jan. 1964, 41 p., TR142 and rept. no. 4853 22T, AD 431 267.

In the last several years the use of matrices to characterize time-varying discrete-time, linear systems has been growing. Attention hereto has been centered on single-input, single-output systems. This article shows that the previously developed methods can be applied, after certain changes and re-interpretations, to multivariable systems.

GENERALIZED FREQUENCY RESPONSE CONCEPTS FOR TIME-VARYING, DISCRETE-TIME LINEAR SYSTEMS
A.W. Naylor, IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 428/440.

. . . It is shown that many of the frequency response concepts associated with time-invariant linear systems can be expanded in a meaningful

manner to time-varying, discrete-time linear systems. Generalized frequency domain representations of the input and output are introduced along with a generalized frequency response or transfer function relating input and output. In addition, generalizations of bandwidth, gain bandwidth product, and Parseval's (Plancherel's) theorem are introduced. . . .

UCHET PEREKHODNOGO PROTESSA V ZADACHE STATISTICHESKOGO SINTEZA IMPUL'SNOI SISTEMY
(Accounting for Transient Response in the Problem of the Statistical Synthesis of a Sampled-Data System) (In Russian)
V.A. Petrov, Akademiia Nauk SSSR, Izvestiia, Tkhnicheskaia Kibernetika, Jan. - Feb. 1964, p. 202/208, 5 refs., A64-16988.

Discussion of the statistical synthesis of automatic control systems by methods for the solution of Wiener-type problems, based on the minimization of steady-state errors. Specifically examined is the development of an analog to Solodnikov'sand Matveev's problem of the total reproduction error, by taking into account the statistical errors in the transient response in the functional to be minimized. The results are applied to the statistical synthesis of sampled-data systems of finite storage capacity.

TOCHNYI METHOD RASCHETA PEREKHODNYKH PROTSESSOV I USTOICHIVOSTI IMPUL'SNYKH SISTEM S KONECHNYM VREMENEM S'EMA DANNYKH)
(Exact Method for the Solution of the Transient Response and Stability of Sampled-Data Systems with Finite Sampling Time) (In Russian)
I.V. Pyshkin, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1303/1316, 14 refs., A64-13213

Investigation of sampled-data switch-key systems. By fitting the solutions of canonic equations of systems that correspond to the closed and open positions of the key, difference equations describing the system are derived . . . The expression for the output process, in the sense of discrete Laplace transform, is obtained in the form of a relation of two determinants, the elements of which are simple functions of the roots of the closed and open systems. A stability analysis of such systems is presented.

OPTIMUM DESIGN OF DIGITAL CONTROLS
J.T. Tou, Computer Sciences Lab., Northwestern Univ., Evanston, Ill., March 1963, 22 p., Research memo 201, AD 422 093.

A solution is presented for the design of time optimal control for discrete-data systems subject to control signal saturation. The state-space approach is used to determine the optimum control policy . . .

A DISCRETE MODEL FOR EYE TRACKING MOVEMENTS
L.R. Young, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April - July 1963, p. 113/115.

A sampled data model was developed to describe the major characteristics of the eye movement control system for nonpredictive tracking. It agrees with experimental transient responses and frequency characteristics for normal eye movements during following of a moving target in a horizontal plane. . . .

Related Publications:

LOGIC FOR A DIGITAL SERVO SYSTEM
R.W. Ketchledge, Bell Syst. Tech., vol. 38, Jan. 1959, p. 1/44.

DESIGN OF DIGITAL CONTROL SYSTEMS
K.S. Fu, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 335/350.

Every digital control system contains at least one signal which is sampled in time and quantized in amplitude. If the system contains a large number of levels of quantization, it is often possible to obtain a satisfactory design by neglecting the nonlinear nature of the system. However, there are many practical situations where only a few levels of quantization are available and where full account must be taken of the nonlinear nature of the system. Two techniques useful in the design of these nonlinear systems are presented . . . using a digital computer to carry out the numerical calculations.

SYNTHESIS OF NONLINEAR DIGITAL CONTROL SYSTEMS
Y. Fujimoto, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 1, Jan. 1963, p. 61/69.

. . . a new method for the synthesis of nonlinear digital control systems to fulfill an optimum performance criterion. . . .

THE USE OF PULSE - FREQUENCY MODULATION FOR ADAPTIVE CONTROL
G.J. Murphy, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 271/278.

TECHNIQUES FOR THE OPTIMIZATION OF CONTROLLED PROCESSES
A.D. Booth, J. Brit, Instn. Radio Engrs., vol. 25, no. 6, June 1963, p. 517/524.

Some mathematical representations of processes are considered and a general statement made of the requirements for optimization. . . . it is shown how various approximation techniques can be adapted to sampled systems. Finally a transformation is given, which enables the past history of a process to be of utility in correcting deviations which occur in a process already optimized. . . .

SETTING UP A DIGITAL COMPENSATOR FOR USE IN A DATA SAMPLING SERVOMECHANISM (In French)
H. Dampure, Onde Electr., vol. 43, no. 443, April 1963, p. 415/424.

In order to improve the initial response of a sampling data system which includes a digital compensator, the capabilities of this type of compensator are studied. First of all the transfer characteristics are established. The performance in a closed loop is then described: first of all in a general case, and then in the particular case of a discrete quantum step. A simple example is worked out by way of a practical application.

ON THE STABILITY OF A CERTAIN CLASS OF NONLINEAR SAMPLED-DATA SYSTEMS
E.I. Jury, et al., IEEE Trans. on Automatic Control, vol. AC-9, Jan. 1964, p. 51/61, 16 refs., A64-15913.

Application of a extension of Popov's method to a study of nonlinear sampled-data systems . . . Examples are discussed and the results compared with Liapunov's quadratic and quadratic plus integral forms as well as with other methods. The results obtained from the new theorem yield less conservative gain values than Liapunov's method. . . .

STABILITY STUDY OF PWM FEEDBACK SYSTEMS
E.I. Jury, et al., (American Socity of Mechanical Engineers, Joint Automatic Control Conference, Minneapolis, Minn., June 19-21, 1963.) ASME, Transactions, Series D - Journal of Basic Engineering, vol. 86, March 1964, p. 80/86, 22 refs., A64-15437.

Derivation of a fundamental equation which yields the limit-cycle feature of PWM feedback system. The application of this equation to obtain the response of the autonomous as well as the forced PWM system is indicated. The application of this fundamental equation to other types of nonlinear sampled-data feedback systems is also demonstrated. . . .

OPTIMAL SYNTHESIS OF LINEAR PULSE-WIDTH-MODULATED COMPUTER CONTROLLED SYSTEMS
G.J. Murphy, et al., Franklin Institute, Journal, vol. 277, Feb. 1964, p. 128/139, 13 refs., A64-15308.

. . . optimal synthesis of linear control systems with pulse-width mdoualtion. The criterion of system performance is a quadratic index . . . The technique, which is based on the state-variable concept and on dynamic programming, leads to the determination of a computer program for calculating the optimum sequence of signals to be applied to the input of the pulse-width modulator.

ON THE ASYMPTOTIC STABILITY OF A CLASS OF SATURATING SAMPLED-DATA SYSTEMS
J.B. Pearson, Jr., et al., (IEEE, Illinois Institute of Technology, Northwestern University, and University of Illinois, National Electronics Conference, Chicago, Ill., Oct. 28-30, 1963, paper 63-1440.) IEEE Trans. on Applications and Industry, March 1964, p. 81/85; Discussion, G. P. Szego and Ia. Tsypkin, p. 85/86; Authors; Reply, p. 86, 28 refs., A64-15861.

Presentation of an extension of the Lur'e stability function to a class of discrete-time systems which may contain saturation-type nonlinear elements. Examples are presented which demonstrate the improved stability inequalities available from this function.

PERFORMANCE MEASURES AND OPTIMIZATION CONDITION FOR A THIRD-ORDER SAMPLED-DATA TRACKER
H.R. Simpson, IEEE Trans. on Automatic Control, vol. AC-8, April 1963, p. 182/183, A63-17526.

SUPPRESSION OF NOISE EFFECTS IN PULSE WIDTH MODUALATED SYSTEMS
H.J. Stein, Coordinated Science Lab., Univ. of Illinois, Urbana, Jan 1964, 55 p., Rept. no. R190, AD 437 495.

. . . sampled data feedback system, consisting of a lead type pulse width modulator, a general (n-th order), linear, time-invariant plant, and unity feedback. The closed loop system is assumed to be stable, and it is assumed that plant time constants are of the order of, or shorter than, the pulsing period.

The modulator is assumed to be imperfect (noisy). . . .

SUR LA STABILITE ASYMPTOTIQUE DES SYSTEMS ECHANTILLONNES (Asymptotic Stability of Sampled-Data Systems) (In French with summary in Russian)
S. Wegrzyn, et al., Academie Polonaise des Sciences, Bulletin, Serie des Sciences Techniques, vol. 11, no. 2, 1963, p. 9/11, A63-19795.

. . . rigorous mathematical proof for a stability criterion of a nonlinear sampled-data system expressed by a finite-difference equation of the m-order. The proof is based on the use of the corresponding Liapunov function, and is a generalization of a previous criterion derived for a non-linear second order, finite-difference equation.

Section 1.48
Other Sampling Modulation Methods

1.482: Pulse Slope Modulation

Included: Triangular pulse waveforms.

Cross References: Pulse position modulation (1.442); FSM = frequency slope modulation (1.920).

Principal Publications:

TRANSMISSION CHARACTERISTICS OF PULSE-SLOPE-MODULATED SIGNALS THROUGH BAND-LIMITED SYSTEMS
J. Das, Indian J. Phys., vol. 35, no. 5, May 1961, p. 245/260.

Distortion, crosstalk and noise characteristics of pulse-slope modulation were determined. Maximum harmonic distortion is about 2% for slow cut-off rate of the medium and about 5% for sharp-cut-off filters. Slicers introduce more distortion and non-linearity in modulation. . . .

SOME EFFECTS OF BANDWIDTH LIMITATION ON P.S.M., P.L.M., AND P.P.M. SIGNALS
J. Das, Proc. Instn. Elect. engrs. London (Part C), vol. 109, no. 16, Sept. 1962, p. 646/655, 23 refs.

A comparative study has been made of the effects of bandwidth reduction on such important parameters as sideband and harmonic distortions, crosstalk attenuation and message/noise ratios, in pulse-slope modulation, pulse-length modulation and pulse-position modulation systems. . . .

Division 1.5
PULSE CODE MODULATION (PCM)

Pulse code modulation is a special form of a digital transmission method and many characteristics of PCM are identical to those of data transmission systems referenced in division 1.3.

There is one major difference: PCM was originally invented as a highly reliable method for the transmission of analog voice waveforms. It has remained a method for the transmission of continuous input information with the help of digital signals. Data transmission systems, on the other side, are primarily designed for the communication of discrete information and the particular arrangements of the information digits into words (groups of digits) is normally of secondary inportance.

Thus it should be noted by the user of this bibliography that the problems associated with the conversions of analog information into digital symbols and vice versa are discussed in this division on PCM. On the other hand it has been stressed in the comment to division 1.3 that most problems of the actual transmission of digital information over communications channels are the subject of division 1.3.

This situation leads to a split of this division into four sections. The first one is the analytical section. It contains references to the important quantization process and to a number of variations of the basic pulse code modulation principle.

The second section deals with several design problems of complete PCM systems, such as synchronization and repeater problems. Again it is necessary to point out that this volume is not concerned with actual equipment design. Hardware and circuit details are not included, except in cases where a publication deals with both the analytical (systems) and practical (equipment) problems.

The third section presents references to delta modulation, which may be considered a subclass of PCM, but which may also be operated as a special variation of a quantized semi-analog pulse time modulation system. Such a system is quantized in the amplitude domain, but its sampling intervals are not quantized in the time domain, as sampling takes place instantaneously whenever an amplitude level is exceeded.

The last section (1.57) gives an account of recent publications about special applications of PCM in telemetry and for picture transmission. Again readers are reminded that equipment descriptions and publications about operational experience are not included in this volume. Volume 4 of this series is a bibliography of space communications systems and equipment actually used and there are descriptions of PCM telemetry systems in the subdivisions of the various space projects.

Section 1.50

1.500: Survey of Pulse Code Modulation

Included: Books on PCM; General references on PCM.

Not Included: Coding theory (2); Gray code (2).

Cross References: Digital transmission systems (Div. 1.3).

Principal Publications:

NOISE-REDUCING CODES FOR PULSE-CODE MODULATION
J. E. Flood, Proc. Instn. Elect. Engrs., London, pt. C, vol. 105, Sept. 1958, p. 391/397.

PULSE CODE MODULATION SYSTEMS, (Volume I)
W. Hatton, et al., Raytheon Mfg. Co., Waltham, Mass., Semi-annual progress rept. no. 1, 15 Nov. 1958 - 14 June 1959, AD 226 318.

PULSE CODE MODULATION SYSTEMS (VOL. 1)
W. Hatton, et al., Raytheon Co., Waltham, Mass, Semi-annual progress report no. 2, 15 June - 14 Dec. 1959, 205 p., AD 231 780.

STANDARDS FOR PULSE CODE MODULATION (PCM) TELEMETRY
IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 4, Dec. 1959, p. 194/195.

RESEARCH MODEL FOR TIME-SEPARATION INTEGRATED COMMUNICATION
H. E. Vaughan, Bell System Tech. Journal, vol. 38, July 1959, p. 909/932.

A new communication system concept which is an important step toward an all-digital telecommunication plant is discussed. A research model combines remote line concentration, time-separation switching and PCM transmission.

PCM SYSTEM TRENDS
R. L. Sink, IRE WESCON Conv. Record, 1960, pt. 5.

A SURVEY OF PCM PROGRESS
R. L. Sink, Proc. Natl. Telemetering Conf., May 1960, p. 261/269.

PULSE CODE MODULATION - PART 1 - AN INTRODUCTION TO PULSE CODE MODULATION
J. S. Whyte, Post Off. Elect. Engrs. J., vol. 54, no. 2, July 1961, p. 86/91.

PROBLEMS AND PROGRESS IN PCM
M. R. Aaron, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 72/81, 54 refs.

Recent progress in the design of PCM systems is traced. Since band-limiting and sampling are basic to PCM, the design of filters for the application is considered. A simple approximation technique is sketched that reduces a switched network to a stationary network for purposes of design. Several restricted-tenary codes suitable for baseband PCM transmission are displayed. Advances in the understanding of the timing performance of self-timed reconstructive repeaters are given brief coverage.

RADIO TELEMETRY (In Russian)
F. I. Barsukov and M. V. Maksimov, Moscow, Oborongiz, 1962, 184 p.

. . . elements of radio telemetering systems with frequency, time, code, and combined division of channels. Particular attention is devoted to the problems of encoder and decoder construction in radio telemetering systems and also to the features of transmitter-receiver and antenna systems. . . . intended for those familiar with the principles of radio engineering. . . .

PULSE CODE MODULATION STUDY CONTRACT
C. M. Shapiro, et al., Philco Corp., Philadelphia, Pa., Rept. no. 3 (Final), 1 Nov 1961 - 1 June 1962, July 1962, 44 p. incl. illus., table, AD 283 579.

. . . 6-channel Pulse Code Modulation (PCM) system using new techniques is . . . Multiplex logic . . . special sync circuits . . . tested with the operation of one channel to give voice demonstration. . . .

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK - PART 2 - TRANSMISSION AND ENCODING
A. Chatelon, Elect. Commun., vol. 38, no. 1, 1963, p. 32/43.

DELTA MODULATION
R. H. Maschhoff, Electro-Technology, vol. 73, Jan. 1964, p. 91/97. A64-13655.

. . . The delta modulation is compared to PCM and PRM.

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK - PART 1 - ADVANTAGES OF PULSE CODE MODULATION
P. Mornet, Elect. Commun., vol. 38, no. 1, 1963, p. 23/31.

Related Publications:

CHANNEL PULSE CODE MODULATION SYSTEM
W. Hatton, et al., Raytheon Manufacturing Company, 1958, 64 p., AD 206 770.

STUDY OF PCM-FM TRANSMISSION OVER TROPOSPHERIC SCATTER SYSTEMS
F. Assadourian, RCA Defense Electronic Products, N. Y., Final rept. on Task 4, Sept. 1959, AD 230 426.

. . . . transmission of PCM-FM signals. . . . preliminary in the sense that it is devoted primarily to a detailed survey of necessary background topics such as binary digital error rates for various types of PCM-FM signals and for correlation or non-correlation detection. . . .

A SURVEY OF LITERATURE ON TECHNIQUES AND INSTRUMENTATION FOR MEASURING ELECTRICAL PULSE INTERVALS
B. A. Cryce, et al., Autonetics, Downey, Calif., 28 Feb. 1963, lv, AD 403 137.

. . . bibliography . . . on rise time and width range of very short electrical pulses. Emphasis has been placed on how to measure time and peak amplitude by accurate nanosecond measurements. . . . covers approximately a 12-year period with most of the literature encompassing the last four years.

Section 1.51
Analysis of Pulse Code Modulation Methods

For the analysis of PCM systems, it is important to discriminate between the signal conditioning function, the signal transmission function, the detection function and the signal processing function.

The first of these four functions is the subject of this section. The transmission function is discussed in division 1.3; the detection function is referenced in volume 2; and the processing function is, to some extent, identical with other signal processing functions to be discussed in subject 3A of this series.

The signal conditioning function incorporates the complete analog to digital conversion process. The AD conversion requires the sampling process (1.41) and the quantization process (to be treated here). The closely related process of commutation (multiplexing) is subject of a section in volume 2. Design details of logical circuits for PCM encoders and decoders will not be discussed in this bibliography. The same applies to A/D converters for control or computer applications.

1.510: Theory of PCM Systems in General

Included: Total noise in PCM systems; Performance criteria of PCM systems.

Not Included: Coding theory (2).

Cross References: Quantization noise (1.511); Performance criteria of communications systems (1.810); Analysis of PCM telemetry systems (1.573).

Principal Publications:

THE PHILOSOPHY OF PCM
B. M. Oliver, et al., Proc. Inst. Radio Engrs., vol. 36, Nov. 1948, p. 1324/1331.

THE RATE OF TRANSMISSION OF INFORMATION IN PULSE-CODE MODULATION SYSTEMS
A. R. Billings, Proc. Instn. Elect. Engrs., London, pt. C, vol. 105, Sept. 1958, p. 444/447.

CHANNEL CAPACITY OF A BINARY PULSE-CODE SYSTEM FOR UNEQUAL SYMBOL DISTORTION PROBABILITIES
L. Z. Kliachkin, Radio Engineering, vol. 13, no. 4, 1958, p. 33/38.

SIGNAL/NOISE RATIO IN PULSE-CODE MODULATION SYSTEMS--USE OF THE "IDEAL OBSERVER" CRITERION
J. W. R. Griffiths, J. Brit. IRE, vol. 19, March 1959, p. 183/186.

DETECTION LEVELS AND ERROR RATES IN PCM TELEMETRY SYSTEMS
A. V. Balakrishnan, et al., IRE Conv. Rec., pt. 5, 1960, p. 37/55.

STATISTICAL EVALUATION OF DIGITAL—ANALOG SYSTEMS FOR FINITE OPERATING TIME
R. B. Northrop, et al., IRE Trans. Automatic Control, vol. AC-5, no. 2, June 1960. p. 118/128.

A frequency-domain mathematical model for comparing the performance of a linear sampled-data channel to a linear continuous channel is developed. . . . The model allows an explicit albebraic definition of ensemble mean-squared error, after a finite operating time, by application of residue theory. . . . The technique developed is utilized to evaluate the ensemble mean-squared error due to processing a vehicle velocity estimate . . . in a digital computer. . . . This problem is of fundamental importance in present-day pure inertial, pure Doppler, or inertial-Doppler navigation systems. The effect of quantization, inherent in the process of analogue-to-digital conversion, may be included in this evaluation. . . .

NOISE IN A PCM TRANSMISSION SYSTEM
H. Scheftelowitz, Ericsson Tech. (Sweden), vol. 16, no. 2, 1960, p. 207/244.

The different noise sources in a p. c. m. transmission system have been evaluated and their impact on the overall signal-to-noise ratio calculated. Formulas are given which show the signal-to-noise ratio in relation to repeater spacing. . . .

THE THEORY OF PULSE SYSTEMS
Y. Z. Tsypkin, Moscow, Fizmatgiz, 1958.

. . . At the present time a new scientific discipline, the theory of pulse systems has

arisen . . . Ya. Z. Tsypkin's monograph . . . constitutes a fundamental work describing the state and development of the theory of pulse systems. The greater part of the monograph is concerned with the theory of linear pulse systems with constant parameters. For pulse system with variable parameters and non-linear pulse systems the basic theory and some particular solutions which are of considerable practical value are described. By the common nature of their development the theory of pulse systems is similar to the theory of discontinued systems. The result is that it has proved possible to transfer, after the appropriate variations, the well known methods and concepts of the theory of discontinuous systems to pulse systems. . . . (Book Review).

COMMENTARY ON A PAPER BY KUKLEV CONCERNING THE INFLUENCE OF NOISE ON A DECODING UNIT USING A PULSE CODE GROUP

D. Middleton, Lincoln Lab., Mass. Inst. of Tech., Lexington, 28 Dec. 1961, 53 p. incl. illus., 10 refs. (Rept. no. 42G-1), (AFESD TDR 62-143), AD 287 162.

A 1959 paper by Kuklev . . . employing a pulse code group of up to five pulse elements . . . A translation of Kuklev's paper is given . . . Kuklev's basic model is found to be satisfactory and his approximations in most instances are reasonable. However, the accuracy of his calculations can be noticeably improved by more refined approximations. Calculations are presented for false-alarm probabilities different from the values considered by Kuklev. The calculations show the required increase in input signal level as the number of pulses in the code group is increased.

CONSTRUCTION AND DECISION DETECTION OF BINARY INFORMATION

B. W. Russell, Proc. Nat. Aerosp. Electron. Conf., vol. 9, May 1961, p. 302/306.

. . . definition of "information" . . . description of a simple Pulse Code Modulation communication system . . . derives basic signal power, bandwidth, information rate and error loss factor relationships . . .

PCM SIGNAL-TO-NOISE PERFORMANCE

J. H. Crow, Nat. Telem. Conf., May 1962, no. 5-1, p. 1/12.

PROBABILITY OF DISTORTION OF PULSE CODE MODULATED SIGNALS DUE TO CERTAIN NON-GAUSSIAN NOISE (Translation)

R. F. Matveev, Radio Engineering and Electronic Physics, vol. 7, Oct. 1962, p. 1577/1584. AD63-19212.

. . . probability of incorrect reproduction of signals in the regenerator . . . due to the combined action of Gaussian noise and dispersion distortion of the pulses. . . .

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS (PHASE 3 REPORT)

J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Final rept., Feb, 1962 - Feb 1963, May 1963, 175 p., RADC TDR63 147, AD 407 343.

. . . bounds on the performance of PCM systems for transmitting analog information . . . compared with theoretical bounds for systems of prescribed complexity. . . .

PCM TELEMETRY PERFORMANCE

H. Scharla-Nielsen, Instruments and Control Systems, vol. 36, Sept. 1963, p. 91/95, A63-25966.

. . . methods for specifying PCM telemetry accuracy and for measuring equipment performance. Discussed are error categories in PCM systems which may be separately measured and specified, including noise, quantizing error, crosstalk, common mode error, source impedance error, and sample-time error. . . .

AN ANALYSIS OF THE FACTORS WHICH DETERMINE SIGNAL/NOISE DISCRIMINATION IN PULSED-CARRIER SYSTEMS

D. O. North, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1016/1027.

. . . Reprint of North's classical paper written in 1943 (see next reference).

PREFACE TO NORTH PAPER

L. Blake, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1015/1027.

This classic report written in 1943 by Dwight O. North, appears here for the first time in a publication readily available to the engineering profession, although it was issued as a military-security-classified report during World War II (RCA Laboratories Report PTR-6C, dated June 25, 1943). It is reprinted here because of its historical importance and because it is still a basic but otherwise unavailable reference of great value in current research. . . .

SAMPLED DATA MODULATION SYSTEMS

R. Sanders, In: Space Communications, Edited by A. V. Balekrishnan, New York, McGraw-Hill Book Co., Inc., 1963, p. 104/122, A64-11236.

Survey of three classes of modulation techniques: (1) that which transforms a signal waveform into some continuously variable modulation parameter where no sampling or time quantization of the signal source is performed prior to modulation; (2) that involving continuously variable modulation parameters; and (3) that commonly referred to as any general method of

digital transmission . . . Included . . . synchronization requirements in class (2) modulation systems; PCM systems; bandwidth requirements for PCM systems; error correction and detection methods in PCM systems; and orthogonal systems.

Related Publications:

THEORETICAL FUNDAMENTALS OF PULSE TRANSMISSION
E. D. Sunde, Bell Systems Tech. J., May 1954, p. 729.

POWER-BANDWIDTH TRADE-OFFS FOR FEEDBACK FM SYSTEMS: A COMPARISON WITH PULSE-CODE MODULATION
E. Bedrosian, Rand Corp., Santa Monica, Calif., Oct. 1961, 59 p. (Rept. RM-2787), AD 264 781.

. . . For a given quality of service, power can be traded against bandwidth depending on the amount of feedback used. Large amounts of feedback in a typical system can reduce the amount of transmitter power required by as much as 8 db while roughly doubling the radio channel occupied, compared with a conventional FM system designed to minimize transmitter power. Assuming an optimum detection process, a comparable PCM system requires about 3 db less power than a conventional toll-quality FM system but about 5 db more power than a feedback FM system using 35 to 40 db of feedback.

TECHNIQUES FOR TRANSMISSION OF PULSE CODE MODULATION SIGNALS
D. D. McRae, Proc. Nat. Telemetering Conf., May 1961, p. 11-75/11-86.

The designer of a pulse code modulation system which is to be used with an RF link is faced with the choice of a number of system parameters. Among those which he must choose, perhaps the most difficult are the characteristics of the three filters which determine to a great degree the operational capability of the system. These are the premodulation filter, the IF band-pass filter, and the post-detection (but predecision) filter. The location of these filters in the system is shown in Figure 1.

CLASSIFICATION AND EVALUATION OF COHERENT SYNCHRONOUS SAMPLED-DATA TELEMETRY SYSTEMS
A. Viterbi, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, 15 June 1961, 10 p., (Technical rept. no. 32-123), AD 260 585.

An analysis is given of the various types of continuous wave and pulse modulation for the transmission sampled data over channels perturbed by white gaussian noise. . . .

TRANSMISSION OF INFORMATION BY MEANS OF ORTHOGONAL SIGNALS
I. M. Teplyakov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 4, April 1963, p. 1/5.

. . . We shall consider the transmission of quantized functions, the spectrum of which is contained within the band from zero to a frequency W_0. The interval T_0 between two adjacent samples of a function will then be determined by W_0, i. e., $T_0 = 1/2\ W_0$. All quantization levels will be assumed equiprobable, their number being denoted by L. . . . It is well known that if no delay is introduced either in transmission or reception, the L/1 possible quantization levels must be transmitted by means of a system of L/2 equiprobable orthogonal signals and their opposite signals. . . . Such a system of signals will be termed optimum. . . . A reduction of the required signal power can be obtained by introducing delays in the transmission and reception of information in the following manner. Two function samples will be combined into one sample having L^2 quantization levels. At the same time an additional delay of value T_0 will be required in transmission. . . .

1.511: Quantization Processes

Included: Quantization noise; Correlation properties of quantized processes; Quantization errors; Block quantization; Dithering; Independent quantizer activators; Spectra of quantized signals.

Not Included: Gray codes (2).

Cross References: Nonlinear quantization (1.512); Spectra of pulse trains (1.413).

Principal Publications:

THE EFFECT OF QUANTIZATION IN SAMPLED-FEEDBACK SYSTEMS
J. E. Bertram, AIEE Paper No. 58-91, Library Letter no. 10, March 31, 1958.

ON THE QUANTIZATION OF FINITE DIMENSIONAL MESSAGES
M. P. Schutzenberger, Information Control, vol. 2, May, 1958, p. 153/158.

THE QUANTIZATION OF STOCHASTIC SIGNALS WITH INFINITE SPECTRUM AND SOME RESULTS OF THE THEORY OF PULSE TRANSMISSION OF INFORMATION (In Russian)
N. A. Zheleznov, Radiotekhnika i Elektronika, vol. 3, 1958, p. 1/23.

A theorem is proved about the optimum resolution of signals into orthogonal components, which gives the smallest mean square error.

ELECTRONIC QUANTIZING DEVICES (Review)
M. A. Aingorn, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 56/69.

QUANTIZING FOR MINIMUM DISTORTION
J. Max, IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 7/12.

ON MARKOV PROCESSES IN CONTROL SYSTEMS WITH QUANTIZERS
R. P. Wishner, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 72/78.

It is shown that the theory of Brownian motion is applicable to solving for probability densities in a class on nonlinear control systems when the disturbance input is white noise with a Gaussian probability density function. Attention is focused on first-order nonlinear systems. . . . Analytical solutions are given for the case in which the compensating elements form a quantizer. . . .

QUANTIZATION IN COHERENT AND QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Review, vol. 22, no. 3, Sept. 1961, p. 461/486.

. . . The analysis is given for both coherent and quadrature detection with ideal analog signal processing and for digital processing using time and amplitude quantization.

ON SOME PROPERTIES OF THE CORRELATION FUNCTIONS OF QUANTIZED LAPLACE SIGNALS (In French)
G. Bonnet, C. R. Acad. Sci., vol. 255, no. 6, Aug. 1962, p. 1064/1066.

. . . For the study of weak signals the discrete expression for the correlation function obtained by quantization of a stationary random signal is transformed into an analytic form. The properties of the correlation functions of strong and weak functions are briefly discussed.

ON THE SECOND ORDER STATISTICS OF QUANTIZED RANDOM SIGNALS (In French)
G. Bonnet, C. R. Acad. Sci., vol. 255, no. 5, July 1962, p. 825/827.

Real random signals are replaced by a quantized step-function approximation. Quantized expressions are given for the characteristic function, mathematical expectation, mean square and covariance. The particular case of a random stationary Laplace function is treated and the normed correlation function and characteristic function determined. . . .

THE MAJORIZATION OF QUANTIZATION ERRORS IN DYNAMIC PROGRAMMING CALCULATIONS (In French)
J. J. Guignabodet, C. R. Acad. Sci., vol. 255, no. 5, July 1962, p. 828/830.

Expressions are found for upper bounds of the error in the decision function assuming that the process transition function satisfies a Lipschitz condition. The result is extended to the case of quantization.

REDUCTION OF QUANTIZING NOISE BY USE OF FEEDBACK
H. A. Spang, III, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 373/380.

. . . using linear feedback around the quantizer to shape the noise spectrum. Each output sample will then contain not only signal information but also information about the errors in the previous samples. Such a system is analyzed for random input signals of a rather general nature. . . . A comparison is made of the mean-square error with and without feedback. . . .

CORRELATION FUNCTION AND SPECTRAL DENSITY OF A QUANTIZED PROCESS
A. I. Velichkin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 70/77.

. . . of a level- and time-quantized process . . . Several investigations of the correlation function and spectral density of a quantized process are known. . . . were limited to an examination of the case when the level-quantization unit had a uniform characteristic. Moreover, the level quantization and the time quantization were analyzed jointly and this led to such complex expressions for the correlation function that the spectral density could only be determined approximately. . . . solution . . . below. . . is valid for any characteristics of the unit carrying out the level quantization. Moreover the level and time quantizations are examined separately. . . .

A GENERAL THEORY OF AMPLITUDE QUANTIZATION WITH APPLICATIONS TO CORRELATION DETERMINATION
D. G. Watts, Proc. Instn. Elect. Engrs., London, (Part C), vol. 109, no. 15, March 1962, p. 209/218.

. . . used to investigate the effects of signal quantization on the determination of

correlation function. Theoretical expressions are obtained for the cross-correlation between signals and quantization noises and for the cross-correlation between quantization noises. From considerations of the theory of amplitude quantization, a general form for multiplier correlators is determined. The perfect analogue correlator, the digital computer applied to corrleation determination, the relay correlator and the polarity-coincidence correlator are all shown to be special cases fo this general form. In addition, a new correlation method termed Stieltjes correlation is deduced. This method, in which one of the inputs is coarsely quantized and the other is not, is described in detail and is shown to possess many advantages over the correlators mentioned above. . . .

ASYMPTOTICALLY OPTIMUM QUANTIZERS AND OPTIMUM ANALOG TO DIGITAL CONVERTERS FOR CONTINUOUS SIGNALS (Correspondence)

L. I. Bluestein, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 242/246.

. . . concerned with the quantization of noisy, continuous signals. . . . consider the problem of finding a discrete-output transducer whose output is a close replica of the noise-free signal in an appropriate statistical sense. . . .

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK Part 2—Transmission and Encoding

A. Chatelon, Elect. Commun., vol. 38, no. 1, 1963, p. 32/43.

CONSIDERATION OF LEVEL QUANTIZATION IN THE SYNTHESIS OF DIGITAL AUTOMATIC CONTROL SYSTEMS.

S. M. Fedorov, (Tekhnicheskaia Kibernetika, Jan.—Feb. 1963), In Russian, Engineering Cybernetics, Jan.—Feb. 1963, p. 101/108, 16 refs., Translation, A64-15934.

Establishment of conditions that eliminate the possibility of periodic oscillations in a digital control system synthesized by the method of typical logarithmic frequency characteristics. These periodic oscillation regimes arise from level quantization in digital automatic control systems . . .

NUMBER OF QUANTIZATION LEVELS AND INTERVALS REQUIRED FOR THE DISCRETE REPRESENTATION OF WEAK SIGNALS IN NOISE

L. I. Filippov, (Radiotekhnika i Elektronika, vol. 8, March 1963, p. 497/499.) In Russian, Radio Engineering and Electronic Physics, March 1963, p. 440/442, Translation, A64-10445.

Note on a method for quantizing weak signals in noise, a procedure which is necessary for the computer processing of the signals. An interval in the time quantization can be determined by means of Kotel'nikov's theorem, which can only be applied to infinite waveforms. The error incurred when the theorem is applied to a finite waveform is calculated.

IMPROVING THE QUANTIZATION OF RANDOM SIGNALS BY DITHERING

G. G. Furman, RAND Corp., Santa Monica, Calif., May 1963, 35 p., RAND RM3504 PR, AD 405 473.

. . . practical problems of determining the effects of independent quantizer activators called dithers upon the statistical processing properties of the quantizer. . . For the highly important sinusoidal and sawtooth dithers exact anaylsis yields for the first time answers . . . to the question of what upper bounds does the dither impose.

SOME RELATIONS BETWEEN DIGITIZING PARAMETERS AND CALCULATED STATISTICS OF A WAVEFORM

R. McAulay, Illinois Univ. Engineering Experiment Station, Urbana, 15 Aug. 1963, 35 p., Rept. nos. TRI8, TRI., AD 419 905.

. . . to investigate the effect which the analog-to-digital converter has in perturbing the values of certain statistics from their true values. . . . the analog of the actual sampling and quantizing process is developed as a computer program. This program can then be used to operate on the mathematical analog of the waveform under consideration to produce a new set of data points which represents the quantized amplitudes at successive sample times. Using these data the sample statistics are calculated and compared with the true values, which, in this case, can be calculated directly using the mathematical expression for the incoming waveform. . . .

BLOCK QUANTIZATION OF CORRELATED GAUSSIAN RANDOM VARIABLES

J. J. Y. Huang, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 289/296.

For the transmission of information from a continuous source over a digital channel . . . The usual procedure is to sample the continuous source output at regular time intervals and then quantize the samples in amplitude. . . . This paper is concerned only with the quantization process. . . . If successive samples are statistically dependent it should clearly be possible to reduce the average quantization error without increasing the total number of digits used for representing a set of N samples. . . . The present paper deals with a more restricted procedure. Its merits are the absence of any limitation of fineness of quantization and the relative ease of designing quantizers of moderate block length. . . .

NEKOTORYE VOPROSY MATEMATICHESKOGO OBOSNOVANIIA VYBORO CHISLA OBLASTEI KVANTOVANIIA V ANALOGODISKPETNYKH PREOBRAZOVATELLIAKH (Certain Problems Involved in the Mathematical Substantiation of the Selection of the Number of Quantization Domains in Analog Discrete Converters) (In Russian)
M. I. Lanin, et al., Avtomatika i Telemekhanika, vol. 24, April 1963, p. 573/578, A63-19820.

. . . relation between the quantity of information and the magnitude of the quantitization domain, for both normal and nonuniform error distributions introduced prior to conversion. A solution is obtained for purely additive errors in the automatic control and telemetering problems.

QUANTIZATION ERRORS IN DIGITAL CONTROL SYSTEMS
J. B. Slaughter, IEEE Trans. Automatic Control, vol. AC-9, Jan. 1964, p. 70/73; Discussion, Bernard Widrow, p. 73, 74; Author's Reply, p. 74, 5 refs., A64-15915.

. . . The amount of error introduced in the output by any one quantization operation was found to depend upon the sampling rate, system time constants, and the form of the controller chosen for system compensation. For a third-order plant the error due to quantization was determined to be approximately ten times the value of the quantizing level, and was reduced six times by increasing the sampling rate by a factor of two.

QUANTIZATION ERRORS AND THEIR EFFECTS IN DIGITAL CONTROL SYSTEMS
J. B. Slaughter, Navy Electronics Lab., San Diego, California, 31 Jan. 1963, 30 p., (NEL rept. no. 1156), AD 298 934.

KVANTOVANIE NEPRERYVNYKH SOOBSHCHENII S MINIMAL'NOI SREDNE KVADRATICHNOI OSHIBKOI (Quantification of Continuous Information at Minimum Mean-Square Error) (In Russian)
A. I. Velichkin, Radiotekhnika, vol. 19, March 1964, p. 66/75, A64-17755.

Investigation of the conditions of minimum distortion in the quantification of continuous information with respect to time and levels. It is shown that the determination of the optimum parameters of the quantifier with respect to levels requires a two-dimensional probability density distribution of the quantized information; the selection of these optimum parameters depends upon both the quantization step with respect to time, and the delay in the communication channel . . . The quantification of information having both a normal and a Rayleigh distribution of the probability density is examined in detail.

OPTIMUM CHARACTERISTICS OF QUANTIZERS
A. I. Velichkin, Telecommunications and Radio Engineering, Part II-Radio Engineering, vol. 18, Feb. 1963, p. 1/7, A63-20638.

. . . criterion used is that of a minimum mean-square error. . . . the optimum characteristics are determined by the primary distributions of the continuous messages to be transmitted. . . . Quantizing devices having uniform characteristics have optimal features if they are preceded by suitable compressors and followed by suitable expanders. . . . The optimum characteristics of expanders are not the inverse of the compressor characteristics. A convenient measure of the distortions introduced in a process by quantization is, in certain cases, the entropic noise power of quantization.

DEVELOPMENT AND EVALUATION OF PROCEDURES FOR QUANTIZING MULTIVARIATE DISTRIBUTIONS
P. Zador, Stanford U., Calif., 10 Dec. 1963, 64 p., Rept. no. TR92, AD 426 677.

. . . approximation generated by a specific but arbitrary partition and a specific but arbitrary set of representation points is examined. A statistical measure of error is investigated. The size of the error is measured by some moment of the random variable . . . The behavior of the minimum error when there is a large number of representation points is demonstrated. This extension takes into account the entropy rate of the discrete quantizing sequence.

Related Publications:

GRAY CODES AND PATHS ON THE N-CUBE
E. N. Gilbert, Bell Systems Tech. J., vol. 37, no. 3, May 1958, p. 815-.

CAPACITY OF A CHANNEL WITH QUANTIZED MODULATION
V. M. Baykovskiy, Radio Engng: Trans. of Radiotekhnika, vol. 16, no. 7, 1961, p. 9/18.

A THEORY OF QUANTUM COMMUNICATIONS
J. B. O'Neal, Jr., Florida U., Gainesville Engineering and Industrial Experiment Station, 5 Dec. 1962, 74 p., refs., AFCRL 64-3, AD 429 721, N64-15808.

. . . Bounds for the capacity of a band-limited quantum channel in the absence of external or thermal noise are found. . . .

TIME QUANTIZATION OF A SIGNAL OF FINITE AREA
M. V. Rybashov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 11/14.

. . . problem of time quantization of a signal . . . of finite area with bounded frequency spectrum. . . .

STANDARDIZED METHOD FOR DETERMINATION AND PRESENTATION OF QUANTIZED COMMUNICATION REQUIREMENTS
ITT Communication Systems, Inc., Paramus, N. J., June 1962, 57 p. incl. illus., refs., Rept. no. ICS-62-MGT-36, AD 295 574.

Raw communication data must be quantized in order to take advantage of EDP applications to design problems (file maintenance and information retrieval). . . . program of developing and analyzing Air Force Communications requirements.

SAMPLING AND QUANTIZATION ERRORS IN A DIGITALLY MECHANIZED INERTIAL NAVIGATOR
N. A. Boehmer, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 1, Jan. 1963, p. 56/61.

. . . Time and frequency domain analysis of the sampled-data system is presented and the effects of quantization present at the digital computer input and output are evaluated. . . .

SYNTHESIS OF OPTIMAL FILTERS FOR A FEEDBACK QUANTIZATION SYSTEM
E. G. Kimme, et al., IEEE Intern. Conv. Rec., pt. 2, vol. 11, March 1963, p. 16/26; IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 405/413.

. . . proposal for a base-band quantization system for narrow-band television signals incorporates linear predistortion and reconstruction, and a linear noise feedback loop around the quantizer. . . .

METOD VYCHISLENIIA VEROIATNOSTI DOSTIZHENIIA ZADANNOGO UROVNIA DISKRETNYM NAKOPITELEM (A Method for Determining the Probability of Attaining a Given Level by a Discrete Storage Unit) (In Russian)
B. B. Levin, Radiotekhnika i Electronika, vol. 9, Feb. 1964, p. 211/218, 11 refs., A64-17125.

A THEORY OF QUANTUM COMMUNICATIONS
J. B. O'Neal, Florida U., Engineering and Industrial Experiment Station, Gainesville, Dec. 1963, 66 p., Rept. no. SR2, AFCRL 64 3, AD 429 721.

A model for a bandlimited quantum communications channel and the channel capacity of such such a channel in the absence of external and thermal noise are investigated. . . . The mere fact of quantization itself, i. e., that a quantized signal is restricted to a finite number of states which it can assume, limits the ability of the signal to contain information. The other factor which degrades the performance of a channel is that every bandlimited signal contains an irreducible uncertainty which is due to the uncertainity principle. This report represents an attempt to construct a reasonable model which takes these two factors into consideration.

1.512: Nonlinear PCM

Included: Logarithmic PCM; Logarithmic quantization; PCM companding laws; Amplitude compression in PCM; Nonlinear characteristics of quantizers; Companded pulse coders.

Not Included: Nonlinear control systems; Companding processes (2); Amplitude compression in general (2); Signal encoding equipment.

Cross References: Quantization processes in general (1.511).

Principal Publications:

REGARDING THE COMPUTATION OF THE CHARACTERISTICS OF COMPRESSION IN SYSTEMS WITH PULSE-CODE MODULATION (English translation)
I. A. Lozovoy, Telecommunications, no. 10, Oct. 1961, p. 18/25.

. . . The stated problem is the determination of compression which, in a telephone signal transmission system with pulse-code modulation will permit one to obtain the highest signal-to-quantization noise ratio for signals with variable power. Described is the method of computations of the characteristics of compression for a given dependence of the signal-to-quantization noise ratio on the power of the signal.

A P.C.M. LOGARITHMIC ENCODER FOR A MULTI-CHANNEL T.D.M. SYSTEM
J. C. Davis, Proc. Instn. Elect. Engrs. London, Part B, vol. 109, no. 48, Nov. 1962, p. 481/483.

A digitally controlled logarithmically-varying current source is described which is suitable for incorporation in a p.c.m. feedback encoder and decoder working at 1.6 megabits/sec and transmitting telephone-quality speech. . . . P.C.M. systems for the transmission of speech often use some form of linear encoder and decoder with a separate compandor. Instantaneous compandors have been described for use in multichannel systems where they form part of the equipment common to a number of channels. . . . In the development of practical and rugged p.c.m.

systems there are advantages in using a coding system which has an inherent non-linear characteristic and thus needs no separate compandor. . . .

A COMPANDED CODER FOR AN EXPERIMENTAL PCM TERMINAL
H. Mann, et al., Bell. Syst. Techn. J., vol. 41, no. 1, Jan. 1962, p. 173/222.

. . . consists of a logarithmic instantaneous compandor plus a linear (equal step) coder. The companded coder plays a major role in determining the over-all performance of the 1-1/2 megabit system. . . . performance of the all-semiconductor equipment that performs the analog-to-digital and digital-to-analog conversions for the PCM terminal.

A SURVEY OF TELEPHONE SPEECH-SIGNAL STATISTICS AND THEIR SIGNIFICANCE IN THE CHOICE OF A P.C.M. COMPANDING LAW
R. F. Purton, Proc. Instn. Elec. Engrs., London, (Part B), vol. 109, no. 43, Jan. 1962, p. 60/66.

CODING AN ANALOG VARIABLE FOR CONSTANT PERCENTAGE ERROR
R. A. Cliff, NASA, Goddard Space Flight Center, Greenbelt, Md., March 1964, 20 p., refs., NASA TN D-2257, N64-17727.

. . . It is shown that a logarithmic quantization scheme produces an uncertainty in the output that is constant over the input range that the system is designed to cover. Relationships are derived between the uncertainty that must be tolerated, the width of the input range to be covered, and the number of discrete outputs required . . .

LOGARITHMIC PCM ENCODING WITHOUT DIODE COMPANDOR
H. Kaneko, et al., IEEE Intern. Conv. Record, Pt. 8, vol. 11, March 1963, p. 266/281, IEEE Trans. Commun. Systems, vol. CS-11, no. 3, Sept. 1963, p. 296/307.

Instantaneous companding is a useful technique for the improvement of the transmission quality of PCM systems. . . . various nonlinear encoding and decoding techniques without using diode compandors are stated.

OPTIMUM CHARACTERISTICS OF QUANTIZERS
A. I. Velichkin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 2, Feb. 1963, p. 1/7.

. . . the characteristics which are optimum both with respect to the mean-square-error and the information criteria are established. . . . Level quantization is the transformation of a process ξ (t) by means of a nonlinear device having a stepped characteristic. . . . The problem of selecting optimum characteristics for a quantizing device has been investigated in a number of papers. . . . nonlinear characteristic that ensures a minimum mean-square deviation of the quantized process . . . from the input process . . .

Related Publications:

REDUCTION IN QUANTIZING LEVELS FOR DIGITAL VOICE TRANSMISSION
M. J. Wiggins, et al., IEEE Intern. Conv. Rec. Pt. 8, vol. 11, March 1963, p. 282/288.

. . . A method of processing speech to allow a reduction of quantizing levels for PCM has been developed and applied to a tropospheric scatter communication system. A unique PCM is used which is derived from PPM and is applicable to a random access system for increased bandwidth utilization. An improved detector and demodulator has been developed to provide discrimination against noise and cross talk. . . .

1.518: Various Special PCM Methods

Included: Bi-ternary PCM; Multi-level PCM; M-ary PCM encoding; Non-binary pulse code modulation; Bi-orthogonal PCM; Quaternary PCM; Weighted PCM; Di-pulse PCM; Di-phase PCM cable system; Bi-polar signals in PCM; PCM with PPM vernier operations; Vernitel system; Quadraphase subcarrier techniques for independent PCM channels.

Cross References: PCM systems for special applications (Sect. 1.57); Higher order digital transmission systems (1.313); Bi-orthogonal digital sequences in data transmission (1.314); Bi-polar repeaters for PCM (1.522).

Principal Publications:

WEIGHTED PCM
E. Bedrosian, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 45/49.

. . . relative amplitudes of the pulses within the pulse-code groups are adjusted so as to minimize the noise power in the reconstructed signal due to errors in transmission.

ON WEIGHTED PCM AND MEAN-SQUARE DEVIATION (Correspondence) (The RAND Corporation, Santa Monica, California)
R. Bellman, et al., IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 58/59.

A COMPARISON OF TRANSMISSION METHODS FOR PULSE CODE MODULATION COMMUNICATION SYSTEMS
A. P. Brogle, Army Signal Research and Development Lab., USASRDL Technical rept. no. 1954, Oct. 1958, 47 p., AD 227 104.

. . . A new method of transmission, called biternary, is described and is compared with quaternary transmission as a means of doubling the channel capacity of PCM systems without requiring increased bandwidth or transmission facilities. . . .

A NEW TRANSMISSION METHOD FOR PULSE-CODE MODULATION COMMUNICATION SYSTEMS
A. P. Brogle, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 155/160.

. . . study of the basic factors underlying the selection of a preferable method of transmission for pulse code modulation communication systems. A new method of transmission, called biternary, is described and is compared with quaternary transmission, as a means of doubling the channel capacity of PCM systems without requiring increased bandwidth or transmission facilities . . . The use of biternary transmission is planned in present and future military pulse code modulation communication systems.

A HIGHLY PRECISE FM/FM TELEMETERING DEVICE
H. K. Schoenwetter, IRE Conv. Rec. Pt. 5, Communs. Systems, Space Electronics & Telemetry, N.Y., vol. 8, March 1960, p. 56/62.

The heart of the Vernitel is a special quantizer which converts the input signal voltage into two voltage components - a quantized voltage and a vernier voltage - whose sum is equal to the input voltage.

ANALYSIS OF A PCM SYSTEM EMPLOYING A PPM VERNIER
W. H. Lob, IRE Trans. Commun. Systems, vol. CS-9, no. 9, Dec. 1961, p. 342/349.

The upper limit to the output SNR of sampled-data PCM systems is set by the quantization noise. The present study . . . overcoming this limitation by employing time shifting of the PCM pulse groups so as to constitute an analog encoding of the difference between the sample amplitude and the nearest quantization level.

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. A. Couturier, Stelma, Inc., Stamford, Conn., Quarterly progress rept. no. 1, and addendum, 29 May-15 Sept. 1962, 12 Oct. 1962, 15 p. incl. illus., AD 288 000.

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. Couturier, Stelma Inc., Stamford, Conn., Quarterly progress rept. no. 2, 16 Sept.-15 Dec. 1962, 15 Dec. 1962, 28 p., Rept. no. 2, AD 298 585.

TRANSMISSION OF MULTI-LEVEL DIGITAL SIGNALS THROUGH NOISE-FREE DISTORTING CHANNELS
L. W. Hill, Proc. Instn. Elect. Engrs., London (Part B), vol. 109, no. 44, March 1962, p. 165/173.

. . . The transmission of digital information by variation of the energy level of pulses of fixed shape is limited by channel distortion even in the absence of noise. . . . The case of a channel with an exponentially decaying impulse characteristic, for which the maximum rate is independent of the number of levels, is of special interest as a large class of passive linear networks has this characteristic at least asymptotically. . . .

BINARY TO TERNARY CONVERSION BY LINEAR FILTERING
J. K. Wolf, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., May 1962, 8 p. incl. illus., 3 refs., RADC TDR 62-230, AD 278 264.

A simple linear filter consisting of a delay element and an adder is described for converting a random stream of binary pulses into a stream of ternary pulses . . . Another simple linear filter is described for reconverting the stream of ternary pulses into the stream of binary pulses. Results of an experimental implementation of such a system are presented. Also, a generalization of this scheme for binary to N-ary to binary conversion is discussed.

A QUADRAPHASE SUBCARRIER TECHNIQUE FOR TRANSMISSION OF TWO INDEPENDENT PCM CHANNELS
D. L. Anderson, Proc. Nat. Telem. Conf., May 1963, no. 10-3.

A phase-division multiplex technique (quadraphase modulation) for the simultaneous transmission of two independent PCM Channels is described, analyzed, and compared to frequency and time division multiplex techniques . . . use of a product demodulator for demodulation of the IF carrier. . . .

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. Couturier, Stelma, Inc., Stamford, Conn., Quarterly Progress rept. no. 3, 15 Dec. 1962-15 March 1963, 1 vol., AD 409 919.

THEORETICAL DISCUSSION OF DIPHASE TRANSMISSION
L. U. Dworkin, Army Electronics Research & Development Agency, Ft. Monmouth, N.J., Sept. 1963, 26 p., AELRDL TR 2358, AD 421 519.

The problems of sendings many communication channels over a single cable for relatively great distances has long been one of the primary problems in military communications. . . . approach that can be used to greatly improve PCM transmission over Cable, CX-4245. The present cable transmission system consists of attended repeater points every 40 miles with unattended repeater points every mile. These repeaters must carry out total pulse regeneration for signals at a pulse rate of 2.304 megabits per second. The present modulation approach . . . is called dipulse and has a variety of

deficiencies associated with its realized system. . . . The use of diphase modulation is proposed in place of dipulse with no change in repeater spacing or pulse transmission frequency. A differential diphase repeater was subjected to extensive theoretical analysis. . . .

SOME ASPECTS OF BITERNARY TRANSMISSION
M. Hooten, et al., Army Electronics Research & Development Agency, Ft. Monmouth, N.J., April 1963, 6 p., AELRDL 2357, AD 420 286.

The transmission of a PCM signal using biternary signaling is reviewed. Two different biternary signals are compared with respect to their ease of generation and detection. . . .

Related Publications:

PROBLEMS AND PROGRESS IN PCM
M. R. Aaron, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 72/81, 54 refs.

. . . Several restricted-ternary codes suitable for baseband PCM transmission are displayed. . . .

ERROR RATES IN COHERENT COMMUNICATION SYSTEMS
A. V. Balakrishnan, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 86/89.

In coherent PCM communication systems where the noise is additive and Gaussian (such as in space communication systems) two classes of nonredundant coding are of special interest. One is Regular Simplex Coding which yields the lowest possible error rate for fixed SNR. The other is Bi-orthogonal Coding because of its many desirable features from the practical point of view. . . .

AFFINE M-ARY GRAY CODES
M. Cohn, Inform. Control, vol. 6, no. 1, March 1963, p. 70/78.

. . . presents a nontable-lookup technique for generating a class of n-dimensional m-ary Gray codes for every pair (n, m) of integers. It does not seek to exhaust all such codes, but restricts itself to a class characterized by simple encoding and decoding schemes. . . .

A VERNIER AMPLIFIER FOR PRECISION TELEMETRY
S. S. Thaler, Missiles and Space, vol. 11, Feb. 1963, p. 32, 33, 55, A63-12995.

Description of a miniaturized and transistorized electronic analog of the mechanical micrometer. The transfer function and specifications of the device are presented, and the theory of operation is outlined. The digital-telemetry and data-transmission systems are discussed, and application possibilities are noted. A block diagram of the device is presented.

CODING METHOD FOR TRANSMISSION OF BINARY NUMBERS OVER A NOISY CHANNEL
E. V. Voronov, Radiotekhnika i Elektronika, Aug. 1963, p. 1312/1318, In Russian, A63-25287, Radio Engineering and Electronic Physics, Aug. 1963, p. 1273/1279, 6 refs., Translation, A64-17668.

Section 1.52
Design Problems of Pulse Code Modulation Systems

There are two special problems which require the application of unusual techniques differing from the normal design practice in other branches of communications.

Special PCM repeaters, so called regenerative repeaters, are necessary when making full use of the noise reducing characteristics of PCM. Subdivision 1.522 has references to such repeaters, but also to associated link problems, such as order wire operation in PCM systems.

The second key problem is the synchronization subsystem in PCM installations. It is more complex than the synchronization circuits which are required for clocked digital transmission systems. PCM requires word and frame synchronization in addition to bit synchronization. (See 1.523).

1.522: PCM Repeaters

Included: Order wires in PCM systems; Regenerative repeaters; Bi-polar repeaters, Reconstructive repeaters; Digital regenerators; Negative impedance repeaters.

Not Included: Amplifier design; Time division multiplex systems (2); Radio relay links.

Principal Publications:

STATISTICS OF REGENERATIVE DIGITAL TRANSMISSION
W. R. Bennett, Bell System Tech. Journal, vol. 37, Nov. 1958, p. 1501/1542.

AN EXPERIMENTAL PULSE REPEATER FOR TRANSMISSION OF INVERTED BINARY PULSE SIGNALS OVER FIELD WIRE
H. Wolf, Army Signal Research & Development Lab., Fort Monmouth, N.J., ASRDL technical rept. no. 2082, Oct. 1959, 36 p., AD 232 499.

The problems connected with the transmission of a one megabit binary pulse signal over field wire WD-1/TT are discussed. The inverted binary pulse signal is introduced and the design of a repeater for inverted binary pulses is described. The results of cascading a series of these repeaters are shown. It is concluded that the lack of an inexpensive and reliable retiming circuit is a problem which requires further study.

THE E6 NEGATIVE IMPEDANCE REPEATER
A. L. Bonner, Bell Syst. Tech. J., vol. 39, no. 6, Nov. 1960, p. 1445/1504.

. . . a low-cost, transistorized, voice-frequency, two-way repeater for use in the exchange area plant, including use in trunks between local offices and between local and toll offices. . . .

PROBABILITY DISTRIBUTIONS FOR THE PHASE JITTER IN SELF-TIMED RECONSTRUCTIVE REPEATERS FOR PCM
M. R. Aaron, et al., Bell Syst. Techn. J., vol. 41, no. 2, March 1962, p. 503/558.

PROBLEMS AND PROGRESS IN PCM
M. R. Aaron, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 72/81, 54 refs.

. . . Advances in the understanding of the timing performance of self-timed reconstructive repeaters are given brief coverage.

AN ORDER-WIRE FOR PCM SYSTEMS
R. Gardner, et al., RCA Defense Electronic Products, New York, Final rept., Task IIA on Microwave Radio Relay Systems Study, 28 Feb. 1962, 72 p. incl. illus., 3 refs., Rept. no. CR-62-419-2, AD 274 840.

TIMING ERRORS IN A CHAIN OF REGENERATIVE REPEATERS, I AND II
B. K. Kinariwala, Bell Syst. Tech. Journal, vol. 41, no. 6, Nov. 1962, p. 1769/1797.

The pulse displacements produced by timing errors in a chain of regenerative repeaters (using tuned-circuit timing filters) are represented by a linear transformation of the pulse displacements at the output of the first repeater. . . .

PROBABILITY OF PCM SIGNAL DISTORTION BY GAUSSIAN NOISE AS A FUNCTION OF THE NUMBER OF REPEATERS AT LARGE SIGNAL-TO-NOISE RATIOS
R. F. Matveev, Radiotekhnika i Electronika, vol. 7, Aug. 1962, In Russian, Radio Engineering and Electronic Phyiscs, vol. 7, Aug. 1962, p. 1217/1224, Translation, A63-12856.

Estimation of the probability of false detection for communication links consisting of n-repeater sections. The relation between the optimum limiting level and the relative number of repeaters in the circuit is assessed for ideal regenerative amplifiers and for amplifiers which differ slightly from the ideal. A large SNR is postulated in the calculations.

A BIPOLAR REPEATER FOR PULSE CODE MODULATION SIGNALS
J. S. Mayo, Bell Syst. Techn. J., vol. 41, no. 1, Jan. 1962, p. 25/97.

Designed for use on unloaded exchange cable. . . . utilizes a pulse repetition frequency of 1.544 mc, and 6000-ft repeater spacing.

BIT SYNCHRONIZATION AND DATA REGENERATION TECHNIQUES
R. C. Payne, et al., Proc. Nat. Telem. Conf., vol. 2, May 1962. no. 5-2.

. . . with regard to . . . serial PCM data trains . . . certain restrictions are placed on the system for the sake of approximating the actual hardware with a simplified model. . . .

SYSTEMATIC JITTER IN A CHAIN OF DIGITAL REGENERATORS
C. J. Byrne, et al., Bell Syst. Tech. Journal, vol. 42, no. 6, Nov. 1963, p. 2679/2714.

Digital pattern variations are a major source of timing jitter in self-timed digital regenerators. In a chain of similar regenerators, the same jitter is introduced at each one. Therefore, the jitter accumulates systematically.

A model is introduced to predict the accumulation of jitter in a chain of identical regenerators with single tuned timing filters . . .

Measurements on a chain of 84 regenerators in a field installation are in excellent agreement with the theory.

ENGINEERING OF T1 CARRIER SYSTEM REPEATERED LINES
H. Cravis, et al., Bell Syst. Tech. Journal, vol. 42, no. 2, March 1963, p. 431/486.

The repeatered lines for the T1 carrier system (24 voice channels, PCM) are cable pairs equipped with transistorized regenerative amplifiers. The line signal is a train of 1,544,000 bipolar pulse positions per second. The line engineering methods, which tell how to select cable facilities and where to place repeaters, are based on the theory and measurements reported here . . .

Related Publications:

TRANSISTOR PULSE CIRCUITS FOR 160-MC CLOCK RATES—PART I—PULSE REGENERATION
W. J. Giguere, et al., IRE Trans. Electronic Computers, vol. EC-8, no. 4, Dec. 1959, p. 432/435.

THEORETICAL DISCUSSION OF DIPHASE TRANSMISSION
L. U. Dworkin, Army Electronics Research & Development Agency, Ft. Monmouth, N.J., Sept. 1963, 26 p., AELRDL TR 2358, AD 421 519.

. . . The present cable transmission system consists of attended repeater points every 40 miles with unattended repeater points every mile. These repeaters must carry out total pulse regeneration for signals at a pulse rate of 2.304 megabits per second. . . .

EFFECT OF A NONIDEAL REGENERATOR SLICING CHARACTERISTIC ON THE ERROR RATE OF A BINARY PULSE TRANSMISSION SYSTEM
V. Keder, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 308/314.

. . . Numerous theoretical studies have been made of the error rate of a binary pulse transmission system using ideal regenerators . . .

A MAGNETIC AMPLIFIER FOR LOW-LEVEL TELEGRAPH SIGNALS
L. A. Rioual, J. Brit. Instn. Radio Engrs., vol. 25, no. 6, June 1963, p. 541/546.

In the design of submerged repeaters for submarine telegraph cables, the need arises for a circuit capable of amplifying very low frequency signals with great reliability. It is highly desirable that the bulk of the apparatus be reduced to a minimum. A repeater circuit is described, in which a magnetic amplifier is used for frequency conversion of the telegraph signals. . . .

ON THE TRIGGER-TIME JITTER OF A REGENERATIVE PULSE CIRCUIT
C. Yen, IEEE Intern. Conv. Rec. Pt. 2, vol. 11, March 1963, p. 27/32.

. . . When a regenerative pulse circuit is excited by a ramp input, a pulse is triggered when the circuit becomes regenerative. If the triggering process is repeated many times, however, it will be observed that the pulse is not initiated at precisely the same moment. The trigger-time jitter refers to this randomness of the initiation of a pulse, and the jitter time or the jitter voltage is a measure of this randomness. . . .

1.523: PCM Synchronization

Included: Group synchronization; Pseudo-random coding for synchronization; Frame separation methods; Frame synchronization in PCM; Sync search procedures; Bit synchronization in PCM; Legendre PCM synchronization codes.

Not Included: Theory of synchronization codes (2); Error correction coding (2); Atomic clocks and time standards; Frequency dividers; Synchronization circuits; World-wide synchronization systems; Master oscillators; Phase lock loops.

Principal Publications:

GROUP SYNCHRONIZING OF BINARY DIGITAL SYSTEMS
R.H. Barker, In: Communication Theory, ed. by Willis Jackson, New York, Academic Press, Inc., 1953, p. 273/287.

THE NOTS PCM TIMING SYSTEM; AN OVER-ALL DESCRIPTION
J.B. Moffett, Naval Ordnance Test Station, China Lake, Calif., Aug. 1959, 59 p., Report no. NOTS TP 2316, AD 231 118.

SYNCHRONIZATION OF BINARY MESSAGES
E.N. Gilbert, IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 470/477.

PHASE INTERCEPT DISTORTION IN PULSE CODE MODULATION
L. Kosowsky, et al., Dunham Lab., Yale U., New Haven, Conn., Quarterly progress rept. 8, 1 June 1960, AD 240 402.

. . . A time multiplex system using received code digits was investigated. The various possibilities of trouble which might arise are: (1) The clock pulses might be at the wrong part of the digit cycle (increased noise and cross-talk susceptibility). (2) False reading might occur due to the presence of a non-zero steady state level in the absence of a pulse, or due to the spikes generated. (3) Group synchronization might be affected so that readings occur at a poor time in the pulse interval (as results from 1 above). (4) Group synchronization could be shifted and cause wrong interpretation of the received pulses. (See also AD 226 643).

CONSIDERATIONS ON SYNCHRONIZATION FOR PCM TELEMETRY
L. L. Rauch, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 3/4, Sept. - Dec. 1960, p. 95/98.

OPTIMUM PCM FRAME SYNCHRONIZATION CODES AND CORRELATION DETECTION
G.E. Goode, et al., Proc. Nat. Telemetering Conf., May 1961, p. 11-15/11-50.

Basic to all time-division multiplex PCM systems is the requirement for both bit and group synchronization before received data can be demultiplexed . . . This paper reports both on analysis and the results of experimental work done in conjunction with the design of the frame synchronization correlator and acquistion logic for Texas Instruments ULTRALOC PCM Data Recovery System . . .

SYNCHRONIZATION METHODS FOR PCM TELEMETRY
E.R. Hill, et al., Proc. Nat. Telemetering Conf., May 1961, p. 11-87/11-106.

AN OPTIMUM SELF-SYNCHRONIZED COMMUNICATION SYSTEM
S. S. L. Chang, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 110/116.

One set of optimum signal waveforms for unidirectional transmission with minimum error probability, when the interference is additive gaussian noise, consists of sequencies of binary waveforms resembling a modified Reed Code. The binary waveforms considered here are phase-shifted sinusoids. The theoretical design of the receiver is given such that the reference signal required for correlation detection is directly generated from the message signal itself. Thus multipath and doppler are automatically compensated for. . . . The transmitted signal consists of two-phase modulation (0 and 180 degrees) of a sinusoidal carrier. . . . The output . . . is squared so that the resulting signal is statistically the same when the transmission is the in-phase carrier tone burst or the out-of-phase carrier tone burst. The resulting signal is used to control a crystal oscillator which acts essentially as a very high Q resonant circuit at the frequency $2\omega_0$. . . . By frequency dividing . . . a phase reference signal is obtained . . .

LEGENDRE PCM SYNCHRONIZATION CODES
R.S. Codrington, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 2-5, 17 refs.

One of the severest specifications on an operational PCM system is the short time required for the ground station to acquire synchronization with the airborne equipment. Synchronization is achieved by the ground station recognizing a coded binary sequence occupying one or more word positions in each frame. . . . The criterion most commonly used in choosing a synchronization code of a given length is that the aperiodic correlation coefficients C_k have the minimum absolute values. The Barker 3, 7, and 11 bit codes have this property but no systematic method of generating longer codes with minimal $|C_k|$ has been available. In this paper it is shown that some Legendre sequences have the desired properties, and methods of generating Legendre codes of any prime length of 47 bits are given together with their periodic and aperiodic correlation coefficients. . . . In particular it is shown that all the Barker maximal length codes are Legendre codes and Legendre codes of prime length $p = 4q + 3$, where q is any integer, are pseudo-random codes. . . .

A STATISTICAL ANALYSIS OF THE SYNCHRONIZATION OF DIGITAL RECEIVERS
H. Kaneko, Electronics Research Lab., U. of Calif., Berkeley, 11 April 1962, 79 p., AFCRL 62 938, AD 411 994.

The probability of error of certain digital transmission systems is investigated, under the condition that the transmitter-receiver synchronization is imperfect. It is assumed that the receiver is the Bayes receiver that would be optimum were the synchronization perfect. It is further assumed that a synchronizating signal is transmitted separately from the information-bearing signals, and that the sum of the two signal powers is constrained to a given value. The conditional error probability for a given synchronization error is evaluated for two particular binary systems, one using bipolar rectangular pulses and the other using unipolar cosine-squared pulses. The optimum synchronizer for the case of a sine-wave synchronizing signal is analyzed. . . .

STUDY ON TELEMETRY AND RANGE SAFETY TECHNIQUES FOR ADVANCED AEROSPACE VEHICLES
M.H. Nichols, et al., Michigan U., Ann Arbor, Final rept., 1 Feb. 1961-31 ASD TDR 62 1073, March 1962, 74 p., AD 412 464.

. . . four more or less independent monographs covering certain aspects of the areas of bit, word and frame synchronization for random non return-to-zero PCM and improved demodulation of FM signals.

BIT SYNCHRONIZATION AND DATA REGENERATION TECHNIQUES
R.C. Payne, et al., Proc. Nat. Telem. Conf., vol. 2, May 1962, no. 5-2.

. . . with regard to . . . serial PCM data trains . . . certain restrictions are placed on the system for the sake of approximating the actual hardware with a simplified model. . . .

CORRELATION DETECTION AND SEQUENTIAL TESTING FOR PCM GROUP SYNCHRONIZATION
J.L. Phillips, et al., Nat. Telem. Conf., May 1962, no. 5-4, p. 1/15.

ADVANCEMENTS IN THE DESIGN AND EVALUATION OF GROUP SYNCHRONIZERS FOR PCM TELEMETRY
M.B. Rudin, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 3-5.

. . . Early systems employed relatively crude techniques such as zero crossing bit detection, and arbitrary word and frame sync patterns of low error tolerance. . . . more

sophisticated techniques are aptly reported in a series of papers at the 1961 NTC session XI. . . . In 1962 NTC, additional papers on PCM synchronization were presented in session V. . . . present authors . . . several significant extensions . . . One . . . is a parameterized method . . . for evaluation of PCM group synchronizers -- the "Confidence Criterion." . . . 2) Selection of Optimum Parameters for a Digital Group Synchronizer. 3) Digital vs. Analog Group Sync Detector. 4) The Dependence of Group Synchronization on the Bit/Bit Clock Regenerator. 5) A Simplified Procedure for Synthesizing Barker and Barker-like Codes. 6) Detection of Synchronous Phase Modulation with Digital Group Sync Techniques. . . .

GROUP SYNCHRONIZATION FOR DIGITAL TRANSMISSION SYSTEMS
T. Sekimoto, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 381/390.

. . . particularly applicable for PCM systems. . . . used to determine the time origin of a sequence of binary signals by finding a specified deterministic pattern from a randomly modulated binary sequence. . . . A new system with faster recovery characteristics is presented, and an optimal framing pattern is shown. . . .

SYNCHRONIZATION OF TELEMETRY CODES
J. J. Stiffler, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 112/117.

A well-known means of efficiently transmitting information over the continuous white Gaussian channel involves the encoding of successive blocks of data into sequences of binary digits (called code words). Efficient decoding of these sequences in turn necessitates a knowledge of the instants in time at which one code word ends and the succeeding word begins.

This paper presents a method for obtaining this synchronization which neither decreases the channel capacity nor increases the complexity of the encoding equipment. . . . This technique is applied to an important class of block codes, the binary orthogonal codes. An algorithm for constructing these codes with the desired self-synchronizing properties is presented, and upper bounds on the value of p_0 are thereby established. . . .

OPTIMUM CODE PATTERNS FOR PCM SYNCHRONIZATION
M. W. Williard, Nat. Telem. Conf., May 1962, no. 5-5, p. 1/11.

MEAN TIME TO ESTABLISH PCM SYNCHRONIZATION
M. W. Williard, Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 3-4.

SYNCHRONIZATION METHODS FOR PCM TELEMETRY
Naval Ordnance Lab., Corona, Calif., Final rept., April 1959-Sept. 1960, Aug. 1962, 59 p., incl. illus., tables, 8 refs., (Rept. no. NOLC-542) (ASD TR 61-9), AD 286 835.

A specially coded synchronization pattern is required for proper identification of repetitive frames of pulse-code-modulated (PCM) sequences of binary bits. Study has shown that, with an assumed set of criteria, there are many favorable sync patterns. . . . A recommendation is made that a maximum frame sync pattern of 33 bits be specified at present and the choice of optimal patterns be determined by future study. . . .

A VERSATILE CLOCKING SYSTEM FOR DIGITAL DATA APPLICATIONS
J. Cottrell, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 151/154.

. . . Timing at the receive terminal of the data link may be provided either by the transmission of clocking signals ona separate channel, or from an examination of the received data itself. . . . But any data transmission system . . . is subject to transmission interruptions. . . . Bit synchronism after interruption is easily regained in almost any device; frame synchronism is more difficult to achieve. For telemetry systems, or whenever security devices are employed, there exists a need for a clocking system which will allow resumption of transmission after interruption without the need for reestablishing frame synchronism. . . . The purpose of this paper is to describe a digital data clocking system which meets the above requirements. . . .

SYNCHRONIZATION
S. W. Golomb, et al., IEEE Trans. Commun. Syst. vol. CS-11, no. 4, Dec. 1963, p. 481/491.

I. The Panel Chairman's Introduction

II. Synchronization in Data Communication

III. On Synchronization in Communication Theory

IV. Synchronization and Bit Timing

V. Word Synchronization Over Noisy Channels.

A NEW METHOD OF FRAME SYNCHRONIZATION USING LINEAR SEQUENTIAL FEEDBACK GENERATORS
G. E. Goode, Proc. Nat. Telem. Conf., May 1963, no. 3-4.

. . . providing frame (or group) synchronization for time division multiplex communication systems such as those commonly found in telemetry, command, and data communication systems. . . .

ANALYSIS OF AN OPTIMUM SYNC SEARCH PROCEDURE
C. Gumacos, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 89/99.

Synchronization of communications receivers can require lengthy sync search procedures. In order to establish theoretical guideposts for evaluating synchronization systems, an idealized model is assumed in which: 1) Sync exists in one, and only one, of a large number of discrete time cells, 2) the a priori probability distribution of sync positions is known and 3) samples taken from any time cell are normally distrubuted. . . .

TECHNIQUES FOR SYNCHRONIZING PULSE-CODE-MODULATED TELEMETRY
E. R. Hill, Naval Ordnance Lab., Corona, Calif., 1 Feb. 1963, 102 p. incl. illus., tables, 11 refs., NAVWEPS Rept. no. 8139, AD 402 154.

. . . theoretical and experimental study . . . of frame synchronization (sync) for non-return-to zero pulse-code-modulated signals . . . Two types of sync pattern detectors are evaluated; the linear matched filter and the shift register recognizer. Effects of data-filter bandwidths on bit sync and bit detection are discussed. The results of a separate study are given, wherin bit sync is aided by an RF carrier coherent with the bit frequency.

TECHNIQUES FOR SYNCHRONIZING PULSE-CODE MODULATED TELEMETRY
E. R. Hill, Proc. Nat. Telem. Conf., May 1963, no. 3-3.

Techniques for bit and frame synchronization of a non-return-to-zero PCM signal are discussed. . . . (1) where all frequency and phase information is obtained from the video signal, and (2) where frequency information is obtained from the RF carrier and phase information from the video signal (here bit frequency is coherent with the RF carrier). Frame synchronization is achieved with a repetitive group of contiguous bits. . . .

A METHOD OF FRAME SEPARATION IN THE TIME-DIVISION-MULTIPLEXED DELTA MODULATION TELEMETRY
H. Inose, et al., Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 375/380.

. . . A method to reduce the time required for the frame separation . . . By assigining '1' to the sync channel in every frame, the system detects the sync channel out of the delta modulated information pulses which occur at an average rate of one half. Using a memory device with the capacity of one frame, the detection is performed by taking successive frame correlation of each channel. In a system of 20 channels, for example, the frame separation is established in 6 frame periods approximately. . . .

A LINEAR AUTOCORRELATOR FOR SYNCHRONIZATION OF BINARY CODED MESSAGES
V. A. Jennings, et al., IEEE Trans. Commun. Electronics., no. 66, May 1963, p. 151/158.

. . . One method by which the synchronization reliability may be improved is to increase the length of the synchronization word, particularly if Barker or other optimum words are employed. The full theoretical improvement. . . . can be approached. . . if the word is recognized . . . by a device which processes the combination of signal and noise as a linear mixture. . . . The delay line auto-correlator provides a convenient method for accomplishing this result. . .

ON SOME PRACTICAL APPROXIMATIONS TO THE IDEAL GROUP SYNCHRONIZATION PROCESS
D. R. Rhodes, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 222/229.

. . . a new and practical philosophy of group synchronization based on statistical hypothesis testing. . . . performances are analyzed for a PCM waveform, for hypothesis tests for least squared error, maximum cross correlation and maximum digital cross correlation. . . .

GROUP SYNCHRONIZATION AS AN INFORMATION DETERMINING PROCESS (Correspondence)
D. R. Rhodes, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 249/250.

Group synchronization in time-division communication is a special case of the general problem of transmission of information, and, as such, can be treated by the methods of information theory. The information to be communicated is the location of the sync position; i.e., the starting position of the group. . . .

PSEUDO-RANDOM CODING FOR BIT AND WORD SYNCHRONIZATION OF PSK DATA TRANSMISSION SYSTEMS
J. C. Springett, Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 410/422, 14 refs.

. . . A method is presented by which bit and word synchronization can be achieved in a p.c.m. data link without the use of zero-crossing detectors and without the inclusion of sync words within the data format. The modulation and detection system employs maximum length linear shift-register codes (p.n. codes) in conjunction with phase-lock techniques to achieve unambiguous code synchronization, from which all bit sync, word sync, and coherent demodulation signals can be obtained. . . .

Related Publications:

MINIMUM ENERGY TRIGGERING SIGNALS
L. A. Beattie, Proc. IRE, vol. 46, April 1958, p. 751/757.

Optimization of the function of time which is used for triggering so as to minimize the energy required of the triggering signal.

PULSE CODE MODULATION STUDY CONTRACT
C. M. Shapiro, et al., Philco Corp., Philadelphia, Pa., Rept. no. 3 (Final), 1 Nov. 1961-1 June 1962, July 1962, 44 p. incl. illus., table, AD 283 579.

. . . 6-channel Pulse Code Modulation (PCM) system using new techniques is . . . Multiplex logic . . . special sync circuits . . . tested with the operation of one channel to give voice demonstration. . . .

COMMAND TECHNIQUES FOR THE REMOTE CONTROL OF INTERPLANETARY SPACECRAFT
J. C. Springett, Proc. Nat. Telem. Conf., vol. 2, May 1962, no. 8-4.

SYSTEMATIC JITTER IN A CHAIN OF DIGITAL REGENERATORS
C. J. Byrne, et al., Bell Syst. Tech. Journal, vol. 42, no. 6, Nov. 1963, p. 2679/2714.

Digital pattern variations are a major source of timing jitter in self-timed digital regenerators. In a chain of similar regenerators, the same jitter is introduced at each one. Therefore, the jitter accumulates systematically.

A model is introduced to predict the accumulation of jitter in a chain of identical regenerators with single tuned timing filters . . .

Measurements on a chain of 84 regenerators in a field installation are in excellent agreement with the theory.

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK. Part 3—Switching
J. Le Corre, Elect. Commun., vol. 38, no. 1, 1963, p. 44/55.

. . . Synchronization of the coded and multiplexed speech signals at the input of each exchange to which they are transmitted. . . .

ON BARKER CODES OF EVEN LENGTH (Correspondence)
D. G. Luenberger, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 230/231.

ERROR-CONTROL CODING IN DIGITAL TELEMETRY SYSTEMS
L. D. Rudolph, et al., Proc. Nat. Telem. Conf., May 1963, no. 10-4.

. . .discusses . . . in broad terms, how error-control coding can be utilized in digital telemetry systems to . . . serve as the basis for a word synchronization technique . . .

DETERMINATION OF AN OPTIMUM SYNCHRONIZATION CODE WORD FOR A CLASS OF BINARY TELEMETRY SYSTEM
A. Romano, et al., IEEE Intern. Conv. Rec. Pt. 5, vol. 11, no. 1, March 1963, p. 225/227.

ON THE TRIGGER-TIME JITTER OF A REGENERATIVE PULSE CIRCUIT
C. Yen, IEEE Intern. Conv. Rec. Pt. 2, vol. 11, March 1963, p. 27/32.

. . . When a regenerative pulse circuit is excited by a ramp input, a pulse is triggered when the circuit becomes regenerative. If the triggering process is repeated many times, however, it will be observed that the pulse is not initiated at precisely the same moment. The trigger-time jitter refers to this randomness of the initiation of a pulse, and the jitter time or the jitter voltage is a measure of this randomness. . . .

Section 1.53
Delta Modulation

Delta modulation originated in Europe 15 years ago and continues to gain in importance. Recently, publications which describe a variety of improved delta modulation systems, some of which have characteristics which classify them as hybrid systems between PCM and other modulation methods, have become available. Consequently this section consists of two subdivisions: Standard delta modulation (1.532) and advanced delta modulation methods (1.533).

1.532: Standard Delta Modulation

Included: Surveys of all delta modulation methods.

Principal Publications:

DELTA MODULATION
F. de Jager, Phillips Res. Reps., vol. 7, Dec. 1952, p. 442/466.

. . . has the interesting property of giving accuracy varying exponentially with the pulse rate (as in PCM), but still without the necessity of framing the pulses . . .

DELTA MODULATION FOR CHEAP AND SIMPLE TELEMETERING
F. K. Bowers, IRE Trans. Space Elec. & Telem., vol. SET-5, no. 4, Dec. 1959, p. 205/208.

DELTA MODULATION (In Norwegian)
H. Daae, Elektrotek. Tidsskrift (Norway), vol. 74, no. 4, Feb. 1961, p. 51/55.

A review of the principles of delta modulation, . . . A brief calculation is made of s.n.r. taking into consideration the quantification noise and the noise generated by the transmission channel. . . .

SIMPLE DELTA MODULATION SYSTEM
F. W. Arter, Proc. Instn. Radio Engrs. Australia, vol. 23, no. 9, Sept. 1962, p. 517/523.

The transmission performance of coded pulse modulation systems in the presence of high levels of channel noise is discussed and Delta Modulation systems are compared briefly with Pulse Code Modulation systems. The design of an experimental Delta Modulation system for speech transmission is presented for a required set of performance specifications. A feature of the system is its fully transistorized circuitry. . . .

VIDEO TRANSMISSION BY DELTA MODULATION USING TUNNEL DIODES
J. C. Balder, et al., Proc. IRE, vol. 50, no. 4, April 1962, p. 428/431.

. . . With a new and very simple circuit, operating at a bit rate of 100 MC, a ratio of signal-to- quantizing noise of 42 db is obtained. A more conventional circuit, that combines tunnel-diodes with transistors, makes an even lower quantizing noise possible . . .

AN EXPERIMENTAL DELTA PULSE CODE MODULATION SYSTEM
E. C. Bullwinkel, et al., Army Signal Research and Development Lab., Fort Monmouth, N. J., April 1962, 21 p. incl. illus.,tables, 2 refs. (ASRDL technical rept. no. 2274), AD 283 821

. . . The results show that uncompanded delta pulse code modulation is more complex than standard pulse code modulation but yields no additional increase in signal-to-quantizing noise.

DEMONSTRATION OF THE FEASIBILITY OF USING DELTA MODULATION FOR PICTORIAL TRANSMISSION
R. V. Cotton, et al., Philco Corp., Blue Bell, Pa.,Rept. for 15 April-15 Nov. 1962 on Phase 1. Nov. 1962, lv. inc. illus.,tables, refs. (Rept. no. 9040-TN), (ASD TDR 62-1037), AD 294 689.

. . . for encoding pictorial data. . .to determine the parameters of delta modulation systems for various image communication applications by (1) system analysis, (2) computer simulation, and (3) experimentation. The analysis of delta modulation techniques included one-bit and two-bit systems with both linear and exponential integration. . . . An experimental two-bit delta modulation encoder with a sampling rate of 50 mc was constructed and tested. A table of the key parameters of pcm and delta modulation systems is presented. . . .

THE SUBSCRIBER-LINE CIRCUIT AND THE SIGNALING AND TONE SYSTEM FOR AN EXPERIMENTAL TIME-DIVISION EXCHANGE FEATURING DELTA-MODULATION TECHNIQUES
H. Inose, et al., IRE Trans. Commun. Syst., vol. CS-10, vol. 4, Dec. 1962, p. 397/407.

The time-slot mismatch loss will be avoided and the time-slot assignment will be simplified in a time-division exchange system in which the calling the called subscriber can use independent time slots arbitrarily assigned. Code-modulation techniques make such systems economically realizable, since a tapped magnetostrictive delay line or a shift register can be used to interchange time slots assigned to the calling and called subscribers. . . .

DEMONSTRATION OF THE FEASIBILITY OF USING DELTA MODULATION FOR PICTORIAL TRANSMISSION
R. V. Cotton, et al., Philco Corp., Blue Bell, Pa. Rept. for 15 April 1962-15 May 1963, lv. RVQ40, ASD TDR53 528, AD 409 600.

. . . to determine the parameters of delta modulation systems for various image communication applications by system analysis computer simulation, and experimentation. . .included one-bit and two-bit systems with linear integration, double linear integration with prediction, and exponential integration. A feasibility model of a 25-mc two-bit exponential integration delta modulation encoding and decoding system with a serial bit rate of 100 mpps was designed, constructed, and tested. . . It is concluded that for a typical image communication system, two-bit delta modulation with exponential integration and sampling at two to three times the information bandwidth represents the best compromise of parameter. The resultant compaction over six-bit PCM is two to three.

CONDITIONS FOR OPTIMUM DIGITAL COMMUNICATIONS WITH APPLICATION TO DELTA MODULATION
T. Fine, Cruft Lab., Harvard U., Cambridge, Mass., 5 March 1963, 39 p., TR 399, AD 405 053.

. . .It is shown that, for the quadratic loss function and any noisy channel, a delta modulation system is an allowable representation of the optimum binary system.

A DETERMINISTIC STUDY OF DELTA MODULATION
C. A. Halijak, et al., Joint Automatic Control Conference, Minneapolis, Minn., June 19-21, 1963, IEEE Trans. Automatic Control, vol. AC-8, Oct. 1963, p. 339/347, A64-12534.

. . . considering it as a combination of pulse duration and pulse amplitude modulation. Previous work on DM is reviewed, and an ideal mathematical model and a deterministic method of analysis for

a DM system are presented. Responses to various step and ramp inputs for unity and nonunity feedback are investigated using a digital computer. . . .

A METHOD OF FRAME SEPARATION IN THE TIME-DIVISION-MULTIPLEXED DELTA MODULATION SYSTEM
H. Inose, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 469/480.

. . . Employing successive "1"s as the sync pattern, the system detects the sync channel out of the delta modulated information pulses which occur at the rate of one half in average. Using a memory device with the capacity of one frame, the detection is performed by taking successive frame correlation of each channel in parallel. . . . A possibility for shortening further the time required for the frame separation is also described. The method is to modify, at the tramsmitting end, the information pattern when it appears the same as the sync pattern. . . .

DELTA MODULATION AS A POSSIBLE SERVO DATA LINK
R. H. Maschhoff, Proc. Nat. Telem. Conf., May 1963, no. 10-5.

Delta modulation, a comparatively simple form of digital modulation using single weighted digits, has possible advantages over other digital methods for use in remotely connecting some types of servo-mechanisms. . . . An experimental circuit of a modification of the original delta approach, which eliminates the objection of cumulative transmission errors, was used successfully to transmit the position signal in a typical positioning servo. . . .

DELTA MODULATION
R. H. Maschhoff, Electro-Technology, vol. 73, Jan. 1964, p. 91/97, A64-13655.

Description of the basic delta-modulation method. Performance of conventional and modified delta-modulation systems. . . . Typical applications to voice and video communications and to control systems are given. The delta modulation is compared to PCM and PRM.

Related Publications:

DESCRIPTION AND RESULTS OF EXPERIMENTS WITH SPEECH USING DIGITAL COMPUTER SIMULATION
E. E. David, Jr., et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 766/775.

. . . Results are reported from a comparison of two digital encodings of speech, pulse code modulation and delta modulation, simulated on a digital computer.

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION).
K. D. Kryter, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Sept. 1961, 32 p.,(Rept. 7), AD 269 194.

. . . Also included are results of experiments on companding, delta modulation and straight pulse code modulation of a speech signal. . . .

HIGH-SPEED PULSE GENERATION AND CODING DEVICE USING AN ESAKI DIODE AND SHORT-ENDED CABLE
S. Yamada, et al., Rev. Elect. Commun. Lab., vol. 10, no. 56, 1962, p. 237/247.

. . . development of a high-speed A-D convertor, a Delta modulator, and a coding circuit. . . .

1.533: Advanced Delta Modulation Methods

Included: Exponential delta modulation; High information delta modulation; Delta-sigma modulation; Unity-bit coding method.

Principal Publications:

DIGITAL COMMUNICATION SYSTEM (DIGICOM)
W. G. Brown, et al., ITT Labs., Nutley, N. J., March 1960, AD 236 133.

. . . An automatic telephone system was developed which employs digital transmission of speech signals coded in the form of exponential delta modulation.
(See also AD 208 310)

A TELEMETERING SYSTEM BY CODE MODULATION-Δ-Σ MODULATION
H. Inose, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 204/209.

. . . incorporates an integration process in the original delta modulation system and is named delta-sigma modulation. . . has an advantage over delta modulation in dc level transmission and stability of performance, although both require essentially an equal bandwidth and complexity of circuitry. . . .

A DELTA-SIGMA MODULATION SYSTEM FOR TIME DELAY AND ANALOG FUNCTION STORAGE
H. Handler, et al., Arizona Univ., Tucson, Jan. 1964, 41 p., AD 434 539.

. . . permits magnetostrictive delay line function storage of analog data with the significant advantages of pulse regeneration with clock gated logic and relatively inexpensive conversion equipment. Five to 10 msec delay lines with a 2 mc bit-rate accommodate analog signals of up to 8 kc with phase shift below 2 degrees; total

dynamic error is within 0.2% of half scale up to 1 kc. An adaptive filter permits a further trade-off of accuracy for bandwidth during computation. . . .

VIDEO TRANSMISSION BY DELTA-SIGMA MODULATION
H. Inose, et al., Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 307/312.

. . . Describes that a unity bit modulation technique proposed by the authors is one of the appropriate approaches to digital transmission of video signals. . . . The modulation system incorporates an integration process in the original delta modulation and has an advantage in d. c. level transmission and stability of performance. . . .

A UNITY BIT CODING METHOD BY NEGATIVE FEEDBACK
H. Inose, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1524/1535.

. . . The system contains a signal integration process in addition to the original delta modulator and features capability of transmitting dc component of input signal. . . .

HIGH INFORMATION DELTA MODULATION
M. R. Winkler, IEEE Intern. Conv. Rec. Pt. 8, vol. 11, March 1963, p. 260/265.

. . . a new pulse coding technique which will overcome some of the deficiencies of ordinary delta modulation and retain most of its advantages.

It provides more information per pulse. It will provide a dynamic range 20 db greater than ordinary delta modulation. Excellent voice communications at 20,000 pps has been demonstrated.

Section 1.57
Special Applications of Pulse Code Modulation

1.572: Pulse Code Modulation for Multiplex Voice Channels

Included: Experimental PCM systems for voice channels.

Not Included: Time division multiplex systems in general (2); Complete descriptions of operational equipment.

Cross References: PCM-FM systems (1.934).

Principal Publications:

PULSE CODE MODULATION: PART 2 - AN EXPERIMENTAL 12-CHANNEL EQUIPMENT
J. R. Jarvis, et al., Post Off. Elect. Engrs. J., vol 54, no. 3, Oct. 1961, p. 189/195.

. . . using a code of eight binary digits; it was developed to investigate the manner in which the subjective assessment of the transmission performance is related to the design parameters. . . .

AN EXPERIMENTAL PULSE CODE MODULATION SYSTEM FOR SHORT-HAUL TRUCKS
C. G. Davis, Bell Syst. Techn. J., vol. 41, no. 1, Jan. 1962, p. 1/24.

An experimentation on 24-channel pulse code modulation system employing solid-state devices is described. Economy of design and ability to operate over existing exchange cable.

PERFORMANCE LIMITATIONS OF A PRACTICAL PCM TERMINAL
R. H. Shennum, et al., Bell Syst. Techn. J., vol. 41, no. 1, Jan. 1962, p. 143/171.

. . . Limitations which make performance different from more conventional frequency-division systems are considered. Particular emphasis is placed on limitations resulting from nonideal circuits and signal conditions.

EXPERIMENTAL PULSE-CODE-MODULATION TRANSMISSION FOR LOCAL-AREA TELEPHONY
K. W. Cattermole, et al., Elect. Commun., vol. 38, no. 1, 1963, p. 56/75.

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK: PART 3- SWITCHING
J. Le Corre, Elect. Commun., vol. 38, no. 1, 1963, p. 44/55.

. . . examination of the 3 main points. . . . A. Design of a switching stage connecting voice-frequency subscribers' lines to a pulse-code-modulation multiplex highway. B. Design of a switching stage for interconnecting pulse-code-modulation multiplex highways. C. Synchronization of the coded and multiplexed speech signals at the input of each exchange to which they are transmitted. . . .

DEVELOPMENT OF (PCM) DATA BUFFERS
W. Reymond, Stelma, Inc., Stamford, Conn., Quarterly progr. rept. no. 1, 21 June-23 Oct. 1963, Oct. 1963, 23 p., AD 428 080.

. . . two advanced development models of a low-speed and a high-speed converter . . . digital-to-digital—each for inserting a number of digital data channels into Data I or Data II of the PCM Multiplexers TD-352()/U or TD-353()/U . . .

Related Publications:

MICROWAVE RADIO RELAY SYSTEMS STUDY
A. A. Meyerhoff, et al., RCA Defense Electronic Products, N. Y., Final rept. on Task 2, Aug. 1959, 1 vol., AD 230 425.

Several methods of detection of PCM-FM are analyzed to determine means of lowering the received carrier threshold. . . . (See also AD 230 426).

FORWARD AREA PCM TERMINAL (6/12 CHANNEL PCM)
W. Hatton, et al., Raytheon Co., Norwood, Mass., Semi-annual progress rept. no. 1, 1 April 1963, lv., AD 415 000.

. . . breadboarding of the multiplexer and power supply circuits has been completed. . . .

DEVELOPMENT OF RADIO SET AN/GRC103
D. F. Lee, et al., Canadian Marconi Co., Semi-annual progress report. no. 1, vol. 1, 31 March 1963, AD 406 891.

. . . a transportable, medium-power radio set capable of carrying 12 pulse-code-modulated voice channels, operating on 0.5-mc spaced channels in the UHF band. . . .

1.573: Pulse Code Modulation for Telemetry and Command Links

Included: Principles of coding and decoding processes for PCM telemetry; Adaptive techniques in PCM telemetry; Systems design of PCM telemetry installations; RF parameters for PCM telemetry systems.

Not Included: Equipment design for PCM telemetry; PCM telemetry systems for special space missions (4);.

Cross References: PCM-FM modulation methods (1.934); PCM-PS modulation methods (1.940); synchronization problems for PCM telemetry (1.523).

Principal Publications:

CODING FOR SUPPRESSION OF NOISE AND INTERFERENCE IN AIRBORNE PCM TELEMETERING SYSTEMS
H. F. Harmuth, IRE Trans. Telem. Remote Cont., vol. TRC-3, no. 1, April 1957, no. 7.3, p. 1/10.

For the transmission of data from aircraft and missiles to a ground station, compact low-power equipment in the air is mandatory, but considerable complexity can be acceptable for the receiver. . . one may apply noise suppressing coding techniques such as PCM.

COMPARISON OF PCM AND PPM FOR RADAR COMMAND
S. Kazel, Proc. Nat. Symp. Telem., Sept. 9, 1958, no. 9.3, p. 1/2.

. . . For PCM, it is shown that when the effects of both quantization noise and noise breaking through the receiver threshold are considered, there is optimum number of pulses which results in maximum S/N improvement. For PPM, it is shown that when both edge-shift noise and noise breakthrough are considered, there is an optimum deviation that maximizes the output S/N ratio. . . . under the assumed system limitations, PPM is superior to PCM in regard to maximum reliable range, S/N improvements, and minimum required bandwidth. . . .

CODING AND DECODING DEVICES IN PULSE-CODE TELEMETERING SYSTEMS
I. A. Kupershmidt, Automation & Remote Control, vol. 19, Sept. 1958, p. 858/868.

A systematic survey of conversion methods from voltage and current to binary pulse codes and vice versa is given. A comparative evaluation of these methods from the point of view of their applicability to pulse-code telemetering systems is given. Spheres of application of three binary code varieties: the normal, sign-reversing and reflected are shown.

PULSE CODE MODULATION OF COMMUTATED SUBCARRIER CHANNELS
T. D. Warzecha, Proc. Nat. Symp. Telem., Sept. 9, 1958, no. 12-3, p. 1/14.

COMMENTS RELATIVE TO THE APPLICATION OF PCM TO AIRCRAFT FLIGHT TESTING
R. R. Djorup, IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 3, Sept. 1959, p. 148/153.

The pending widespread use planned for PCM telemetry has caused some confusion in the area of PCM or digital standards. . . . to discuss proposed PCM standards . . . to show by example the organization of an integrated digital flight test system using these standards.

CONSIDERATION OF RF PARAMETERS FOR PCM TELEMETRY SYSTEMS
D. D. McRae, IRE Trans. Space Electronics Telemetry, vol. SET-5, June 1959, p. 61/65.

NEW DEVELOPMENTS IN PCM TELEMETRY
R. E. Marquand, National Telemetering Conference, May 1959, p. 25/30.

COMMUNICATION EFFICIENCY OF SPACE TELEMETRY SYSTEMS
R. W. Sanders, National Telemetering Conference, May 1959, p. 4/13.

THE USE OF PCM IN DATA LINKS WITH SATELLITES, SPACE VEHICLES AND LONG-RANGE MISSILES
R. L. Sink, Nat. Symp. Space Electronics Telem., Sept. 1959, no. 1.2, p. 1/21.

DETECTION LEVELS AND ERROR RATES IN PCM TELEMETRY SYSTEMS
A. V. Balakrishnan, et al., IRE Conv. Rec. pt. 5, Communs. Systems, Space Electronics Telemetry, vol. 8, March 1960, p. 37/55.

EVALUATION OF TECHNIQUES FOR PCM RANGE TELEMETRY
D. G. Childers, Proc. Nat. Telemetering Conf., May 1960, p. 271/289.

AN INTEGRATED AIRBORNE PCM TELEMETRY SYSTEM
N. Aron, et al., Proc. Nat. Aerosp. Electron. Conf., vol. 9, May 1961, p. 512/519.

AN ANALYSIS OF MULTI-PHASE RF MODULATION FOR PCM TELEMETRY
F. H. Goodenough, Proc. Nat. Telemetering Conf., May 1961, p. 14-61/14-82.

SYSTEM DESIGN OF A MISSILE LOW LEVEL PCM TELEMETRY SYSTEM
P. Spergel, et al., Proc. Nat. Aerosp. Electron. Conf., vol. 9, May 1961, p. 267/274.

A P. C. M. CODING AND DECODING SYSTEM
J. Bradley, (British Interplanetary Society, Symposium on Communications, Satellites, London, England, May 12, 1961.), In: Communications Satellites, New York, Academic Press, Inc., 1962, p. 75/83, A63-12458.

Description of a method by which the required PCM coding and decoding may be achieved using any code. For the proposed type of code, the method appears to offer a fairly simple, reliable, and inexpensive solution, though it would not meet the speed requirement necessary for the transmission of video signals. It is suggested that this method is tentative and has not been proven, though much of the circuitry is standard computer practice. It uses ferrite cores as memory units for coding and decoding, though there may be some advantage in using multiapertured ferrite cores. In addition, other possible coding and decoding methods are briefly outlined.

ADAPTIVE TECHNIQUES FOR LONG RANGE TRANSMISSION OF PULSE CODE MODULATION TELEMETRY DATA
D. H. Ellis, et al., Dynatronics, Inc., Orlando, Fla., Final rept., June 1960-May 1961, Aug. 1962, 244 p. incl. illus., tables, refs., ASD TR 61-198, AD 288 076.

. . . long range transmission of PCM telemetry data. . . . optimization of system information capacity, selection of an optimum R. F. link, and investigations of format compromises, to attain the maximum information rate possible over a wide range of transmission path lengths, and a variety of data requirements. The type of modulation (phase) for the R. F. link is shown by theoretical analysis to be superior to any other. A system design and engineering model verify the feasibility of the engineering design.

ADAPTIVE TELEMETRY FORMAT GENERATOR
R. E. Gottfried, et al., Proc. Nat. Telem. Conf., vol. 2, May 1962, p. 10/1.

. . . The great utility of time multiplexed formats for use in telemetry, communications, and data processing has been well established over the years. . . . The majority of telemetry formats . . . are fixed according to some prearranged sampling plan. . . . This practice has often resulted in great transmission inefficiency . . . excessive sampling results in redundance. . . . This paper describes a format generation technique which is believed to have great simplicity in terms of implementation and operational usage. The device which results can be controlled by command or self-adaptive means. . . .

PCM TELEMETRY SUPPLEMENTAL DATA SHEETS: GTM 004C-MAB 2
Boeing Co., Seattle, Wash., 30 March 1962, 244 p., AD 404 660.

PCM TYPE TELEMETRY (In French)
L. W. Gardenhire, Onde Electr., vol. 43, no. 440, Nov. 1963, p. 1072/1109.

. . . history of telemetry . . . examples in connection with the American ICBM programme (Titan, Munuteman) as well as those arising in different types of satellites (Nimbus, OAO, Telstar). . . improvement in efficiency and in reliability obtained over 7 years. Future methods of direct coding are glanced at. . . . Telstar satellite and of the different telemetry devices carried . . . PCM telemetry equipment in the Apollo capsule . . . errors and their various causes in PCM telemetry . . .

APPLICATION OF SWEPT-FREQUENCY MODULATION TECHNIQUES TO PCM TELEMETRY
E. K. Holland-Moritz, et al., Institute of Science and Tech., U. of Michigan, Ann Arbor, Final rept., May 1962-Aug 1963, Jan 1964, 122 p., Rept. no. 5097 17F, TRD 63 4126, AD 432 244.

. . . design criteria for the application of the SFM technique to practical PCM telemetry systems. It compares optical, acoustic, and electrical techniques for generating and processing SFM signals, and it discusses the effects of doppler shift and multipath propagation on

PCM/SFM signals. Error rates have been calculated for a PCM/SFM telemetry link operating in the presence of simultaneous gaussian and impulse noise. Error due to single impulses, clusters of impulses, periodic impulses, and impulses having a Poisson distribution are treated. Computations are given for the approximate error rate when short channel interruptions or short fading periods are present. . . .

Related Publications:

A PCM DATA ACQUISITION AND PROCESSING SYSTEM FOR SOLID PROPELLANT ENGINE TESTING
J. P. Knight, Nat. Symp. Space Elec. Telem., Sept. 1959, no. 5.1, p. 1/9.

A UNIVERSAL PCM DATA TRANSMISSION SYSTEM
D. H. Ellis, et al., Proc. Nat. Telemetering Conf., May 1961, p. 14-41/14-60.

A NOTE ON DEMODULATION OF PCM/PM SIGNALS WITH SWITCHING TYPE PHASE DETECTORS
J. A. Develet, Jr., IRE Trans. Space Elecs. Telem., vol. SET-8, no. 1, March 1962, p. 39/43.

THE MARINER PLANETARY COMMUNICATION SYSTEM DESIGN
B. D. Martin, Proc. Nat. Telem. Conf., vol. 2, 1962, p. 8/3.

. . . will be used on the first Mariner spacecraft, a Venus probe, to be launched during the summer of this year. While the basic design philosophy and implementation techniques remain essentially the same, the major system difference between that reported here and that used in the Mariner is the deletion of the S-band transponder system. . . .

PRACTICAL DESIGN OF PACM TELEMETRY EQUIPMENT
G. J. Pastor, Nat. Telem. Conf., May 1962, no. 13-4, p. 1/13.

. . . hydrid Pulse Amplitude and Pulse Code Modulation . . . Feasibility Model . . . completed early this year and its evaluation is in progress. . . .

THE ORTHOMATCH DATA TRANSMISSION SYSTEM
B. G. Kuhn, et al., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 3, Sept. 1963, p. 63/66.

. . . Envelope-orthogonal signals in the transmitter and matched filters in the receiver are employed; Orthomatch at 16 levels requires 5.6 db less power than orthogonal incoherent PCM and 1.9 db less power than biphase PCM. . . .

1.574: Pulse Code Modulation for Picture Transmission Links

Included: Picture regeneration from quantized data; Delta modulation for picture transmission.

Not Included: Theory of smoothing quantized signals after detection (2); Picture tubes; Camera techniques; Video compaction techniques (2); Picture transmission links for special space missions (4); Optical communications systems (3B)

Cross References: Delta modulation, fundamentals (Sect. 1.53)

Principal Publications:

A RESEARCH STUDY & ENGINEERING INVESTIGATION OF A DIGITAL TELEVISION SYSTEM
R. E. Sturm, et al., Colorado Research Corp., Denver, Colorado, March 1959, AD 216 325.

Discussion of the merits of exponential integration for Delta Modulation encoders . . . Experimental results pertaining to the three different forms of Delta Modulation. . . . Included are kinescope photographs obtained using the conventional delta, delta-PCM and split-band delta methods of encoding. . . .

VIDEO TRANSMISSION OVER TELEPHONE CABLE PAIRS BY PULSE CODE MODULATION
R. L. Carbrey, Proc. IRE, vol. 48, Sept. 1960, p. 1546/1561.

. . . experimental seven digit pulse code modulation (PCM) system has been built for the transmission of monochrome and color television signals over seven pairs of 22-gauge exchange area telephone cable . . . A beam coding tube converts the signal to seven parallel digits of a binary Gray code at a 10 mc rate . . .

MINIMUM POWER WIDEBAND COMMUNICATION SYSTEM FOR SPACE VEHICLES
R. M. Gagliardi, et al., Proc. Nat. Telemetering Conference, May 1961, p. 10-11/10-29.

. . . transmission bandwidth for space applications is at a somewhat lower premium than transmitter power. Therefore it becomes desirable to investigate applicable modulation techniques for their efficacy in trading off power for bandwidth. . . . A high quality TV

picture can be reproduced from an analogue channel having an output average signal-to-noise ratio of 30 db. . . . Recent tests have demonstrated that acceptable TV pictures can be reproduced from a digital transmission system employing a binary coded signal consisting of 5 information bits. . . .

DEMONSTRATION OF THE FEASIBILITY OF USING DELTA MODULATION FOR PICTORIAL TRANSMISSION
R. V. Cotton, et al., Philco Corp., Blue Bell, Pa., Rept. for 15 April-15 Nov. 1962 on Phase 1, Nov. 1962, lv., incl. illus., tables, refs., (Rept. no. 9040-TN) (ASD TDR 62-1037), AD 294 689.

. . . for encoding pictorial data . . . to determine the parameters of delta modulation systems for various image communication applications by (1) system analysis, (2) computer simulation, and (3) experimentation. The analysis of delta modulation techniques included one-bit and two-bit systems with both linear and exponential integration. . . . An experimental two-bit delta modulation encoder with a sampling rate of 50 mc was constructed and tested. A table of the key parameters of PCM and delta modulation systems is presented. . . .

MAXIMUM ACCEPTABLE BIT ERROR RATES FOR PCM ANALOG AND DIGITAL TV SYSTEMS
J. M. Knight, Jr., Nat. Telem. Conf., May 1962, no. 10-3, p. 1/9.

HIGH-SPEED PCM ENCODER-DECODER
J. A. Arida, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 155/157.

. . . A video signal, used as a typical analog information signal, was digitally coded in a PCM encoder and then time division multiplexed, with a low-speed digital signal. The multiplexer output was used to amplitude modulate a 13.2—gigacycle carrier. . . . An analog input signal is sampled 5.5 million times per second, and for each sample, a 5-bit serial code is generated. Therefore, the output code rate is 27.5 megabits per second. . . .

DEMONSTRATION OF THE FEASIBILITY OF USING DELTA MODULATION FOR PICTORIAL TRANSMISSION
R. V. Cotton, et al., Philco Corp., Blue Bell, Pa., Rept. for 15 April 1962 - 15 May 1963, lv., ASD TDR63 528, AD 409 600.

. . . to determine the parameters of delta modulation systems for various image communication applications by system analysis computer simulation, and experimentation. . . included one-bit and two-bit systems with linear integration, double linear integration with prediction, and exponential integration. A feasibility model of a 25-mc two-bit exponential integration delta modulation encoding and decoding system with a serial bit rate of 100 mpps was designed, constructed, and tested . . . It is concluded that for a typical image communication system, two-bit delta modulation with exponential integration and sampling at two to three times the information bandwidth represents the best compromise of parameter. The resultant compaction over six-bit PCM is two to three.

VIDEO TRANSMISSION BY DELTA-SIGMA MODULATION
H. Inose, et al., Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 307/312.

. . . describes that a unity bit modulation technique proposed by the authors is one of the appropriate approaches to digital transmission of video signals. . . . The modulation system incorporates an integration process in the original delta modulation and has an advantage in d. c. level transmission and stability of performance. . . .

SYNTHESIS OF OPTIMAL FILTERS FOR A FEEDBACK QUANTIZATION SYSTEM
E. G. Kimme, et al., IEEE Intern. Conv. Rec. Pt. 2, vol. 11, March 1963, p. 16/26.

. . . One proposal for a baseband quantization system for narrow-band television signals incorporates linear predistortion and reconstruction, and a linear noise feedback loop around the quantizer. . . .

PICTURE REGENERATION FROM QUANTITIZED DATA
J. G. Raudseps, Ohio State U., Research Foundation, Columbus Antenna Lab., July 31, 1963, 34 p., 3 refs., (Rept. 122-19), N63-22505.

. . . The reduction of the essential information contained in a picture to constant-intensity contours for computer storage and subsequent regeneration by a modified Flexowriter, is reported. Six quantitizing levels were used, and data smoothing methods were developed for both horizontal and vertical scans . . .

BAND LIMITATION AND ERROR RATE IN DIGITAL UHF-FM TRANSMISSION
H. J. von Baeyer, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 110/117.

The literature on systems design for the transmission of high speed digital data in the "megabits per second" range over UHF links is scarce and somewhat contradictory. . . . problem of finding the best compromise between radiated bandwidth, power balance, and output SNR, the latter being directly related to the error rate. Confining the analysis to frequency modulation, . . . optimization is analyzed. The effects of intersymbol interference, FM transient characteristics, and FM improvement threshold are discussed.

Related Publications:

STATISTICAL PROPERTIES OF THE CONTOURS OF RANDOM SURFACES
P. Swerling, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 315/321.

OPTIMIZING SPACE TELEVISION TRANSMISSION
F. A. Gicca, Proc. Intern. Telem. Conf., vol. 1, Sept. 1963, p. 313/321.

. . . This paper explores how optimum digital television systems may be developed which require a minimum of spacecraft power and weight. Four digital television processing techniques are presented and their performance is compared with conventional analog television. The most promising of these approaches, called 'elastic encoding', provides telemetry power savings of about 5 db when compared to analog television. . . .

A UNITY BIT CODING METHOD BY NEGATIVE FEEDBACK
H. Inose, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1524/1535.

Signal-to-noise performances of a unity bit coding method and the characteristics of an experimental video encoder based upon the principle are described. . . .

A PRECISION FLYING SPOT FILM DIGITIZER
J. A. G. Russell, California U., Livermore, Calif., Lawrence Radiation Lab., 13 Dec. 1963, 14 p., refs., N64-17291.

. . . measure locations of images on transparent film by automatically scanning an area on the film with a mechanically generated flying spot of light. These location measurements are directly transmitted to a digital computer for subsequent processing. The digital computer controls and monitors the digitizing equipment operations . . .

INSERTION OF WIDE BANDWIDTH VIDEO DATA FOR COMMUNICATIONS FROM RECONNAISSANCE SATELLITES
General Electric Co., Utica, N. Y., Final Rept., Sept. 1962-June 1963, ASD TDR 63 815, 20 Sept. 1963, 81 p., AD 421 526.

. . .design and . . . breadboard implementation of a wide band, high resolution data conversion system for reconnaissance satellites applications. . . . capability of 6 bit quantization of video signals with frequency components up to 25 MC. . . . the system includes parallel to series and series to parallel converters and a digital to analog converter to afford simulation of a complete communications link.

DIVISION 1.6:
DISTORTION CHARACTERISTICS OF COMMUNICATIONS CHANNELS

Space communications systems have to meet the toughest conceivable requirements of all communications systems. The range in deep space communications is far beyond any distance previously covered by radio communications. The relative velocity between terminals exceeds the velocity of aircraft terminals by orders of magnitudes causing unprecedented Doppler effects. Desirable information rates and ultimate reliability requirements demand still further advances in communications technology. Even the requirements for the supporting ground communications facilities on Earth exceed present standards for transoceanic communications. Beyond the immediate needs one can anticipate future demands for surface communications on other celestial objects and for personal mass communications facilities when future space populations need to establish conversations in an air-less environment.

This situation calls for the most efficient exploitation of every conceivable communications medium, including those which do not appear promising at first glance.

The compilers of this bibliography attempted to present all the pertinent material in a suitable system of classification. The characteristics of communications media fall broadly into two groups: Characteristics which effect the propagation of the transmission signals and which may cause distortions of these signals are in one group. Characteristics which may be associated with additional disturbances (noise) and the effects of such disturbances on the channel quality are in a second group. Division 1.6 contains references to the first group; division 1.7 contains references to the second group. Understandably, there is no clear-cut interface between these two groups; many distortions have the same effect as certain disturbances and very strong noise is likely to cause additional distortions in the transmitted signals. Thus the reader is warned that publications registered in division 1.6 will frequently contain material of division 1.7 and vice versa.

Division 1.6 itself is divided into 8 sections; the first two deal with the analytical background of channels and distortions. The next two sections present the natural characteristics of communications media in two different dimensions. Section 1.63 is arranged according to the geo-astro-physical aspect or the geographical location of the media. This section stresses the common characteristics of such complexes as the ionosphere or the polar region on Earth. Section 1.64 is arranged according to the various wavebands (frequency regions) from VLF (very low frequencies) to microwaves. Any references to communications media in still higher frequency ranges, such as optical communications or X-ray channels, may be found in volume 3B of this series.

The remaining sections are grouped according to practical communications facilities. The reader may find here, among others, the characteristics of telephone lines (section 1.65), of scatter channels (section 1.66) and of omnidirectional channels, such as may be required in personal communications for astronauts (section 1.67). The last section (1.68) contains references which do not fit the descriptions of the other sections.

Section 1.60:
General References to Communications Channels

This section is comprised of references to papers which stress the importance of investigations on channel characteristics. Books and surveys, which summarize the results of such investigations, and publications which deal with the common aspects of several classes of communication channels are referenced in this introductory section.

Subdivision 1.602 summarizes results on space communications channels. Common fundamentals on space links will be included in this subdivision. Special missions and their communication links will be discussed in volume 4. The review of the design of particular subsystems of space communications links and of the design aspects of specialized space links, such as telemetry links, command links, picture links etc., is outside the subject areas of this bibliography.

1.600: Common Aspects of All Communication Channels and Transmission Media

Included: Books and surveys; Historical notes; Comparative discussion of several transmission media.

Not Included: Antennas; Communications traffic statistics; Switching centers and terminals; Propagation theory; Geophysics; Astrophysics; Characteristics of optical communications channels (3B).

Cross References: Information theory (Sect. 1.12); Mathematical models of ideal channels (Sect. 1.13); Comparison of various modulation methods (Div. 1.8).

Principal Publications:

INFORMATION TRANSMISSION, MODULATION AND NOISE: A UNIFIED APPROACH TO COMMUNICATION SYSTEMS
M. Schwartz, New York, McGraw-Hill Book Co., Inc., 1959, 461 p.

COMPARATIVE EVALUATION OF COMMUNICATIONS TRANSMISSION MEDIA
J. H. Vogelman, IRE Trans. Commun. Syst., vol. CS-7, no. 4, Dec. 1959, p. 230/231.

. . . a first-order approximation method is provided to limit the number of specific transmission media which must be considered in any specific application.

DATA TRANSMISSION OVER MAXIMUM DISTANCES (In German)
W. T. Runge, Elektrotech. Z (ETZ)A, vol. 81, no. 24, Nov. 1960, p. 854/860.

. . . various kinds of transmission medium available . . . recent developments in cable transmission . . . increasing use of coaxial cables, both on land and sea, with built-in repeaters . . . Waveguide systems are mentioned . . . The favorable position of radio systems as regards actual propagation in comparison with cable system is . . . illustrated by graphs, together with their drawbacks as regards serviceability. . . . recent advances in shortwave and microwave systems . . . use of satellites . . . discussed with reference to the I. T. T. System of three 24-stage satellites to give complete world coverage for telephone service. . . .

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . The book is essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." The 18 authors are recognized authories in their respective specialities, and the reader can appreciate the effort required to edit the contributed material into the 23 chapters which make up the book. . . .

DEVELOPMENT OF A STANDARD COMMUNICATION RATING SYSTEM
D. L. Scidmore, et al., Minneapolis-Honeywell Regulator Co., Seattle, Wash., 5 Jan. 1962, 144 p., incl. illus., refs., (Rept. no. 872), RADC TRD 62-70, AD 274 545.

. . . useful for comparison and evaluation of communication systems. . . . The rating system evolved has few limitations, is quite flexible and easily used, and is applicable to a wide range of point-to-point communications problems.

THEORY AND PERFORMANCE LIMITATIONS OF ANALOG SYSTEMS
W. M. Brown, et al., IEEE Trans. Mil. Electronics, vol. MIL-8, no. 2, April 1964, p. 102/113.

Performance limitations due to phase errors, stochastic delays, and clipping are discussed . . . some results of filtering for the modulus of a complex signal . . . some problems in scatter communications. . . .

DATA TRANSMISSION FOR MILITARY COMMUNICATION: PARAMETERS AND CAPABILITIES
J. Polyzou, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 454/464, 40 refs.

. . . a difficult problem for system designers because there are so many different types of communications facilities with widely differing characteristics which must be considered. Additionally, the system designer must consider the type of digital data modulation which best serves his purposes, the economics of the various approaches and a host of related problems such as clocking, synchronization, standardization, etc. . . . discussion . . . includes delay distortion, noise, multipath distortion, bandwidth and amplitude response, transmit level, level variations, frequency translation errors, synchronization, standardization, cost considerations and facilities characteristics. . . .

INTERSTATION DATA. TRANSMISSION STUDY
Philco Corp., Palo Alto, California, Final rept., 28 Feb. 1963, lv. incl. illus., tables, (Rept. no. WDL-TR 2017), AD 297 409.

. . . equipment to transmit data through a single voice channel . . . requirements placed on transmission medium, transmission rates, equalization provided, size weight, prime power requirement. . . . media include: wire lines, HF radio, microwave line of sight, and the various scatter propagation techniques. . . . reliability, error rate, and availability. Error detection and error correction for both white noise and burst error interference are considered. It is concluded that long word codes (100-500 bits) with error detection is the most promising technique, but that a feedback path is required.

THE CHARACTERIZATION OF TRANSMISSION CHANNELS
IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 259/260.

. . . editorial . . . the greatest limitation of our transmission accomplishments to date is imposed by our ignorance of the most vital link in the system—the transmission medium . . . .

Related Publications:

SURVEY OF DIGITAL COMMUNICATIONS
C. A. Deutschle, Hughes Aircraft Co., Culver City, Calif., Rept. on 480L System, 15 April 1961, 386 p. incl. illus., tables, 7 refs., (Rept. no. TR-1), AD 277 176.

Discrete message types . . . Transmission requirements and techniques . . . cryptography . . . Transmission media . . . Error control . . . Comparative evaluations . . .

EUR-MED COMMUNICATION SYSTEM BASE AREA AND SYSTEM TERMINALS GENERAL PERFORMANCE SPECIFICATION
ITT Communication Systems, Inc., Paramus, N. J., 31 Aug. 1962, 79 p., AD 431 584.

. . . Typical circuits are given for the purpose of illustrating the performance standards and objectives. . . . The system will interconnect the trunk stations and military base sites using both tropospheric scatter and line-of-sight microwave propagation.

1.602: General References to Space Communications Channels

Included: General requirements for space communications links; Surveys of the transmission media of importance in space links.

Not Included: Sky noise in space links; Re-entry links; Design procedures for space links; Discussion of range equation.

Cross References: Point-to-point space channels (1.667); Beyond line-of-sight satellite channels (1.675).

Principal Publications:

PERFORMANCE IMPROVEMENT IN SINGLE-CHANNEL VOICE COMMUNICATION RADIO SYSTEM IN SPACE
L. P. Yeh, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 151/162.

. . . explores the possibilities of improving the performance of a single-channel voice communication radio system, when the transmitter power is at a premium, as when communicating in space. . . . The only techniques covered are AM (double sideband with full carrier), DSBSC (double-sideband suppressed carrier), SSB (single-sideband) and NBFM (narrow-band frequency-modulation—an FM channel restricted to AM spectrums). . . .

THEORETICAL STUDY OF THE BANDWIDTH CAPABILITIES OF RADIO PROPAGATION MEDIA
B. M. Fannin, Electrical Engineering Research Lab., U. of Texas, Austin, 31 Aug. 1962, 41 p. incl. illus., 21 refs., (Rept. no. 6-49), AFCRL 62-584, AD 286 387.

The question of what limitations the atmosphere may impose on the useful bandwidth for line-of-sight propagation in the centimetric-millimetric wavelength region was investigated. . . . definition of a really suitable, unique parameter to be taken as the bandwidth of a time-varying system. . . . results for the existing theories based on a multiple-scatter mechanism furnish an adequate base for performing bandwidth calculations.

DIGITAL COMMUNICATIONS BETWEEN AEROSPACE VEHICLES AND STATIONS ON THE GROUND
K. W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 58/66, 23 refs.

. . . tutorial paper presents an introduction to the problems of communications between aerospace vehicles and stations on the ground. The possible types of aerospace-to-ground communication links are described and classified according to the mode of signal propagation and according to obtainable range. The suitability of carrier frequencies throughout the electromagnetic radiation spectrum from very-low radio frequencies to light frequencies is discussed for the various types of links. . . . selection of modulation and demodulation techniques. . . practical value of digital coding. . . transmitter power requirement . . .

POLARIZATION CONSIDERATIONS IN SPACE COMMUNICATIONS
B. C. Potts, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 103/107.

Ground-space and space-to-space communication involving propagation in or through a magneto-ionic medium, such as the earth's ionosphere, often requires minimization of the effects of the rotation of the polarization plane. . . .

HF AND VHF IONOSPHERIC WAVE-GUIDANCE
J. I. Barker, et al., Proc. Nat. Aerospace Electronics Conf., May 1963, p. 238/244.

The results of a recent study of HF and VHF frequencies for satellite-to-satellite communications are presented. . . .

HIGH-SPEED DIGITAL DATA TRANSMISSION OVER THE TELSTAR SATELLITE (Correspondence)
F. E. Froehlich, et al., Proc. IEEE, vol. 51, no. 4, April 1963, p. 609.

RESULTS OF THE TELSTAR SYSTEM COMMUNICATIONS TESTS
R. W. Hatch, et al., Bell Syst. Tech. J., vol. 42 no. 42, July 1963, p. 1561/1629.

. . . results of the communications tests on the Telstar satellite system which have been conducted at the Andover earth station are presented. . . included successful transmissions of telephone, television, and data signals. . . measurements of received carrier power, noise, transmission characteristics, linearity, data system errors, absolute delay, and Doppler shift have been made. The results are in good agreement with expected performance.

PROPAGATION OF INFORMATION BEARING SIGNALS THROUGH SPACE
R. F. Leach, IRE-NASA-AEC, International Symposium on Space Phenomena and Measurement, Detroit, Mich., Oct. 15-18, 1962, IEEE Trans. Nuclear Sci., vol. NS-10, Jan. 1963, p. 146/152, 11 refs., A63-11758.

Analysis of the distortion of a band-pass information-bearing signal by a medium. A general band-pass signal is assumed and, from this, narrowness can be defined explicitly for any signal, in any medium. A general method is presented for determining the effect of the interplanetary gas and the effect of the ionosphere (where Faraday rotation is neglected). The inverse of this method may be used to measure band-pass characteristics of any medium.

AN EXPERIMENTAL STUDY OF RAPID PHASE FLUCTUATIONS INDUCED ALONG A SATELLITE - TO EARTH PROPAGATION PATH
L. J. Porcello, Institute of Science and Tech., Univ. of Michigan, Ann Arbor, April 1964, 125 p., Rept. no. 4563 57T, AD 437 587.

. . . has as its objective the examination of high-frequency phase fluctuations induced by the atmosphere along a satellite-to-ground propagation path. The phase fluctuations of interest lie in a spectral band ranging from approximately 0.1 cps to a maximum of 3kc; the radio frequencies employed range from 54 to 400 Mc. The ionosphere-induced compononent of the observed phase fluctuation is of primary interest. . . .

Section 1.61
Analytical Descriptions of Practical Communications Channels

For the design of space communications channels it is necessary to describe the communications medium and its variations in mathematical terms. Statistical mathematics (1.11) is the principal tool. This section contains a wide selection of special publications which demonstrate the progress made during the last five years. The section primarily contains references to analytical publications. The reader should note that publications with practical backgrounds and those concerned with rather specialized tasks may also contain valuable analytical contributions. Such combined analytical-practical (experimental) reports are usually referenced under their special subdivision and not in analytical subdivisions.

This section deals primarily with the analysis of the time variable characteristics of communications channels and media. The next section (1.62) deals with the analysis of distortions in communications channels. We assume for this purpose that the channels are time-invariant. This is why the analytical description of time-invariant channels is incorporated in subdivision 1.621.

1.611: General Theory of Time-Variant Communications Channels

Included: Randomly time-variant linear channels; Time stability of multipath jitter; General theory of scatter channels; Log-normal probability distributions in scatter channels; General theory of noiseless channels.

Cross References: Channel models for all sorts of communications channels (1.130); Theory of Needles channels (1.666); Channel characteristics of practical scatter channels (Sect. 1.66); Fundamentals of special statistical distributions (1.117); Analytical background for the description of natural propagation media (1.631).

Principal Publications:

FREQUENCY-DOMAIN STATISTICAL MODEL OF LINEAR VARIABLE NETWORKS FOR FINITE OPERATING TIME
G. W. Johnson, IRE Nat. Conv. Rec., March 1958, p. 70/78.

The analysis and synthesis techniques for the propagation of random signals through linear variable networks have been well defined in the time domain, are not amenable, except for trivial cases. In contrast, the conventional frequency domain techniques developed for the steady-state propagation of stationary random signals in linear invariant networks have proven extremely useful.

AN ALTERNATIVE APPROACH TO THE REALIZATION OF NETWORK TRANSFER FUNCTIONS: THE N-PATH FILTER
L. E. Franks, et al., Bell Syst. Tech. J., vol. 39, no. 5, Sept. 1960, p. 1321/1350.

A particular time-varying network consisting of several parallel transmission paths, each containing input and output modulators, is described and analyzed. It is shown that, under certain conditions, the network may be characterized by a transfer function.

TIME-VARYING CHANNELS WITH DELAY SPREAD

P. E. Green, Jr., In: RADIO WAVES AND CIRCUITS; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 208/224; Discussion, p. 225/226, 21 refs., A64-10835.

. . . results on two topics, (1) the characterization of time-varying linear communication channels (or radar targets) having a spread of propagation delays . . . (2) the design of optimum receivers for detecting or distinguishing between signals propagated by such media. . . .

STATISTICAL METHODS IN RADIO WAVE PROPAGATION, (Proceedings of a symposium held at the University of California)

W. C. Hoffman (editor), Oxford, England, Pergamon Press Ltd., 1960, 334 p.

. . . symposium held at the University of California, June 18-20, 1958. . . . current state of the art in the use of statistical techniques in radio wave propagation. . . .

A NOTE ON RANDOMLY VARIABLE BINARY CHANNELS

J. Loeb, In: RADIO WAVES AND CIRCUITS; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 195/199, A64-10833.

. . . Statistical properties of random binary channels are represented by 2 x 2 matrices built with error probabilities. Cascading elements of a complex matrix amount to multiplication of elementary matrices. Resulting "equivocation" can be approximately computed by means of the determinant of the matrix product. The results found can be considered as a particular case of Siforov's theory.

ON THE THEORY OF RADIO COMMUNICATION CHANNELS WITH RANDOMLY VARYING PARAMETERS

V. I. Siforov, In: RADIO WAVES AND CIRCUITS; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 164/194, 11 refs., A64-10832.

Description of some results of research on the capacity of radio communication channels having multi-path wave propagation. . . classified into type I and type II with respect to their capacity at a low additive noise level. The concepts of self capacity and conditional capacity for a channel are introduced. It is proved that the capacity drops by not more than 17% for slow random variations in the parameters of a multi-path channel for any signal-to-noise ratio. . . .

APPROXIMATE METHOD FOR ANALYTICALLY EVALUATING THE RESPONSE OF TIME-VARIABLE LINEAR SYSTEMS

E. G. Gilbert, IRE Trans. Circuit Theory, vol. CT-8, no. 3, Sept. 1961, p. 289/295.

ANALYSIS OF TIME-VARYING NETWORKS

B. K. Kinariwala, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 268/276.

THEORY OF OPTIMAL SIGNAL FILTRATION IN THE PRESENCE OF INTERNAL NOISE IN SYSTEMS WITH VARIABLE PARAMETERS

Li Khen Von, ARS Journal, vol. 31, no. 9, Sept. 1961, p. 1306/1314.

TIME-VARYING NETWORKS, I

L. A. Zadeh, Proc, IRE, vol. 49, Oct. 1961, p. 1488/1503.

Bibliography of 138 references.

APPROXIMATE CALCULATION OF THE TRAFFIC CAPACITY OF RADIO CHANNELS HAVING RANDOM PARAMETERS

R. L. Dobrushin, et al., Foreign Tech. Div., Air Force Systems Command, Wright Patterson Air Force Base, Ohio, 26 Sept. 1962, 9 p., 10 refs., (Trans. no. FTD-TT-62-1016 from Trudy Vsesoyuznogo Soveshchaniy po Teorii Veroyatnostey i Matematicheskoy Satistike, Izdatel'stvo AN Armyanskoy SSR, Yerevan, p. 164/171, 1960), AD 288 528.

UPPER BOUND TO THE CAPACITY OF A LINEAR TIME-VARYING CHANNEL WITH ADDITIVE GAUSSIAN NOISE

G. D. Forney, Jr., Lincoln Lab., Mass. Inst. of Tech., Lexington, 26 Sept. 1962, 15 p. incl. illus., 10 refs., (Rept. no. 34G-10), AFESD TDR 62-144, AD 287 453.

. . . obtained by finding the capacity of the same channel when its behavior at all times is known a priori. Numerical evaluation turns out to depend on the distribution of the eigenvalues of a random infinite-dimensional matrix, which is apparently an unsolved mathematical problem. Evaluation is possible in two special cases . . .

ESTIMATION OF THE SECOND-ORDER STATISTICS OF RANDOMLY TIME-VARYING LINEAR SYSTEMS

M. J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 2 Nov. 1962, 42 p. incl. illus., 13 refs. (Rept. no. 34G-7), AFESD TDR 62-147, AD 289 607.

. . . by application of a known input signal and observation of the resulting output which may be obscured by additive white noise. The system is characterized by its impulse response correlation function f(tau lambda) and is approximated by a sampled-data model.

THE APPLICATION OF CERTAIN THEORIES TO THE PROBLEMS OF DETECTION AND COMMUNICATION (In French)
J. Lochard, et al., Onde Electr., vol. 42, no. 426, Sept. 1962, p. 709/737.

A series of 5 papers. . .the first develops the thought that research. . .of signals carrying information has, up to now, been less developed than those applied to. . .materials and mechanism of transmission. . .the second . . .explains. . .results of the theory of probability. . .their applications to signals. . . the third article. . .deals with. . .mathematical statistics . . .in the reception of signals immersed in noise. . .fourth article. . .shows how the results of statistical theory. . .can be applied or cannot be applied to the practical problems of signal transmission. . .the last article. . .shows how the properties of written language. . .can be studied quantitatively. . .

A REMARK ON THE TRAFFIC CAPACITY OF A DISCRETE COMMUNICATIONS CHANNEL WITHOUT NOISE
Y. I. Lyubich, Foreign Tech. Div., Air Force Systems Command, Wright Patterson Air Force Base, Ohio, 29 Aug. 1962, 11 p., 6 refs., (Trans. no. FTD-TT-62-1144 from Uspekhi Matematicheskikh Nauk, 17:103, p. 191/198, 1962), AD 286 609.

SOME STATISTICAL THEORY FOR THE ANALYSIS OF RADIO PROPAGATION DATA
M. M. Siddiqui, J. Res. Nat. Bur. Stand., vol. 66D, no. 5, Sept.-Oct. 1962, p. 571/580.

The statistical theory of stationary processes has wide applications in the analysis of radiowave propagation data. Assuming knowledge of the basic concepts of probability theory, characteristics of stationary processes such as covariance and spectral density functions were developed, problems of estimating these characteristics were tackled, and numerous examples were worked out to illustrate the theory.

CAPACITY OF TWO CLASSES OF INFORMATION CHANNELS WITH RANDOMLY VARYING PARAMETERS (Translation)
N. A. Zheleznov, Telecommun. Radio Engng. Part I - Telecommunications, Oct. 1962, p. 1/7, A63-16480.

. . . a random change in parameters is interpreted as the appearance of additive noise, either correlated or not correlated with the signals. . . .

CHARACTERIZATION OF RANDOMLY TIME-VARIANT LINEAR CHANNELS
P. A. Bello, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 360/393.

. . . it is demonstrated that time varying linear channels (or filters) may be characterized in an interesting symmetrical manner in time and frequency variables by arranging system functions in (time-frequency) dual pairs. Following this a statistical characterization of randomly time-variant linear channels is carried out in terms of correlation functions for the various system functions. These results are specialized by considering three classes of practically interesting channels. These are the wide-sense stationary (WSS) channel, the uncorrelated scattering (US) channel, and the wide-sense stationary uncorrelated scattering (WSSUS) channel. . . . All real-life channels and signals have an essentially finite number of degrees of freedom due to restrictions on time duration and bandwidth. This fact may be used to derive useful canonical channel models with the aid of sampling theorems and power series expansions. Several new canonical channel models are derived in this paper, some of which are dual to those of Kailath. . . .

SOME STATISTICAL PARAMETERS RELATED TO THE NAKAGAMI-RICE PROBABILITY DISTRIBUTION
W. R. Burns, J. Res. Nat. Bur. Stand., Section D-Radio Science, vol. 68D, April 1964, p. 429/434, 9 refs., A64-17497.

TIME-VARIANT COMMUNICATION CHANNELS
T. Kailath, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 233/237, 39 refs.

STATISTICAL CHARACTERISTICS OF THE LOGARITHM OF THE ENVELOPE OF A RANDOM PROCESS
L. E. Kopilovich, Radiotekhnika i Elektronika, vol. 8, March 1963, p. 494/497, In Russian: Radio Engng. Electronic Phys., March 1963, p. 436/439, Translation, A64-10444.

. . . dependence between the statistical characteristics of the logarithm of the envelope of a random process and the envelope itself, or its square, the power. The analysis is applicable to the investigation of radio-wave propagation in which it is necessary to determine the level of the field at the receiving point, or the random process at the output, of a logarithmic apparatus.

RESPONSE FUNCTIONS OF LINEAR TIME-VARYING SYSTEMS
J. C. Lindenlaub, Lincoln Lab., MIT, Lexington, 9 Sept. 1963, 48 p. Rept. no. 41G6, ESD TDR 63 558, AD 422 263.

Linear time-varying networks are considered from the communication systems viewpoint where the emphasis is primarily on the relationships between the input and output signals. . . . Results may serve as a basis for a number of problems associated with communicating through random time-varying

channels; among them, the identification problem, signal design, and optimum processing.

GENERALIZED FREQUENCY-RESPONSE CONCEPTS FOR TIME-VARYING DISCRETE-TIME LINEAR SYSTEMS
A. W. Naylor, Institute of Science and Tech., U. of Michigan, Ann Arbor, Feb. 1963, 30 p., Rept. no. 4563-32-T, AD 297 536.

A NOTE ON THE CAPACITY OF DISCRETE NOISELESS CHANNELS
F. M. Reza, Z. Angew. Math. Phys., vol. 14, March 25, 1963, p. 175/178, A63-17890.

Presentation of a mathematical proof for a statement by Shannon concerning the channel capacity of a class of simple memoryless channels.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART XIV. TIME VARYING SYSTEMS WITH SEPARABLE SYSTEM FUNCTIONS
L. Weiss, Johns Hopkins U., School of Engineering, Baltimore, Md., 30 Jan. 1963, 94 p., AD 411 274.

The relationship of the differential equation of a system to the system's weighting pattern (impulse response) is discussed. The realization of linear differential systems is discussed, and some "tricks" regarding manipulation of the position of function generators in an analog computer type realization (without changing the input-output relation) are presented. . . .

Related Publications:

PREDICTION AND FILTERING FOR RANDOM PARAMETER SYSTEMS
F. J. Beutler, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 167/171.

APPROXIMATION OF AUTOCORRELATION FUNCTIONS BY A SERIES OF DAMPED COSINE FUNCTIONS
D. T. Friest, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 709/714.

. . . This technique of analyzing a random function is analogous to the conventional Fourier analysis of a nonsinusoidal wave, except that it leads to bands of frequencies which are integrally related rather than discrete frequencies. . . .

CORRELATION DETECTION OF SIGNALS PERTURBED BY A RANDOM CHANNEL
T. Kailath, IRE Trans. on Inform. Th., vol. IT-6, no. 3, June 1960, p. 361/366.

COMMUNICATION THROUGH RANDOMLY VARYING MEDIA
G. L. Turin, In: RADIO WAVES AND CIRCUITS; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 201/207, 10 refs., A64-10834.

. . . the form of the optimum receiver. . . is outlined. The behavior of the error probability for this receiver is discussed for the binary case, for various types of fading and orders of diversity. A special case is a frequency-shift telegraph channel.

SOME TECHNIQUES FOR THE ANALYSIS AND SYNTHESIS OF NONSTATIONARY NETWORKS
J. B. Cruz, Jr., IRE Internat. Conv. Rec., vol. 4, March 1961, p. 277/285.

A class of nonstationary or time-variable linear networks which are realizable as cascades of fixed multi-output networks and multi-input modulators is studied.

SHORT TIME STABILITY IN LINEAR TIME-VARYING SYSTEMS
P. Dorato, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 83/87.

RESEARCH ON CORRUPTED DATA PROCESSING SYSTEMS
A. R. Bergen, et al., Final Rept., June 1, 1959-May 31, 1962, California U., Berkeley, Electronics Research Lab., 1 June 1962, 15 p., 26 refs., AFCRL-62-780, N63-17505.

. . . includes research on randomly time-varying systems, optimal control systems, and the stability of nonlinear control systems.

A COMPUTER-AUGMENTED TECHNIQUE FOR THE DESIGN OF LIKELIHOOD-RADIO RECEIVERS
T. G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Oct. 1962, 36 p. incl. illus., tables, 9 refs., Technical Rept. no. 130; 3674-3-T, AD 292 161.

Standard approximation methods of design of detection receivers are reviewed, and a method based on fitting curves calculated on a high-speed computer is presented. This computer-augmented technique is applied to the design problem of a signal distorted by a sign-preserving, rapidly varying transmission gain.

ON THE DETECTION OF A RANDOMLY DISTORTED SIGNAL IN GAUSSIAN NOISE.
L. Halsted, et al., Michigan U., Ann Arbor, Oct. 1962, 38 p. incl. illus., 8 refs., Technical rept. no. 129; Rept. no. 3674-2-T, AD 291 982.

. . . The optimum receiver was evaluated for the two-input-samples case using a digital computer. . . Various facets of the performance of two nonoptimum receivers, the cross-correlator and the clipper crosscorrelator, were also evaluated using the computer.

MEASUREMENTS ON TIME-VARIANT COMMUNICATION CHANNELS
T. Kailath, IRE Trans. Inform. Th., Intern. Symp. Brussels 1962, vol. IT-8, no. 5, Sept. 1962, p. 229/236.

. . . the use of such media as tropo-scatter links, meteor trails, auroral belt, and orbital-chaff channels makes the assumption of slow changes unsatisfactory. . . . The. . . signals

. . . pass through a (linear or nonlinear) filter

. . . for example the ionosphere or an underwater link. . . . we put in suitable probing signals. . . and make appropriate computations on the output . . . in order to calculate the filter parameters. There is also, of course, the problem of determining the characteristics of the additive noise . . .

TECHNIQUES FOR EXAMINING THE STATISTICAL AND POWER SPECTRAL PROPERTIES OF RANDOM TIME HISTORIES

H. A. Leybold, Virginia Polytechnic Inst., Blacksburg, May 1963, 69 p., 29 refs., N63-16730.

A technique for digitally generating random time histories having arbitrarily shaped power spectra is presented. . . .

TRANSMITTED-REFERENCE TECHNIQUES FOR RANDOM OR UNKNOWN CHANNELS

C. K. Rushforth, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 39/42.

. . . The channel is assumed to be linear, and is divided into a multiplicative and an additive portion. . . . The channel outputs and the additive noises are further assumed to be Gaussian. . . .

1.612: Analysis of Multipath and Fading Channels

Included: Rician fading channels; Rayleigh fading channels; Theory of multipath distortions in general; MRF = multipath reduction factor; Rician multi channel; Mathematical models of scatter channels; Inverse ionosphere; Models of multipath structures.

Not Included: Anti-multipath detection systems (2).

Cross References: Scatter communications channels (Sect. 1.66); HF communications channels (1.644); Analytical background of natural propagation media (1.631); Regular characteristics of the ionosphere (1.632); Medium wave fading characteristics (1.643); Special signal distortions (Sect. 1.62); Surveys of multipath communications methods (1.660); FM distortions caused by multipath effects (1.623); Scatter system design information (1.661).

Principal Publications:

DISTRIBUTION OF THE DURATION OF FADES IN RADIO TRANSMISSION: GAUSSIAN NOISE MODEL

S. O. Rice, Bell Syst. Tech. J., vol. 37, no. 3, May 1958, p. 581/635.

. . . Estimates of the distribution of the fade lengths for various depths of fades . . .

THE EFFECTS OF PULSE SHAPE AND FREQUENCY SEPARATION ON FSK TRANSMISSION THROUGH FADING

G. L. Turin, IRE Nat. Conv. Record, vol. 6, March 1958, p. 217/224.

MEAN ABSOLUTE VALUE AND STANDARD DEVIATION OF THE PHASE OF A CONSTANT VECTOR PLUS A RAYLEIGH-DISTRIBUTED VECTOR

J. R. Johler, et al., J. Res. Nat. Bur. Stand., vol. 62, May 1959, p. 183/186.

An evaluation of the first-and second-moment integrals of the probability distribution . . . tabulated over a wide range of values of average relative intensity (K2 = 0.010 to 1000.)

THE SPEED OF TRANSMISSION OF INFORMATION AND THE CARRYING CAPACITY OF A MULTIPATH SYSTEM AND RECEPTION BY THE LINEAR OPERATOR CONVERSION METHOD

I. A. Ovseyevich, et al., Radio Engng., vol. 14, no. 3, 1959, p. 13/29.

SOME COMPUTATIONS OF ERROR RATES FOR SELECTIVELY FADING MULTIPATH CHANNELS

G. L. Turin, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 431/440.

The probability that an ideal receiver makes an error in receiving a binary transmission through a noisy, selectively fading, discrete-multipath channel can often be related to the probability that the difference of two quadratic forms in complex normal variables, in itself a quadratic form is less than a given constant. An expression for this error probability is presented and condition are discussed under which this expression may be easily evaluated. . . .

THE SUM OF LOG-NORMAL PROBABILITY DISTRIBUTIONS IN SCATTER TRANSMISSION SYSTEMS

L. F. Fenton, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 57/67.

V. H. F. SOUND BROADCASTING, SUBJECTIVE APPRAISAL OF DISTORTION DUE TO MULTI-PATH PROPAGATION IN F. M. RECEPTION

R. V. Harvey, Proc. Instn. Elect. Engrs., pt. B (London), vol. 107, no. 35, Sept. 1960, p. 412/422.

. . . The mechanism of multi-path distortion is discussed. . . .

CORRELATION BETWEEN AMPLITUDES OF RADIO WAVES OF DIFFERENT FREQUENCIES IN UHF BEYOND-THE-HORIZON PROPAGATION
M. Hirai, et al., J. Radio Res. Lab., vol. 7, Sept. 1960, p. 509/529.

Selective fading in u. h. f. transhorizon propagation is caused by interference between multipath waves. On this basis, a correlation coefficient between the amplitudes of waves of different frequencies is derived. The relationship between this coefficient, the amplitude ratio distribution and multipath wave distribution is analyzed . . .

INVERSE IONOSPHERE
G. D. Hulst, IRE Trans. Commun. Syst., vol. CS-8. no. 1, March 1960, p. 3/9.

The distortion introduced into a large-range communication system by unpredictable multipath conditions of the ionosphere is described . . .

SOLUTION OF AN INTEGRAL EQUATION OCCURRING IN MULTIPATH COMMUNICATION PROBLEMS (Correspondence)
T. Kailath, IRE Trans. on Inform. Th., vol. IT-6, no. 3, June 1960, p. 412.

INVESTIGATION OF THE PROPERTIES OF RADIO COMMUNICATION CHANNELS CONTAINING STATISTICALLY INHOMOGENEOUS MEDIA
V. I. Siforov, et al., In: Radio Waves and Circuits; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 251/268, 125 refs., A64-10837.

Brief survey of the basic trends in investigating the properties of radio communication channels containing statistically inhomogeneous media The neessity is indicated for developing new communication systems using the potential possibilities of channels with fluctuating parameters to a larger extent than has been done in the past.

ON THE THEORY OF RADIO COMMUNICATION CHANNELS WITH RANDOMLY VARYING PARAMETERS
V. I. Siforov, In: Radio Waves and Circuits; Proc. of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 164 194, 11 refs., A64-10832.

Description of some results of research on capacity of radio communication channels having multi-path wave propagation . . . classified into type I and type II with respect to their capacity at a low additive noise level. The concepts of self capacity and conditional capacity for a channel are introduced. It is proved that the capacity drops by not more than 17% for slow random variations in the parameters of a multi-path channel for any signal-to-noise ratio. . . .

PHASE-SHIFT KEYING IN FADING CHANNELS
H. B. Voelcker, Proc. Instn. Elect. Engrs., pt. B, vol. 107, no. 31, Jan. 1960, p. 31/38.

A NOTE ON ERROR STATISTICS IN FADING RADIOTELETYPE CIRCUITS (Correspondence)
H. Voelcker, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 558.

SOLUTION OF AN INTEGRAL EQUATION OCCURRING IN MULTIPATH COMMUNICATION PROBLEMS (Correspondence)
IRE Trans. Inform. Th, vol. IT 6, no. 3, June 1960, p. 412.

CODED, DIVERSIFIED, RAYLEIGH-FADED BINARY SYMMETRIC THRESHOLD CHANNELS
Research Lab. of Electronics, MIT, Cambridge, 4 Dec. 1960, 32 p. (Tech. rept. 384), AD 264 722.

. . . with null-zone detecting and diversity . . . bounds of decoding error of a coding scheme designed for a null-zone channel are evaluated. . . .

STATISTICAL ANALYSIS OF MULTIPATH JITTER
J. J. Brandinger, et al., RCA Rev., vol. 22, no. 3, Sept. 1961, p. 487/507.

. . . time stability of multipath jitter. . . . first-order statistics . . . determination of the autocorrelation and power spectral density functions . . .

ERROR PROBABILITY OF CASCADED BINARY COMMUNICATION LINKS PERTURBED BY ADDITIVE GAUSSIAN NOISE AND RAYLEIGH FADING
H. D. Goldman, et al., New York U., Coll. of Engineering, N. Y., Sept. 1961, 46 p., (Rept 6), AFCRL-900, AD 269 087.

. . . the cases of independent and completely correlated fading are considered.

FREQUENCY ERROR EFFECTS ON A BINARY COMMUNICATION SYSTEM UTILIZING COHERENT INTEGRATORS
H. J. Juda, et al., Rec. Nat. Commun. Symp., vol. 7, Oct. 1961, p. 247/253.

. . . to evaluate the performance . . . as a function of frequency mismatch between the signal and the signal detector. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS

J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., 3 Jan. 1961, (Rept. no. UA-1420-S-1), RADC TR 61-58, AD 256 584.

. . . performance of m-slate differentially coherent multiplexed PSK data links operating over a Rayleigh fading tropospheric scatter link is analyzed. The properties of impulse noise are examined . . . effect of packed codes are investigated. . . .

THE CHANNEL CAPACITY OF ONE-AND TWO-PATH COMMUNICATION CHANNELS WITH POLARIZATION (In Russian)

L. Khai-Tsyuan', Radiotekhnika i Elektronika, vol. 6, no. 2, Feb. 1961, p. 200/203.

The channel capacity of the received signal is calculated for a uniform distribution of the angle between the electric field and a horizonal vibrator, with additive Gaussian noise. Particular cases given are for small signal to noise power ratios and for a high signal to noise power ratio. . . .

NEW METHODS OF EVALUATING THE DISTORTION IN THE MULTI-PATH PROPAGATION OF SIGNALS

V. A. Smirnov, Telecommunications, no. 5, Oct. 1961, p. 489/500.

Two methods are given for evaluating the distortion arising from the multi-path propagation of signals. These methods can be called energy methods, since the distortions are measured by the relative values of the power of the products of distortion. The difference between the two methods consists in this: that in one case the ratio of the power of the products of distortion at the input of the receiver to the power of the useful signal is determined, and in the other case the ratio of the power of distortions at the output of the receiver to the power of the useful signal. Both methods are applicable to any form of modulation and manipulation and thus make it possible to compare quantitatively different systems of communication. . . .

SOME STATISTICAL PROPERTIES OF PULSED OBLIQUE HF IONOSPHERE TRANSMISSIONS

M. Balser, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 7 May 1962, 10 p., AD 405 007.

. . . amplitude fading of 35-microsecond hf pulses transmitted via the ionosphere over a 1,566-km path between Atlanta, Ga., and Ipswich, Mass. The distribution functions for about half of the records taken fit the family of distributions for a sine wave in Gaussian noise, with most of these best/fitting the curved for pure noise (the Rayleigh distribution). Some examples of two sine waves with random phase are observed. It is concluded that most of the remaining curves which do not fit these distributions correspond to samples of nonstationary functions. . . .

THE INFLUENCE OF FADING SPECTRUM ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS

P. A. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 160/168.

Previous derivations . . . have assumed that the fading rate is so slow that fluctations within a bit may be ignored. This slow fading assumption is removed in the present paper which derives general expressions for the binary error probabilities of incoherent and differentially coherent matched filter receivers employing post-detection diversity combining. In the analysis it is assumed that the transmitted signals occupy a band-width much smaller than the coherence bandwidth of the medium so that "flat" fading may be assumed. In addition, it is assumed that the amplitude and phase fluctuations produced by the medium have the same statistical character as those of narrowband Gaussian noise. . . .

PREDETECTION DIVERSITY COMBINING WITH SELECTIVELY FADING CHANNELS

P. Bello, et al., IRE Internst. Conv. Rec., Part 8, vol. 10, March 1962, p. 140/155.

NOISE IMMUNITY OF PHASE SHIFT KEYING IN SIGNAL FADING (Translation)

I. V. Dulenko, Telecommun. Radio Engng., Part I - Telecommunications, Nov. 1962, p. 66/68, A63-19197.

. . . The error probability in a channel with slow fading is assessed, using the method of Fink. . . .

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING

G. Einarsson, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 15 March 1962, 76 p. Technical rept. no. 400, AD 416 605.

. . . The possibility of representing a multipath channel as a time-variant filter is investigated. . . .

THE OPTIMUM BIT LENGTH FOR HF DATA TRANSMISSION

H. Fiege-Kollmann, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 108/115, 13 Refs.

THEORETICAL DIVERSITY IMPROVEMENT IN MULTIPLE FREQUENCY SHIFT KEYING

P. M. Hahn, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 177/184.

. . . signals on the several diversity channels are presumed to be perturbed independently by Rayleigh fading and additive white Gaussian noise. Also, it is assumed that fading is slow and that envelope, cross-correlation (matched filter) detection is used. . . .

ON THE TRANSFER FUNCTION FOR A RADIO SCATTER CHANNEL

H. E. Hardebeck, Cornell U., Ithaca, N. Y., 15 March 1962, 23 p. incl. illus., 8 refs., Research rept. no. RS 37: Scientific rept. no. 5, AFCRL 62-571, AD 286 153.

P. A. Bello, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 170/186.

The presence of frequency-selective fading in a communication channel limits the maximum data rate capability of conventional communication systems. . . . receivers employing post-detection diversity combining. . . . it is assumed that the fading is slow enough so that over a few bits at least the channel transfer function remains constant. In addition, it is assumed that the amplitude and phase fluctations on a received carrier have the same statistical character as those of narrow-band Gaussian noise. . . .

INFORMATION CAPACITY OF FADING CHANNELS UNDER CONDITIONS OF INTENSE INTERFERENCE

J. P. Costas, Proc. IEEE, vol. 51, no. 3, March 1963, p. 451/461.

. . . such systems must receive and process two distinct types of information. The first, and quite obvious, type of information concerns the intelligence signal which is provided as an output from the receiving terminal of the system. The second, and much less obvious, type of information concerns medium variations. . . . This paper is concerned with the limiting case of very small channel SNR's that are below the level required for analysis of the medium at the receiver. . . . The mathematical approach used is sufficiently general to permit inclusion of random system variations (such as oscillator phase) as part of the medium variations and hence the results are believed to be applicable to a wide variety of communication situations including deep-space probe telemetry.

ON THE STATISTICAL THEORY OF ELECTROMAGNETIC WAVES IN A FLUCTUATING MEDIUM. I.

K. Furutsu, J. Res. Nat. Bur. Stand., Section D - Radio Propagation, vol. 67 D, May-June 1963, p. 303/323, 12 refs., A63-18084.

. . . symbolic representation of Maxwell's equations is introduced. . . . Feynman diagram method is applied to the computation of the correlation of the fields at different points in space to any order of approximation. . . . The dispersion relation is derived as a connected problem.

DETECTION OF FADING TARGETS IN NOISE: THE CASE IN WHICH THE FADING IS NEITHER FAST NOR SLOW

P. W. James, Royal Aircraft Establishment (Gt. Brit) Jan. 1963, 40 p. RAE TN RAD 828, AD 406 158.

. . . with particular reference to the case when the signal fading period is (a) less than the post-detection integration time, and (b) greater than the time interval over which the noise, after multiplication by an appropriate reference waveform, is predictable . . . The theory leads to expressions for detection probabilities for arbitrary fading rate. Some numerical results are presented in the form of graphs showing how the diversity gain arising out of the signal fluctuation varies with fading rate.

APPROXIMATE DETERMINATION OF THE DISTRIBUTION FUNCTION OF FADE LENGTHS BELOW THRESHOLD LEVEL FOR THE ENVELOPE OF THE SUM OF A DETERMINISTIC SIGNAL AND GAUSSIAN STATIONARY NOISE

B. R. Levin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 20/26.

The distribution function of the axis-crossing intervals for the envelope of the sum of a sinusoidal signal and Gaussian noise by the first-approximation curve for noise alone when the intervals are small and by an exponential curve when the intervals are too large is approximated. . . . compared with known experimental data as well as with Rice's approximation method. . . .

ASYMPTOTIC PERFORMANCE CHARACTERISTICS FOR MULTIRECEIVER COMMUNICATIONS THROUGH THE RICIAN MULTICHANNEL

W. C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, April 30, 1963, 21 p., 19 refs., NASA CR-50655; JPL-TR-32-400, N63-18387.

Ideal . . . characteristics . . . for . . . the coherent adaptive multireceiver and the noncoherent multireceiver. The transmitter for the system selects for transmission one of two equiprobable, equal-energy correlated waveforms. The selected waveform is transmitted into the Rician fading multichannel with additive gaussian noise superposed at the receiver end. The multichannel may take on one of four forms, i. e., it may change from one of a completely random nature to that of a completely fixed nature.

ERROR PROBABILITIES FOR RICIAN FADING MULTICHANNEL RECEPTION OF BINARY AND N-ARY SIGNS

W. C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, June 3, 1963, 24 p., 26 refs., (NASA CR-51853; JPL Tech. Rept. 32-450, N63-22895.

. . . derived for two different forms of multireceivers (the coherent and noncoherent), which are used in binary and N-ary signaling through the Rician fading multichannel . . .

SPECTRAL CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS (Translation)

A. V. Men', Telecommun. Radio Engng, Part 2 - Radio Engineering, July 1963, p. 24/32, 10 refs., A64-15463.

. The result is not unreasonable compared to some experimental results. A correlation function in frequency was also computed. Unfortunately, sweep frequency experiments have not produced enough data as yet to make it possible to compare the data with the computed correlation function.

COMMUNICATION THROUGH RANDOM MULTIPATH MEDA

D. P. Harris, Stanford Electronics Labs., Stanford U., Calif., April 1962, 89 p. incl. illus., 24 refs., (Technical rept. no. 1002-2), AD 291 447.

. . . Analysis is undertaken in sufficient depth to give guidance in the selection of design parameters of various types of systems. . . . comparisons . . . of the performance potentials of different communication techniques. Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sounding effort, the signal characteristics, and the channel characteristics. . . . The performance characteristics of a class of radiometric signal-detection techniques that require no channel-sounding provisions are analyzed. . . . The results appear to be very attractive when relatively large channel bandwidths are available. . . . For many types of multipath channels, the advantages of seeking generally optimum communication techniques are somewhat limited.

EVALUATION OF A BURST-ERROR CORRECTION CODE ON A GILBERT CHANNEL

D. G. Iram, Rome Air Development Center, Griffiss Air Force Base, N. Y., May 1962, 57 p. incl. illus., 8 refs., (RADC-TDR-62-189), AD 276 527.

. . . evaluating the improvement afforded a fading-type channel by the use of a burst-error correcting code . . .

MEASUREMENT OF IONOSPHERIC PATHS AS A TIME-VARYING NETWORK

A. E. Laemmel, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Scientific rept. no. 2, 13 Dec. 1962, 7 p., (Research rept. no. PIBMRI-1102-62), (AFCRL 63-14), AD 298 298.

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS

G. Lieberman, RCA Rev, vol. 23, no. 3, Sept. 1962, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given . . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantities of error probability as well as the mean probability of error.

SIGNAL POWER IMPROVEMENT THROUGH CODING AND DIVERSITY

J. Mott-Smith, et al., Air Force Cambridge Research Labs., Bedford, Mass., June 1962, 37 p. incl. illus., tables, 6 refs., (Rept. no. AFCRL 62-383), AD 283 349.

. . . calculated as a function of bandwidth, capacity, and reliability for gaussian noise and independent Rayleigh fading on a binary symmetric channel.

STUDY OF FINE GRAIN FADING AND PHASE STABILITY OF MULTIPLE CW SIGNALS

G. C. Porter, et al., General Dynamics Electronics, Rochester, N. Y., Interim technical rept. no. 3, 1 Jan - 31 Aug. 1962, lv., AD 406 213.

A NEW IONOSPHERIC MULTIPATH REDUCTION FACTOR (MRF) (Correspondence)

R. K. Salaman, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 220/222.

The concept of the multipath reduction factor (MRF) is due to D. K. Bailey. The MRF may be defined as the lowest per cent of the MUF for which the range of multipath propagation time differences is less than a specified value. The MRF thus defines the frequency above which a specified minimum protection against multipath is provided. . . .

THEORETICAL INVESTIGATION OF DUAL RATE TRANSMISSIONS OVER GAUSSIAN MULTIPLICATIVE CIRCUITS

Final rept. 12 April 1962, 127 p. incl. illus., tables, 12 refs., (Rept. no. F-1004-1), (AFCRL-62-198), AD 278 139.

. . . The effects of Rayleigh fading and additive Gaussian noise in both the forward and feedback channels are studied . . .

A METHOD FOR PREDICTING INTERCHANNEL MODULATION DUE TO MULTIPATH PROPAGATION IN FM AND PM TROPOSPHERIC RADIO SYSTEMS

C. D. Beach, et al., Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 1/36.

. . . Values of signal-to-intermodulation ratio, S/I, are calculated for various pairs of signal reflections in the troposphere, taking into account the base bandwidth and frequency deviation of the system, the antenna patterns, the path geometry, and climatic conditions during the "worst month" of propagation. . . .

THE EFFECT OF FREQUENCY SELECTIVE FADING ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS

. . . . spectral characteristics of phase-difference (amplitude) fluctuations for waves propagating in a turbulent medium . . . It is noted that when measurements are carried out over large bases, the phase-difference fluctuation spectrum has, independently of the path type, an oscillatory behavior. . . .

LINEAR SIGNAL PROCESSING THEORY AND MEASUREMENTS

A. H. Nuttall, Litton Systems Inc., Waltham, Mass., 30 April 1963, 79 p., TR63 2BF, AD 404 712.

A time-varying random linear system model is hypothesized for the communication medium. The fundamental parameters and analysis techniques for the linear system are described, and applied in a multiple alternative communication mode with Rayleigh fading. A comparison of several receiver types is then effected.

STUDY OF FINE GRAIN FADING AND PHASE STABILITY OF MULTIPLE CW SIGNALS

G. C. Porter, et al., General Dynamics Electronics, Rochester, N. Y., Technical rept. no. 4 (Final), 1 Jan. 1962 - 30 April 1963, on task 3, 30 April 1963, lv., AD 420 841.

. . . a study oriented to the collection of statistical data on fine grain phase and amplitude stability of CW signals transmitted over a long range HF path. The received signals were recorded on magnetic tape and analyzed in the laboratory for single tone first difference, two tone difference, and two tone second difference phase measurements; the envelope recordings were analyzed for absolute amplitude probability, fading rate, and fade duration probability. A test facility was used between Hawaii and New Jersey. Signals were transmitted during a 48 hour test period. . . .

OPTIMUM TRANSMISSIONS FOR MULTIPATH CHANNELS

J. G. Proakis, Lincoln Lab., Mass. Inst. of Tech., Lexington, 16 Aug. 1963, 38 p., Rept. no. 64G3, AFESD TDR63 101, AD 416 639.

. . . very restrictive conditions on the channel behavior, namely that the received signal consists of resolvable, independently Rayleigh fading paths each of which has been corrupted additively by independent gaussian noise. Probility of error expressions are . . . generalizations of results obtained earlier by Turin, Hahn, and Pierce. From these expressions the optimum time duration for pulse transmissions is computed for two channels – the orbital dipole channel and the moon.

POWER SPECTRAL DENSITY ESTIMATES OF THE FADING OF HIGH FREQUENCY RADIO WAVES

D. H. Schrader, Boeing Scientific Research Labs., Seattle, Wash., May 1963, 65 p., Rept. no. D1 82 0244, AD 417 190.

The power spectral density of the fading power of high-frequency radio waves and methods of estimating this function are the subject of this report. . . . two different methods . . . The asymptotic low-frequency variation of estimates computed on a digital computer and the expected value of estimates computed with an analog computer are derived. In general, the power density is confined to frequencies below one cycle per second.

RELATION BETWEEN THE AUTO-CORRELATION COEFFICIENTS OF SINGLY-AND MULTIPLY-REFLECTED RADIO WAVES

N. N. Sen, et al., J. Atmos. Terr. Phys., vol. 26, Jan. 1964, p. 25/30, A64-14595.

Establishment of relations between the autocorrelation coefficients of the fading of the first and the third returns and then between the autocorrelation coefficients of the first and the nth returns from the ionosphere. An experimental verification of the relations between the first three orders of reflections from the ionosphere is also given.

FAMILIES OF DISTRIBUTIONS FOR HOURLY MEDIAN POWER AND INSTANTANEOUS POWER OF RECEIVED RADIO SIGNALS

M. M. Siddiqui, et al., J. Res. Nat. Bur. Stant., Section D - Radio Propagation, vol. 67 D, Nov. - Dec. 1963, p. 753/762, A64-10346.

Investigation of the gamma family of probability distributions of connection with the distribution of hourly median received power or transmission loss. By taking a mixture of Rayleigh distributions with gamma distributions as mixing distributions, the long-term distributions of instantaneous signal power are theoretically derived. . . . Graphs and tables are prepared to facilitate the applications of the theory to the data.

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE

I. A. Tsikn, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 1/11.

SIGNALS, SCATTERERS, AND STATISTICS

V. Twersky, IEEE Trans. Antennas Propagation, vol. AP-11, Nov. 1963, p. 668/680, 22 refs., A64-11807.

Study of an ensemble of complex numbers, such as a set of signals in time and the field scattered by different configurations of scatterers . . . considered are: (1) the average total intensity, the coherent intensity, and the incoherent intensity; (2) the coherent phase, average phase, and average-square phase; and (3) the variance of the real and imagary components of the ensemble and their covariance, as well as the higher moments. . . .

REFLECTIVE MULTIPATH EFFECTS ON BINARY PSK TRANSMISSIONS
V. F. Volertas, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 342/349.

The effects of reflective multipaths on pseudo-random, binary PSK transmissions with quadrature detection are investigated. The paper considers reflective multipaths with long delays and reflective multipaths with delays shorter than a keying element duration. . . .

Related Publications:

SOME RELATIONS BETWEEN THE BEARING AND AMPLITUDE OF A FADING RADIO WAVE
H. A. Whale, et al., J. Atmos. Terr. Phys., vol. 13, no. 1-2, 1958, p. 72/85.

CHARACTERISTICS OF MEDIUM-WAVE FADING (In Japanese)
E. Sawamura, J. Inst. Elect. Commun. Engrs., vol. 42, no. 10, Oct. 1959, p. 934/937.

FADING LOSS IN DIVERSITY SYSTEMS
M. Brilliant, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 173/176.

. . . using optimum diversity combining . . . The ratio of the mean to effective signal-to-noise ratios of the combined signal is called the fading loss.

QUESTIONS OF POTENTIAL INTERFERENCE RESISTANCE WHEN THE SIGNAL FADES
D. D. Klovskii, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 24/35.

Criteria are obtained for single coherent and non-coherent reception of discrete messages for an ideal receiver in the presence of fluctuating interference and rapid smooth fadings of the signal. The probability density of the envelope of the signal reaching the receiver is assumed to be distributed according to the generalized Rayleigh law. . . . The minimum probability of faulty reception is calculated for certain classes of systems. . . .

(No Title)
S. H. Chang, et al., Electronics Research Lab., Northeastern U., Boston, Mass., 31 May 1961, 126 p., Final rept., AFCRL-364, AD 264 765.

The basic factors in multipath, and some existing systems of reducing these defects, are examined . . . conjectures on possible modifications . . . to improve bandwidth-time utilization . . . Two novel schemes of detection, an a posteriori probability computer . . . and an asynchronous demodulator . . . are studied.

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING
G. Einarsson, Research Lab. of Electronics, Mass. Inst. of Tech. Cambridge, 15 March 1962, 76 p., Technical rept. no. 400, AD 416 605.

. . . The possibility of representing a multipath channel as a time-variant filter is investigated. . . .

EFFECT OF PROPAGATION FADING AND ANTENNA FLUCTUATIONS ON COMMUNICATION SYSTEMS IN A JAMMING ENVIRONMENT
A. B. Glenn, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1960, p. 43/60.

. . . The results are plotted for a large variety of fading conditions for both the desired and undesired signals and antenna fluctuations. . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATIONS SYSTEMS. PART III. A WIDEBAND ADAPTIVE COMMUNICATION SYSTEM
J. C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961 - June 1962, on Improved Information Transfer Efficiency of Wideband Systems, July 1962, 218 p., incl. illus., 60 refs., (ASD TDR 62-611, pt. 3), AD 284 452.

. . . capable of monitoring the medium through which it must perform while simultaneously transmitting information and continuously adjusting its modes of operation . . . Statistical methods are applied to the adaptive communication problem. . . .

MULTIPATH AND SCATTERED COMMUNICATION TECHNIQUES
D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., Tech. rept. on Flight Sciences, May 1962, 10 p., incl. illus., 16 refs., (rept. no. 6-90-62-42), AD 275 343.

. . . Power requirements and bandwidth requirements per unit information transmission rate are evaluated and compared for these techniques and for differentially coherent narrowband techniques under similar conditions.

ETUDE THEORIQUE ET EXPERIMENTALE DES PROBLEMES DE FLUCTUATIONS RAPIDES EN PROPAGATION TROPOSPHERIQUE (In French) (Theoretical and Experimental Study of Rapid Fluctuations in Tropospheric Propagation)
R. Tremblay, Ann. Radioelect., vol. 17, no. 70, Oct. 1962, p. 280/296.

. . . The instantaneous frequency analysis of the received signal explains the linear aspect

of the observed spectra. It also determines the spreading of the instantaneous values of the frequency bandwith of the tropospheric link, and, finally, gives information about the structure of the propagation medium. . . . shows the correlation which exists between the rate of fluctuation and the transverse component of the altitude wind . . . similarity which exists in this case between the amplitude frequency spectra and the amplitude-time spectra . . . In the case where the fluctuations in time are caused by atmospheric turbulence the preceding conclusions do not apply . . . An elaborate experimental study confirms the theoretical results obtained.

DIVERSITY COMBINATION OF FADING SIGNALS WITH UNEQUAL MEAN STRENGTHS
B. B. Barrow, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 73/78.

. . . comparison . . . for a number of different types of fading, including Rayleigh fading . . . correlated Rayleigh fading, and certain non-Rayleigh types. . . .

DIGITAL TRANSMISSION IN MEDIA OF VARIABLE TIME DELAY
E. M. Bradburd, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 438/442.

. . . requires suitable techniques for bit synchronization, bit identification and time division multiplexing. Increasing refinements in these techniques are needed in the progression from networks of two nodes connected by a single link to a number of nodes joined by tandem links and thence to networks of higher connectivity. The addition of link encryption and multiplexing of information impose even more severe constraints. . . . the three key terms in this analysis . . .

PERIODIC FADING OF VLF SIGNALS RECEIVED OVER LONG PATHS DURING SUNRISE AND SUNSET
D. D. Crombie, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-313.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 27/34, 9 refs., A64-14687.

Account of fading phenomena over two selected long paths, with an outlined explanation. Observations of diurnal phase and amplitude variations between NPM and NBA received at Frankfurt are plotted, and comments made on features of interest. Similar plots and comments are made for seasonal variations and mean rate of change of phase. . . .

SIMULATION OF A FADING MEDIUM
R. Krulee, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 233/240.

Despite the extensive use of HF and scatter techniques on long-haul circuits, surprisingly little is yet understood about the actual performance of such circuits during the deep fading situations which limit the performance . . . In this paper a model that is consistent with observed experimental data is developed for a fading circuit. The instrumentation necessary to allow laboratory simulation and testing under exactly those conditions which are most critical for satisfactory system design is discussed. . . .

MICROWAVE RADIO RELAY. IONOSPHERIC TRANSMISSION MODELS. TASK 5. CORRELATION BETWEEN TRANSMISSION PARAMETERS OF DISPERSIVE CIRCUITS AND SYSTEM PERFORMANCE FOR APPLICATION TO ADAPTIVE COMMUNICATIONS SYSTEMS
M. Masonson, et al., RCA Defense Electronic Products, New York., Final rept. 28 March-30 Sept. 1963, 30 Sept. 1963, 256 p., Rept. no. CR63 419 12, AD 436 390.

. . . The principal objective is to develop suitable models, or concepts of transmission, via HF ionospheric links, on which to base predictions of performance given the expected channel conditions.

LINEAR SIGNAL PROCESSING THEORY AND MEASUREMENTS
A. H. Nuttall, Litton Systems Inc., Waltham, Mass., 30 April 1963, 79 p., TR63 2BF, AD 404 712.

A time-varying random linear system model is hypothesized for the communication medium. The fundamental parameters and analysis techniques for the linear system are described, and applied in a multiple alternative communication mode with Rayleigh fading. A comparison of several receiver types is then effected.

OPTIMUM PULSE TRANSMISSION FOR MULTIPATH CHANNELS
J. G. Proakis, Lincoln Lab., Mass. Inst. of Tech., Lexington, 16 Aug. 1963, 40 p. refs., (Rept. 64G-3), AD 416 639, N64-17454.

. . . computed under very restrictive conditions on the channel behavior, namely, that the received signal consists of resolvable, independent Rayleigh fading paths, each of which has been corrupted additively by independent gaussian noise . . .

METHOD OF PREVENTING SIGNAL DISTORTIONS CAUSED BY MULTIPATH DISTRIBUTION DURING METEORIC COMMUNICATION
V. V. Sidorov, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 25 July 1963, 3 p., FTD TT 63 434, AD 414 686.

PROPAGATION OF WAVES IN A MEDIUM WITH STRONG FLUCTUATIONS OF THE REFRACTIVE INDEX

V. I. Tatarskii, et al., Zh. Eksper. Teor. Fiz., vol. 44, Feb. 1963, p. 676/685, (In Russian), Soviet Physics - JETP, vol. 17, Aug. 1963, p. 458/463, (Translation), A63-21309.

Derivation of the formulas for the real and imaginary parts of the propagation constant of the transmitted wave, and for the scattered intensity of the field, for a wave propagating in a medium undergoing small strong-scale fluctuations of the refractive index. The prepagation constant and the intensity are expressed in terms of the correlation functions of the fluctuations.

1.613: Analysis of Doppler Shifting Channels

Included: Statistics of echoes from moving scatterers; Ionospheric doppler effect; Doppler effects in project West Ford.

Not Included: Doppler phenomena in space communications links; Doppler radar design; Anti-Doppler circuits.

Cross References: Frequency errors in carrier transmission systems (1.628).

Principal Publications:

SIGNALS WITH UNIFORM AMBIGUITY FUNCTIONS
R. M. Lerner, IRE Nat. Conv. Rec., March 1958, p. 27/36.

The response of a correlation detector or matched filter at time t to a signal differing by Doppler shift ω from the expected one is a function of these two variables, $s(t,\omega)$, known as the ambiguity function.

REDUCTION OF DOPPLER-SHIFT ERRORS IN IONOSPHERIC-SCATTER FSK COMMUNICATIONS
J. W. Koch, National Bureau of Standards, Boulder, Colo., May 1959, 8 p., (NBS Rept. no. 6053), AD 232 739.

Meteoric Doppler frequency shifts of signals propagated via ionospheric scattering cause errors in narrow-band FSK communications. A simple method of reducing the Doppler-shift errors has been tried. The principle of operation consists of locking out the mark channel when a space signal is present. The experimental results show a useful reduction in error rate when the Doppler lock-out circuitry is used.

JOINT ESTIMATION OF DELAY, DOPPLER, AND DOPPLER RATE
P. Bello, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 330/341.

THE DICON SYSTEM
R.S. Berg, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 31 Oct. 1961, 28 p., (Technical Rept. no. 251), AD 267 536.

. . . to measure and record the perturbations introduced by the West Ford channel. These perturbations are expected to be due principally to Doppler shift, Doppler spread and multipath delay. Since the fluctuation and multipath times may be of the same order, a noncoherent detection scheme is used.

PERFORMANCE DEGRADATION OF LINEAR FM-PULSE-COMPRESSION SYSTEMS DUE TO THE DOPPLER EFFECT
H. O. Ramp, et al., Proc. IRE, vol. 49, Nov. 1961, p. 1693/1694.

LINEAR FM PULSE COMPRESSION DOPPLER DISTORTION EFFECTS (Correspondence)
C. E. Cook, et al., Proc. IRE, vol. 50, June 1962, p. 1535/1538.

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING
G. Einarsson, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 15 March 1962, 76 p., Technical Rept. no. 400, AD 416 605.

. . . A sampling theorem for linear bandpass filters is derived, and the results that can be expected when it is used to represent a single fluctuating path with Doppler shift are discussed.

DOPPLER EFFECT OF ARTIFICIAL SATELLITES
J. Mass, et al., IN: Advances in Space Sciences and Technology, vol. IV, New York, Academic Press, Inc., 1962, p. 1/38, 43 refs., A63-17567.

Review of the important results published to date concerning the measurement and utilization of the Doppler shift from artificial satellites.

THE EFFECTS OF DOPPLER DISPERSION ON MATCHED FILTER PERFORMANCE (Correspondence)
W. L. Rubin, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2127/2128.

. . . linear FM-pulse compression falls within the broader domain of matched filtering . . . modifying previous expressions for the "matched filter uncertainty function", in which Doppler has been approximated by a simple frequency translation. . . .

DOPPLER PROPAGATION STUDY
Philco Corp., Palo Alto, Calif., 31 Jan. 1963, 61 p., incl. illus., tables, 12 refs., (Rept. no. WDL-TR1993), AD 297 414.

. . . problems encountered in transmitting and receiving Doppler tracking signals through the atmosphere . . . Formulas are presented for the doppler shift, models of the atmosphere and equations for atmospheric refraction.

A MODEL FOR THE POWER SPECTRUM OF RETURNED ECHOES FROM A RANDOM COLLECTION OF MOVING SCATTERERS
D. G. Childers, et al., University of Southern Calif., Engineering Center, Los Angeles, Rept. no. EE102, SSD TDR 63 408, AD 429 475.

RESEARCH IN CONNECTION WITH PROPAGATION OF HIGH FREQUENCY (HF) WAVES
J. Eitzenberger, et al., Batelle Institut, Frankfurt Main (Germany), Special technical rept., 1 July 1962-30 June 1963, 1v., AD 416 552, N63-21673.

. . . Measurments of the ionosphere Doppler effect and the MSF frequencies 2.5 and 5.0 mc/s carried out at the Battelle Institute.

THE EFFECT OF TROPOSPHERIC REFRACTION ON THE DOPPLER SHIFT OF A SATELLITE SIGNAL
H. S. Hopfield, J., Geophys. Res., vol. 68, Sept. 15, 1963, p. 5157/5168, A63-22369.

Derivation of an expression for the contribution made by tropospheric refraction to the Doppler shift of a satellite signal. It is assumed that the troposphere is horizontally stratified and does not vary during the time of a pass; a two-parameter quadratic expression is used as an approximation to the refractivity profile. . . .

FINE STRUCTURE OF THE DOPPLER SHIFT IN HETEROGENEOUS MEDIA
B. Manz, Office of Research Analyses, Mathematics Div., Holloman AFB, N. Mex., March 1963, 44 p., refs., (ORA-63-8), N63-17543.

Formulae . . . signals that either go directly from the emitter E to the missile M, or that reach the receiver R after they have been reflected from M.

THE CORRECTING FOR AND EXTRACTING OF IONOSPHERIC RELATED FREQUENCY ERRORS PRESENT ON SIGNALS RECEIVED FROM COHERNT, MULTIPLE FREQUENCY ULTRA-STABLE RADIO TRANSMISSIONS OF ARTIFICIAL EARTH SATELLITES
G. G. Moore, et al., Texas U., Austin, March 1963, 1v., AD 415 967.

. . . effect of refraction errors on the analysis of Doppler shift data . . . A method of correcting for first order error . . . Both digital and analog correction systems are described, and comparative results are shown . . .

O NAIBOL'SHEM KOLICHESTVE INFORMATSII OT UDALIAIUSHCHEGOSIA ISTOCHNIKA (Concerning the Maximum Amount of Information from a Receding Source) (In Russian)
V. I. Siforov, Tekhnicheskaia Kibernetika, July-Aug. 1963, p. 80/83, A64-11057.

CANCELLATION OF DOPPLER FREQUENCY SHIFT
R. M. Waetjen, Air Force Cambridge Research Labs., Electronics Research Directorate, Bedford, Mass., March 1963, 26 p., 5 refs., (AFCRL-63-70), N63-16389.

. . .circuit . . . is capable of canceling first-order Doppler frequency shifts. . . .

ON THE DOPPLER EFFECT WHEN MOVING THROUGH A HETEROGENEOUS MEDIUM
G. D. Yakovleva, et al., Foreign Tech Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 25 July 1963, 11 p., AD 415 015.

Related Publications:

A DOPPLER-CANCELLATION TECHNIQUE FOR DETERMINING THE ALTITUDE DEPENDENCE OF GRAVITATIONAL RED SHIFT IN AN EARTH SATELLITE
R. S. Badessa, et al., Proc. IRE, vol. 48, April 1960, p. 758/765.

JAMPROOF AUTOMATIC FREQUENCY CONTROL. VOLUME I. ANALYTIC STUDIES
A. Bond, et al., Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., Jan. 1962, 1v., 28 refs., (Rept. no. BSR-546, vol. 1), (ASD TR 61-661, vol. 1), AD 270 529.

. . . to develop design criteria for communication equipment that could provide adequate performance when subjected to severe doppler shifts and other effects encountered in communications from rapidly moving vehicles. . . .

AN IONOSPHERIC PHENOMENON DETECTED BY DOPPLER MEASUREMENTS (Correspondence)
P. R. Arendt, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 375/376.

. . . This fine structure . . . known as frequency scintillations. One specific Doppler curve of satellite 1959 IOTA . . . hump in the 20 Mc Doppler curve occurred about six minutes after the satellite's arrival, about the time when the satellite traveled from darkness into sunlight. The observed increase of frequency cannot be attributable to an abrupt change of the satellite's velocity component. We can rule out a change of the frequency in the satellite's transmitter. The

discontinuity in the general trend of this Doppler curve can only be attributable to a change in the electron distribution. . . .

CHARACTERIZATION OF RANDOMLY TIME-VARIANT LINEAR CHANNELS
P. A. Bello, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 360/393.

ASYMPTOTIC PERFORMANCE CHARACTERISTICS FOR MULTIRECEIVER COMMUNICATIONS THROUGH THE RICIAN MULTICHANNEL
W. C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, April 30, 1963, 21 p., 19 refs., (NASA CR-50655; JPL-TR-32-400), N63-18387.

IMPROVED RADIO DOPPLER DETECTORS
J. L. O'Connor, et al., Airborne Instruments Lab., Inc., Deer Park, N. Y., Final rept., March 1963, 40 p., AD 408 424, N63-17510.

. . . Four X-band FM-CW doppler detectors and two dual-antenna CW S-Band doppler detectors . . . were developed . . .

DOPPLER — AND AIR TRAFFIC CONTROL
E. Swinney, Aircraft, (Australia), vol. 42, March 1963, p. 16/19, 46, 48, A63-17107.

Described are terminal radar communications (including evaluation of the VHF radio telephony), and the Doppler dead-reckoning equipment.

GROUND-AIR-GROUND DATA TRANSMISSION SYSTEMS TESTS
A. J. Uryniak, RADC, Griffiss Air Force Base, N. Y., July 1963, 21 p., RADC RAU TM 63 2, AD 414 629.

. . . feasibility of Air/Ground/Air Narrow Band FSK Data System utilizing frequency diversity and doppler correcting techniques. . . .

CANCELLATION OF DOPPLER FREQUENCY SHIFT
R. M. Waetjen, Air Force Cambridge Research Labs., Bedford, Mass., March 1963, 21 p., AFCRL 63 70, AD 404 428.

A circuit is described which is capable of cancelling first-order Doppler frequency shifts.

PRECISION TIME OR FREQUENCY TRANSMISSION TO MOVING VEHICLES. Research Report
R. M. Waetjen, Air Force Cambridge Research Labs., Electronics Research Directorate, Bedford, Mass., April 1963, 21 p., 3 refs., (AFCRL-63-93), N63-16281.

. . . capable of transmitting the output of an ultrastable oscillator of clock with an extremely high degree of accuracy to a moving vehicle.

. . . Applications of the circuit include radio navigation, guidance, and tracking, as well as data transmission, telemetry, and possibly communications involving earth satellites, moon satellites, and interplanetary and other space vehicles.

1.619: Measurements, Recording and Simulation of Time-Variant Communications Channels

Included: Computer programs to analyze communications channels.

Not Included: Measurement equipment for circuit testing; Simulation of traffic patterns in communications networks; Ionospheric sounding techniques in adaptive HF links (2); Propagation prediction procedures and services.

Cross References: Mathematical models of propagation media (1.631); Experimental evaluation of propagation media (1.639); Experimental evaluation of line facilities (1.659).

Principal Publications:

MEASURING THE MEAN SQUARE AMPLITUDE OF FADING SIGNALS USING A SELECTED QUANTILE OUTPUT DEVICE (SQUOD) (Correspondence)
A. E. Adam, et al., Proc. IRE, vol. 48, June 1960, p. 1172/1173.

AN EVALUATION OF AM DATA SYSTEM PERFORMANCE BY COMPUTER SIMULATION
R. A. Gibby, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 675/704.

. . . suitable for programming on a high-speed digital computer. . . . A data signal composed of a train of raised-cosine shaped pulses is generated in the simulating process. . . . performance of a double-sideband AM data system is evaluated . . .

DATA SYSTEM TESTS USING SIMULATED TRANSMISSION IMPAIRMENTS
F. T. Andrews, Jr., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 590/596.

Test instrumentation has been developed for simulating the principal types of transmission impairments that will be encountered on voice-frequency telephone circuits. Such impairments include delay and attenuation distortion, frequency shift, phase and amplitude hits, interfering tones, and noise. This test equipment, together with conventional random-data signal generators and error comparators, makes possible the evaluation of data systems with a wide range of transmission characteristics. . . .

JAMPROFF AUTOMATIC FREQUENCY CONTROL. VOLUME II. SIMULATOR EQUIPMENT STUDIES
R. Bates, et al., Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., Jan. 1962, 1v., (Rept. no. BSR-546, vol. 2), (ASD TR 61-661, vol. 2), AD 270 530.

. . . Constructed to augment analytical studies of automatic frequency control systems under noise, doppler and jamming conditions. . . . Photographic recordings of the results of 400 data runs using the simulator are included.

TAKING INTO ACCOUNT THE INFLUENCE OF THE COHERENTLY REFLECTED PORTION OF A SIGNAL UPON ITS CORRELATION CHARACTERISTICS
V. A. Chena, Foreign Tech, Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 4 Sept. 1962, 11 p., incl. illus., 8 refs. (Trans. no. FTD-TT-62-1029 from Izvestiya Vysshikh Uchebykh Zavedeniy, Fizika 4: p. 17/22, 1961), AD 286 571.

. . . The results obtained throw light upon previous papers and can be of use in an analysis of the relationship between the experimentally obtained correlation functions and the structure of the reflecting region of the ionosphere.

THE VISUALIZATION OF FREQUENCY-MODULATION TRANSIENTS BY MEANS OF MECHANICAL MODELS
M. J. Golay, IRE Trans. Circuit Theory, vol. CT-9, no. 1, March 1962, p. 78/82.

. . . It has long been known that electrical circuits have equivalent mechanical circuits, . . .

H-F PROPAGATION SIMULATION
R. Mather, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., Nov. 1962, 21 p., incl. 6 refs. (Rept. no. RADC TDR 62-473), AD 288 924.

. . . to be simulated on an analog computer and compared with experimental data collected over a 3800-km path. The experimental complex consists of a transmitter site located in the Panama Canal Zone and a receiver site at Stockbridge, N. Y. Vertical ionospheric sounders are located along the transmission path and are used to measure the spatial distribution of electron density in the volume of interest. A method is described whereby this spatial distribution of electron density is programmed into the analog computer in order that the Hamiltonian equations describing ray paths may be solved. In addition to producing frequency vs. time plots for comparison with the experimental data, the simulator also gives results not easily measured in the field, such as take-off angle, angle of arrival, group time, phase time, off-path deviation, and height of reflection. . . .

LINK EVALUATION AND TAPE MERGING COMPUTER PROGRAMS
B. M. Sifford, Stanford Research Inst., Menlo Park, Calif., Final rept., Dec. 1962, 60 p., Rept. no. TR7., AD 434 833.

. . .Computer program designed to predict the performance of communication networks using HF, ionospheric scatter, and tropospheric scatter propagation modes. The present report outlines the models and procedures used to write a computer routine to convert signal-to-noise predictions into a teletype character error rate for a channel and to estimate the useable number of teletype channels the circuit can support. The conversion considers such circuit parameters as teletype speed, teletype code, diversity reception, modulation and detection techniques.

OUTPUTS FROM THE NETWORK ANALYSIS COMPUTER PROGRAMS: A SUMMARY REPORT
E. M. Young, et al., Stanford Research Inst., Menlo Park, Calif. Final technical rept. no. 3, Dec. 1962, 196 p., AD 434 834.

Several computer programs have been produced that determine various properties of communication systems. These properties include both the performance of individual transmission links and the performance of an entire network . . . A fairly large sample network is described that demonstrates each of the programs. . . .

STATISTICAL INSTRUMENTATION STUDY
A. W. Crooke, et al., Litton Systems, Inc., Waltham, Mass., Final rept., 14 March 1963, 84 p., RADC TDR63 136, AD 405 925.

. . .a breadboard model . . . device will calculate fourth (and lower) order joint and conditional probability density functions and distribution functions for signals with bandwidth less than 10 Kcps . . .

VOICE-FREQUENCY TELEPHONE CIRCUIT DESIGN BY SIMULATION
T. J. Talley, et al., Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 564/568.

Many present-day voice-frequency telephone circuits require two or more electrically short links in tandem, minimum capital investment, and less than a 2-week completion interval. . . . A practical design for a transmission-circuit simulator to determine impedance, return loss, and frequency-attenuation characterictic is discussed. . . .

HF COMMUNICATION EFFECTS SIMULATION: COMPARISON OF THE FORT MONMOUTH/PALO ALTO CIRCUIT PERFORMANCE WITH COMPUTER PREDICTIONS

H. A. Turner, et al., Stanford Research Inst., Menlo Park, Calif., Interim technical rept. 4, Jan. 1964, 98 p., AD 434 579.

Observed and predicted HF propagation data are compared. Observed data were taken by oblique-incidence ionospheric sounders, the Philips sounder (November 1961 and February 1962) and the Granger Associates sounder (1963),

. . . Predictions were taken from the HF propagation prediction program written by Stanford Research Institute for use on the IBM 7090 computer. . . .

DELAY IN DATA TRANSMISSION THROUGH GENERAL NETWORKS

Lincoln Lab., Mass. Inst. of Tech., Lexington, 18 Dec. 1963, 54 p., Rept. no. 65G7, ESD TDR63 597, AD 427 258.

. . . The use of redundant links to reduce delay was investigated by means of a computer simulation program. The link behavior assumed for this program is that obtained from measurements of two HF RTTY links . . . Simulation results . . .

Related Publications:

CORRELATION OF WAVES OF DIFFERENT FREQUENCY AFTER PASSAGE THROUGH A LAYER OF A STATISTICALLY INHOMOGENEOUS MEDIUM (In Russian)

M. F. Bakhareva, Radiotekhnika i Elektronika, vol. 4, Jan. 1959, p. 88/96.

Correlation coefficients are obtained for the amplitude and phase fluctuations of two waves of different frequency traversing a medium with large random inhomogeneities of refractive index. A comparison is made with experimental data obtained by frequency-scatter sounding of the ionosphere. . . .

COMPUTER ANALYSIS OF LARGE COMMUNICATION NETWORKS

E. M. Young, Conf. Proc. Nat. Winter Conv., Mil. Electronics, vol. 1, Feb. 1961, p. 288/291.

. . . The criterion for evaluating a communication network is to determine, in the case of teletype, how fast and how accurately it passes messages from the origin to the final destination, or in the case of voice, how satisfactory in terms of speed of service and audibility the connection is between parties. This paper will deal only with teletype networks . . . Parameters which are optimized by the SRI computer programs are operating frequency for every HF link in the network and routes for message traffic to maximize traffic handling capacity in the network. . . . calculation of signal-to-noise ratio for the individual links . . . optimum frequency determination in the case of skywave . . . calculation of optimum routing of traffic within the network. . . .

AUTOMATED SOLUTION OF COMBINED INTERFERENCE MATRICES

I. E. Perlin, et al., Georgia Inst. of Tech., Engineering Experiment Station, Atlanta, Final rept., 15 Nov. 1961-15 Nov. 1962, 15 Nov. 1962, 178 p., AD 299 248.

DESCRIPTORS: Communication systems . . . Communications theory, Communication equipment, Digital computers . . .

THE PRODUCTION OF RANDOMLY DISTORTED AND DETERIORATED PATTERNS

R. E. Manelis, Air Force Special Weapons Center, Kirtland AFB, N. Mex., 11 April 1963, 23 p., AFSWC TDR63 44, AD 405 587.

A set of computer subroutines which attempt to simulate various degrees of distortion and deterioration on an input character . . . A complete set of the letters of the Cyrillic alphabet, numerals, and some punctuation were quantized and punched to be used as ideal input characters to transforming subroutines.

SOME OBSERVATIONS ON MEASURABLE PROPERTIES OF RANDOM PROCESSES AND FIELDS. I

D. Middleton, Litton Systems, Inc., Waltham, Mass., 16 March 1964, 54 p., Rept. no. TR63 4BF, AD 434 120.

A number of useful, measurable properties of random processes and random fields are defined and discussed, and it is shown how these results may be applied to observations necessarily finite in time and in space. . . .

Section 1.62
Distortions in Communications Channels

This section combines references which investigate the nature of distortions which transmission signals suffer in communications channels. Emphasis is on distortions caused by the characterictics of the transmission medium rather than by the characteristics of the equipment, though many publications do not discriminate between these two causes of distortions.

Distortions specifically caused by any one of the transmission media will also be discussed in publications mentioned in section 1.63. Distortions, typical for particular wavebands, are referenced in section 1.64 and distortions in special classes of communications channels are referenced in the remaining sections of this division.

The subdivisions of this section are arranged in a multi-dimensional way to do justice to the complex problems of modulation distortions. The first two subdivisions deal with the analytical fundamentals of describing and calculating distortions. The third and fourth subdivisions combine papers written with a special modualtion method in mind. The remaining subdivisions are classified according to the nature of the distortion.

This multi-dimensional layout calls for the particular attention of the reader when searching for very specialized references.

1.621: Fundamentals of Signal Distortions in Communications Channels

Included: Characteristics of time-invariant channels; Band pass characteristics of media; Fundamentals of pulse transmission; Field descriptions of electromagnetic pulses; Network functions for describing circuit distortions; Definition of linearity; Narrow-bandedness.

Not Included: Circuit theory; Filter theory; Theory of linear and nonlinear systems; Measurements of distortions.

Cross References: Signal theory (Sect. 1.14); Signal theory of circuits and systems (1.146); Transient response of transmission channels (1.622); Evaluation of distortions in simulated channels (1.619); Theory of multipath distortions in general (1.612).

Principal Publications:

THEORETICAL FUNDAMENTALS OF PULSE TRANSMISSION
E. D. Sunde, Bell Syst. Tech. J., May 1954, p. 729.

MODES IN LINEAR CIRCUITS AND LINEAR SAMPLED DATA SYSTEMS
C. A. Desoer, Electronics Research Lab., U. of Calif., Berkeley, July 1959, AD 227 707.

. . . In particular it is shown that (1) any free oscillation of a linear circuit can be thought of as a superposition of non-interacting modes of oscillation . . . .

EFFECTS OF FREQUENCY CUTOFF CHARACTERISTICS ON SPIKING AND RINGING OF TV SIGNALS
A. D. Fowler, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 173/179.

The spiking and ringing of TV signals depend upon amplitude and delay characteristics associated with frequency cutoff of transmission. The effects of a variety of cutoff characteristics of both ideal and practical systems on rectangular and sine-squared pulses are illustrated by computed waveforms. . . .

DEFINITION AND MESSUNG DER BANDBREITE IN DER FUNKTECHNIK (Definition and Measurement of Bandwidth in Radio Technique) (In German)
U. Schrock, Nachrichtentech. Z (NTZ), vol. 12, March 1959, p. 139/146

A SIMPLIFIED METHOD FOR THE ANALYSIS AND SYNTHESIS OF DISPERSED WAVE TRAINS
J. N. Brune, et al., J. Geophys. Res., vol. 65, no. 1, Jan. 1960, p. 287/304.

NEW METHODS FOR ESTIMATING DISTORTION IN MULTIPATH SIGNAL PROPAGATION (Translation)
V. A. Smirnov, Telecommunications, no. 5, May 1961, p. 9/17.

Two energy methods for estimating multipath signal distortion are presented. Both methods are applicable to any form of signal modulation. Hence the methods serve as a means of quantitative comparison of different communication systems. . . . Analytical expressions are given for the magnitude of the distortion for different forms of signal modulation.

PULSE TRANSMISSION BY AM, FM AND PM IN THE PRESENCE OF PHASE DISTORTION
E. D. Sunde, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 353/422.

MINIMUM-PHASE SYSTEMS (In German)
G. Wunsch, Nachrichtentechnik, vol. 11, no. 3, March 1961, p. 99/102.

A statement of basic princples leads to a discussion of the question whether or not it is possible for a loss of information to take place in a linear network forming part of a communications system. It is shown that no loss of information can take place if the network is of minimum-phase type.

ASYMPTOTIC METHODS IN LINEAR RADIO ENGINEERING (In Russian)
D. Y. Bakman, Moscow, Soviet Radio Press, 1962, 246 p.,

The monograph deals with approximate asymptotic methods for calculating the action of complex signals upon linear and quasi-linear elements in radio equipment. It systematically presents and applies to radio-engineering calculations a powerful and quite rigorous mathematical apparatus that is physically intuitive. The application of the mathematical apparatus to concrete problems of modern radio engineering permits the author to solve several problems (calculation of the spectrum of 40 oscillatory signals, investigation of general methods for analyzing transients in FM examination of the passage of FM pulses through lumped-constant and distributed-constant delay lines, etc.), that have up until now been relatively unamenable to mathematical analysis. . . . intended for engineers. . .

THE DERIVATION OF NETWORK FUNCTIONS FROM PHASE FUNCTIONS
S. Deutsch, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 6 March 1962, 14 p., illus., 12 refs., (Research rept. no. PIBMRI-1006-62) (AFOSR-2406), AD 277 511.

Equations are developed for deriving a network function F(s) given its phase function T(w). Several numerical examples are given. In each case, the recurrence of the given T(w) function in F(jw) is a means of checking the accuracy of the derived F(s) function. The real part of log F(jw) yields the log magnitude response, log M(w). The examples indicate that the mathematical operations of finding F(s) are relatively simple. . .

PROPAGATION OF INFORMATION BEARING SIGNALS THROUGH SPACE
R. F. Leach, (IRE-NASA-AEC, Internat. Symposium Space Phenomena Measurement, Detroit, Mich., Oct. 15-18, 1962), IEEE Trans. Nuclear Sci., vol NS-10, Jan. 1963, p. 146/152, 11 refs., A63-11758.

Analysis of the distortion of a band-pass information-bearing signal by a medium. . . . used to measure band-pass characteristics of any medium.

DIE ZEIGERMETHODE. EIN ANSCHAULICHES VERFAHREN ZUR BEHANDLUNG VON VERZERRUNGEN DER KLEINHUB-FM MIT ANWENDUN AUF FM-RICHTFUNK (The Phasor Method. An Illustrative Method for the Analysis of Distortions of Small Index FM with Applications in Radio Relay Links) (In German)
M. Muller, Arch. Elekt. Ubertragung, vol. 16, no. 2, Feb. 1962, p. 93.

EXTRAPOLATION OF THE ELECTROMAGNETIC FIELD
J. S. Wicklund, Diamond Ordnance Fuze Labs., Wash., D. C., 2 July 1962, 19 p., 1 ref., (Rept. no. TR-1058), AD 278 676.

Given the shape of a pulse of electromagnetic radiation at a known distance from the source, an analytic expression is derived in the electric dipole approximation that yields the shape of the pulse at any other point. . . . The result is useful as a check on machine computation and in those cases where the use of an analog computer is impractical.

ON THE EXTENDED DEFINITION OF LINEARITY (Correspondence)
L. A. Zadeh, Proc. IRE, vol. 50, Feb. 1962, p. 200/201.

Related Publications:

APPLICATION OF FOURIER TRANSFORMS TO VARIABLE-FREQUENCY CIRCUIT ANALYSIS
A. G. Clavier, Proc. IRE, vol. 37, Nov. 1949, p. 1287/1290.

ENVELOPE AND ANGLE RESPONSE OF ASYMMETRICAL NARROW-BAND NETWORKS
J. J. Hupert, IRE Trans. Circuit Theory, vol. CT-6, no. 3, Sept. 1959, p. 292/295.

A SIMPLE GENERAL EQUATION FOR ATTENUATION (Correspondence)
D. K. Gannett, et al., Proc. IRE, vol. 48, June 1960, p. 1161/1162.

POSITIVE REAL FUNCTIONS OF SEVERAL VARIABLES AND THEIR APPLICATIONS TO VARIABLE NETWORKS
H. Ozaki, et al., IRE Trans. Circuit Theory, vol. CT-7, no. 3, Sept. 1960, p. 251/260.

THEORY OF A FREQUENCY-SYNTHESIZING NETWORK
B. M. Wojciechowski, Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 649/673.

The theoretical basis for designing frequency-combining and selecting circuits is developed. By the introduction of "sideband algebra" and of a frequency symbolic network, the new method

offers formal design procedures in place of intuitive ones.

A HIGHLY VERSATILE CORRECTOR OF DISTORTION AND IMPULSE NOISE
E. D. Gibson, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 543.

. . . A device at the receiving station corrects both amplitude and delay distortion. . . . utilizes a "scrambler" (or predistorter) . . . called the ISIC (Inter-Symbol Interference Corrector) and a fixed, "smear" filter. The descrambler consists of another ISIC and a "desmear" filter.

TRANSMISSION ENGINEERING BY COMPUTER SIMULATION (Correspondence)
A. H. Ross, IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 457/459.

Relatively simple mathematical methods are available for computing the maximum bit rates that can be transmitted over a few idealized types of digital circuits. Actual circuits in general can only be approximated by these models. For a more exact mathematical determination of the channel digital capacity, it is necessary to carry out a point by point computation. A versatile digital computer program which does this has been prepared at the U. S. Army Electronics Research & Development Laboratory (USAERDL) at Fort Monmouth, N. J. . . .

THE NETWORK DESCRIPTION OF ELECTROMAGNETIC FIELD PROBLEMS
A. Tonning, Norwegian Defence Research Establishment, 12 Oct. 1962, 23 p., TN4, AFCRL Rept. 62 967, AD 411 503.

It is shown that a body of arbitrary form, consisting of electromagnetic media that are linear and time-invariant may be represented by one of the well-known network matrices and that the ordinary network expressions for power dissipation and mean stored energy remain valid in this general case. . .

A NOTE ON STABLE, PHYSICALLY REALIZABLE, LINEAR, TIME INVARIANT SYSTEMS
N. Wax, RAND Corp., Santa Monica, Calif., Oct. 1962, 20 p., 12 refs., N63-19054.

. . . several necessary, and a few sufficient conditions on the Fourier transform of h(t) are summarized. In particular, the behavior of the transform for complex frequencies, the Bode relations, and the Paley-Wiener criterion, are reviewed.

SIGNAL DISTORTION IN NONLINEAR FEEDBACK SYSTEMS
I. W. Sandberg, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2533/2550.

. . . plays a central role in the theory of signal transmission through a general physical system containing linear time-invariant elements and a single time-variable nonlinear element. . . As a direct application, we consider the range of validity of two simple cascade flow graphs (i. e., flow graphs without feedback loops) for approximately determining the signal distortion in nonlinear feedback systems when the distortion is small. Our discussion is not restricted to specific types of nonlinear characteristics.

1.622: Transient Response of Transmission Channels

Included: Distortions for pulse transmission systems; Impulse response of channels; Time response of channels; Pulse transfer functions.

Not Included: Transient synthesis of electrical networks; Television picture distortions.

Cross References: Pulse modulation methods (Div. 1.4); Signal theory of digital waveforms (1.311); Impulse response of physical channels (1.651).

Principal Publications:

ON THE PROPERTIES OF THE IMPULSIVE RESPONSE FUNCTION OF SYSTEMS WITH VARIABLE PARAMETERS
V. Borskii, Automat. Remote Control, vol. 20, July 1959, p. 822/830.

"SIGNAUX TYPES" ET REGIMES TRANSITORIES EN TELEVISION ("Typical Signals" and Their Transients in Television) (In French)
L. Bourassin, L'Onde Electrique, vol. 39, Jan. 1959, p. 7/31.

A COMPARISON OF THE TRANSIENT RESPONSE OF AMPLITUDE-MODULATED AND FREQUENCY-MODULATED SIGNALS
S. J. Cotton, Proc. Instn. Elect. Engrs., Pt. C, vol. 106, March 1959, p. 91/96.

The paper is an analytical investigation of the transient response of resistance-capacitance and resistance-inductance circuits, filters and transmission lines to a frequency-modulated voltage, using a unit-step function as modulating signal. The transient response is compared with that which is known to occur when the voltage is amplitude modulated, using the same modulating signal. The effects, on the response, of the bandwidth of circuits subsequent to the detector stage of a receiver are compared for the two types of modulation.

EFFECTS OF FREQUENCY CUTOFF CHARACTERISTICS ON SPIKING AND RINGING OF TV SIGNALS
A. D. Fowler, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 173/179.

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

A detailed analytical study of transient cross modulation in the detection of multiple-signal asymmetric-sideband systems is presented. Various signal conditions and detection methods are considered. The transient crosstalk in both an idealized system and in a practical system is determined. Calculations show that the peak amplitude of the transient cross modulation can be many times as large as the steady-state cross modulation. It is shown that product or synchronous detectors can eliminate the effects of cross modulation. . . . if two signals are present at the detector, a sudden change in one of them causes a spurious change in the amplitude and phase of the other. This type of distortion will be called transient cross talk distortion to differentiate it from the normal cross talk between two or more steady carriers. A later section shows that the transient cross talk distortion can be many times the steady-state cross talk. . . .

FEATURES OF THE TRANSIENTS ARISING IN A RESONANT CIRCUIT IN THE CASE OF MODULATION OF EITHER THE PHASE OF THE DRIVING OSCILLATIONS OR THE PARAMETERS OF THE CIRCUIT
A. S. Vinitskii, et al., Radio Engng., vol. 14, no. 7, 1959, p. 23/37.

NETWORK RESPONSE TO TRANSIENT FREQUENCY MODULATION INPUTS
T. T. Bucher, Commun. and Electronics, no. 46, Jan. 1960, p. 1017/1022.

PEREDACHA IMPUL'SOV PO KANALAM SVYAZI (Transmission of Pulses Along Communications Channels) (In Russian)
G. V. Dobrovol'skiy, Moscow, Svyazizdat, 1960, 216 p.

. . . problems in the field of transient processes in electric circuits, particularly in television transmission by wire. The author's analysis permits determining pulse distortion dependent on the characteristic distortions in frequency response, attenuation and phase most often encountered in communications channels. In addition, idealized pulses as well as near-real pulses are discussed. . . .

DISCUSSION ON "TRANSIENT RESPONSE OF BAND-PASS FILTERS TO MODULATED SIGNALS"
J. W. Head, et al., (communicated), D. Q. Mayne (in reply), Proc. Instn. Elect. Engrs. Part C, vol. 107, no. 12, Sept. 1960, p. 366/367.

SINE-SQUARED PULSES IN TELEVISION SYSTEM ANALYSIS
R. Kennedy, RCA Rev., vol. 21, no. 2, June 1960, p. 253/265.

The development of sine-squared pulse testing as it has occured in Europe is traced, followed by a comparison of Heaviside step versus sine-squared pulse spectra and their effect on a system The methods of pulse generation are next presented. The methods of testing various portions of system bandwidths by use of shaped bars, T, and 2T pulses are discussed. Rating factors, time-series computations, envelope delay, and linearity testing are also considered. . . .

OPTIMUM ESTIMATION OF IMPULSE RESPONSE IN THE PRESENCE OF NOISE
M. J. Levin, IRE Trans. Circuit Theory, vol. CT-7, no. 1, March 1960, p. 50/56, 15 refs.

. . . In the fields of communication and control there sometimes arises the problem of determining the characteristics of a time-invariant linear system from records of its input and output during a limited interval of time. . . . the postulate that random noise is superimposed upon the system output appears to lead to estimates of practical value. This paper considers only the estimation of impulse response, and it should be noted that if the interest is really in the frequency response or transfer function of the system, then different procedures are applicable.

A CONTRIBUTION TO THE TRANSIENT CHARACTERISTICS OF A FREQUENCY BANDPASS AMPLIFIER
Y. Mariwaki, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 23 Nov. 1960, (Research rept. no. PIBMRI-835-60), AD 255 546.

Formulas which give the output waveforms of multi-circuit amplifiers having an arbitrary number of stages for an input consisting of carrier frequency modulated by a unit step function are derived. Many numerical results which make clear the transient characteristics of multi-stage amplifiers are presented.

IMPUL'SNYYE REZHIMY V RADIOTEKHNICHESKIKH TSEPYAKH (Pulse Operation in Radio Engineering Circuits) (In Russian)
V. V. Nelepets, et al., Moscow, Oborongiz, 1960, 182 p.

. . . describes the physical processes in pulse operation in various radio circuits. . . . problems associated with conversion, generation and amplification of pulse signals . . .

presented without the use of higher mathematics . . .

DISCUSSION ON 'OPTIMUM COMBINATION OF PULSE SHAPE AND FILTER TO PRODUCE A SIGNAL PEAK UPON A NOISE BACKGROUND'
D. A. Bell, (communicated on), Proc. Instn. Elect. Engrs., pt. C, vol. 108, no. 14, Sept. 1961, p. 531/532.

OPTIMUM COMBINATION OF PULSE SHAPE AND FILTER TO PRODUCE A SIGNAL PEAK UPON A NOISE BACKGROUND
H. S. Heaps, Proc. Instn. Elect. Engrs. pt. C., vol. 108, no. 13, March 1961, p. 153/158.

. . . It is supposed that the propagating medium behaves as a linear filter and that the noise background is independent of the signal. . . . The results of the paper imply that for the range of parameters considered it is advantageous to transmit a succession of short pulses of a determined form rather than a single smooth pulse. . . .

PROPAGATION OF THE LOW-FREQUENCY RADIO SIGNALS
J. R. Johler, Proc. IRE, vol. 50, no. 4, April 1962, p. 404/427.

. . . propagation in the time domain is reviewed for linear amplitude systems. . . . propagation of a ground wave pulse is considered in detail. A stretching in the form or shape of the pulse is noted as a result of the filtering action of the propagation medium. Theoretical transfer characteristics for the media of propagation of LF signals are introduced and methods of computation are considered. . . .

DUAL REQUIREMENTS FOR OPTIMIZING ORTHONORMAL APPROXIMATIONS OF IMPULSE RESPONSES (Correspondence)
G. W. Smith, Jr., IRE Trans. Circuit Theory, vol. CT-8, no. 4, Dec. 1961, p. 486/487.

. . . It has been shown in recent literature that the inverse Laplace transform of a transfer function G(s) be approximated by a finite summation of orthonormal exponential functions (Jacobi polynomials with exponential arguments).

ASYMPTOTIC METHODS IN LINEAR RADIO ENGINEERING (In Russian)
D. Y. Bakman, Moscow, Soviet Radio Press, 1962, p. 246.

The monograph deals with approximate asymptotic methods for calculating the action of complex signals upon linear and quasilinear elements in radio equipment. It systematically presents and applies to radio-engineering calculations a powerful and quite rigorous mathematical apparatus that is physically intuitive. The application of the mathematical apparatus to concrete problems of modern radio engineering permits the author to solve several problems (calculation of the spectrum of 40 oscillatory signals, investigation of general methods for analyzing transients in FM examination of the passage of FM pulses through lumped-constant and distributed-constant delay lines, etc.), that have up until now been relative unamenable to methematical analysis. . . . intended for engineers . . .

OPTIMIZATION OF PULSE TRANSMISSION (Correspondence)
J. C. Hancock, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2136.

. . . In the transmission of digital data it is . . . of interest to design the signaling waveform to insure maximum energy at the output per unit of input energy. . . . design of signaling waveforms for linear systems which will not only insure a time-limited output signal but will also insure maximum energy transfer. . . .

DER EINFLUSS VON SPEZIELLEN SENDEFUNKTIONEN UND UBERTRAGUNSFAKTOREN AUF DEN EINSCHWINGVORGANG VON FREQUENZMODULIERTEN TELEGRAPHIEZEICHEN (The Influence of Special Input Functions and Transmission Factors on the Transient Response for Frequency Modulated Telegraphy Signals) (In German)
H. Jurgens, Frequenz, vol. 15, no. 12, Dec. 1961, p. 377/386; vol. 16, no. 1, Jan. 1962, p. 1/8.

EIN ENERGIEKRITERIUM ZUR BEWERTUNG VON IMPULSFILTERN (An Energy Criterion for the Evaluation of Pulse Filters) (In German)
W. Postl, Arch. elekt. Uebertragung, vol. 16, July 1962, p. 351/355.

. . . The scale of merit . . . as introduced by O. Herrmann and W. Schussler, has turned out to be a useful criterion for the adequate performance of such devices in multi-channel data transmission systems. It can be shown, however, that filters of a high degree are possibly rated too favorably by this criterion. A criterion that may be applied within a wider range, being based on the energy distribution of a single pulse in both the time and frequency spaces, is defined in this paper. . . .

LINEARE IMPULSVERSTARKUNG (Linear Pulse Amplification) (In German)
W. Rupprecht, Hamburg, R. V. Decker's Verlag, 1962, p. 45.

Distortions . . . that in multi-stage amplifiers will be indicated by means of test signals. . . .

RECTANGULAR PULSE DISTORTION DUE TO A NONLINEAR COMPLEX TRANSMISSION PROPAGATION CONSTANT.
R. D. Wanselow, J. Franklin Inst., vol. 274, no. 3, Sept. 1962, p. 178/184.

A theoretical analysis of the waveform distortion of a rectangular r. f. pulse propagating through a guided uniform microwave transmission medium is presented. A nonlinear complex propagation constant as a function of frequency is assumed where the attenuation and phase constants are approximated by a quadratic. By applying Fourier transformation, an expression is derived for the exit waveform as a function of the propagation distance, attenuation, dispersion and input pulse width. . . .

EXTRAPOLATION OF THE ELECTROMAGNETIC FIELD
J. S. Wicklund, Diamond Ordnance Fuze Labs., Wash., D. C. 2 July 1962, p. 19, 1 ref., (Rept. no. TR-1058), AD 278 676.

Given the shape of a pulse of electromagnetic radiation at a known distance from the source, an analytic expression is derived in the electric dipole approximation that yields the shape of the pulse at any other point. . . . The result is useful as a check on machine computation and in those cases where the use of an analog computer is impractical.

APPROXIMATION TO A SPECIFIED TIME RESPONSE
W. C. Yengst, IRE Trans. Circuit Theory, vol. CT-9, no. 2, June 1962, p. 152/162.

. . . This paper presents a procedure by which specified data or a function of time . . . for which the Laplace transformations . . . are known and can be expressed in rational fraction form. . . . often . . . the designer is faced with the problem of translating the time response specifications into a form that is amenable to synthesis of a realizable network. Synthesis procedures have been developed to solve the realization provided the transfer function of the network can be expressed as a rational fraction, i. e., the ratio of polynomials in terms of the complex frequency variables having real coefficients. . . . If the problem of obtaining the Laplace transform for a prescribed impulse response as the ratio of polynomials can be solved, then it is possible to complete the realization of the network. . . . The purpose of this paper is to present a procedure by which data, given as a function of time, can be transformed directly to a rational fraction form while simultaneously providing a least-square approximation to the function of time that minimizes the effect of uncorrelated random noise.

TWO INEQUALITIES USEFUL IN TRANSIENT ANALYSIS (Correspondence)
A. H. Zemanian, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2140/2141.

ASSIGNING MEASUREMENTS TO TELEMETRY CHANNELS TO MEET ERROR SPECIFICATIONS
W. F. Baxter, et al., Army Missile Command, Huntsville, Ala., Army Inertial Guidance and Control Lab., July 22, 1963, p. 22, N63-22456.

. . . intended to be an aid in determining the telemetry channel to which a measurement should be assigned to meet error specification. The ramp responses of several telemetry filters are determined, and the results are extended to cover other filters and other functions.

SINTEZ DINAMICHESKIKH KHARAKTERISTIK MNOGOKANAL'NYKH SISTEM (Synthesis of the Dynamic Characteristics of Multi-Channel Systems) (In Russian)
I. B. Chelpanov, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Nov. - Dec. 1963, p. 25/32, 8 refs., A64-14236.

Development of a method for the determination of transient impulse functions of filters in a continuous multichannel system with noise characteristics. The analysis is based on the condition of minimum mean-square error at an arbitrary moment of time, and assumes alternating switching of the channels.

EFFECT OF AMPLITUDE-FREQUENCY DISTORTION IN TELECOMMUNICATION CHANNELS ON THE TRANSMISSION OF PULSE SIGNALS (Translation)
G. P. Divnogortsev, et al., Telecommun. Radio Engineering. Part I - Telecommunications, Jan. 1963, p. 50/54, A63-21038.

Demonstration that the amplitude-frequency distortion introduced by a communications channel degrades the waveform of the pulse signals being transmitted. This degradation prevents the full exploitation of the effect of applying phase equalization. It is shown that in a telecommunications channel provided with a phase correction having an accuracy equal to the length of a pulse (with more than five networks in the phase equalizing circuit) and an amplitude correction corresponding to 0.1 neper, the amplitude-frequency distortion has almost the same effect as uncorrected phase distortion.

SIMPLE FILTERS FOR PULSE TRANSMISSION OVER RADIO LINKS
P. Gibbons, Signals Research and Development Establishment (Gt. Brit) March 1963, p. 20, AD 409 497.

Five filters are studied to determine how their properties affect the bandwidth and waveform of a transmitted binary pulse train. These are the sine squared, two gaussian types, a modified gaussian, and a very narrow filter with nearly rectangular amplitude response. Computed and experimental results are produced to show that the modified or truncated gaussian filter provide the best compromise between bandwidth reduction and simplicity of construction.

TRANSIT TIME EFFECTS IN PHASED ARRAYS

R: Gildersleeve, Syracuse U. Research Inst., N. Y., Griffiss AFB, N. Y., Techniques Lab., May 1963, p. 121, 3 refs., (RADC-TDR-63-67; N63-16554.

. . . a set of pulses produced at given points in space as a result of exciting an array of 49 elements, with half-wave spacing, by pulses of five cycles and less; the phase of the excitation was varied to cause the main lobe to scan through 20 degrees off boresight. . . .

GROUNDWAVE PROPAGATION EFFECTS ON MICROSECOND PULSES AT 141 MCS
R. W. Heffner, IEEE Internat. Conv. Rec. Pt. 8, vol. 11, March 1963, p. 182/196.

. . . A test program was performed . . . using microsecond pulses of different carrier frequencies. . . . only limited information was applicable to the special wide band multiple pulse system requirements of RACEP. . . .

ESTIMATION OF A SYSTEM PULSE TRANSFER FUNCTION IN THE PRESENCE OF NOISE
M. J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1963, p. 7, AD 411 832.

. . . Some adaptive control systems carry out measurements of plant parameters during normal operation. In communication systems an analogous situation arises in the utilization of time-varying channels (1). Often the application of a special test signal is undesirable so the information must be obtained from ordinary input output data. The presence of random noise and instrumentation errors can render many measurements schemes ineffective. Statistical estimation theory provides powerful methods for dealing with this type of problem. Some of these methods are applied to the estimation of the pulse transfer function of a linear system.

THE IDENTIFICATION OF OVERDAMPED PROCESSES IN THE TIME-DOMAIN
J.M. Mendel, Microwave Research Inst., Brooklyn Polytechnic Inst., 19 April 1963, p. 142, AD 407 687.

The problem of characterizing overdamped systems, from data in the time-domain, by means of exponential functions is studied. . . . extension of the orthonormal exponential approximations of Kautz and Huggins to approximations of any asymptotic-order in the s-domain.

A NUMERICAL METHOD FOR THE TRANSIENT RESPONSE OF NONLINEAR SYSTEMS
G. J. O'Hara, et al., Naval Research Lab., Washington, D. C., 21 June 1963, p. 18, NRL 5917, AD 414 807.

. . . determining the response of nonlinear system subjected to transient loads. . . . approximating the nonlinear variables and the forcing functions in the differential equations over a short interval of time by their mean value, by a straight line, or by a parabola. This allows for Duhamel integral type solutions for the nonlinear terms. . . .

PULSE PROPAGATION INTO WATER
H. J. Schmitt, Cruft Lab., Harvard U., Cambridge, Mass., 18 March 1963 p. 16, TR405, AD 408 445.

The transmission of short unidirectional planewave pulses into water and solutions of sodium chloride has been investigated experimentally . . . The dispersion of the pulse is mainly due to the ionic conductance of the solution . . .

SKIN-EFFECT THEORY FOR TRANSIENT RADIO WAVES
I. P. Verbin, (Radiotekhnika i Elektronika, vol. 8, July 1963, p. 1120/1129) (In Russian), Radio Engng. Electronic Phys., vol. 8, July 1963, p. 1106/1114, 8 refs, (Translation), A64-17512.

Related Publications:

GAUSSIAN-RESPONSE FILTER DESIGN
M. Dishal, Elect. Commun., vol. 36, no. 1, 1959, p. 3/26.

Filters having a gaussian response shape are useful in pulse systems because of the small under - and overshoots or ringing they produce following rapid signal changes. This paper gives a resume of the magnitude, phase, impulse response, step response, and effective thermal noise bandwidth of perfect gaussian filters. . . .

THE PASSAGE OF PULSE SIGNALS THROUGH AN AMPLIFIER WITH A LOW Q-FACTOR
G. V. Voishvillo, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 49/57.

THE PROPERTIES OF POLE AND ZERO LOCATIONS FOR NONDECREASING STEP RESPONSES
A. H. Zemanian, Commun. Electronics, vol. 79, no. 50, Sept. 1960, p. 421/426, 22 refs.

A form of response to a step input in a physical system is the nondecreasing type, which is of interest to the circuit designer, especially when an overshoot in the step response is objectionable. The purpose of this paper is to discuss the properties of the pole and zero locations of rational system functions whose step responses are of this form. . . .

THE RESPONSE OF A LOW-FREQUENCY FILTER WITH TRAPEZOIDAL FREQUENCY CHARACTERISTIC AND LINEAR PHASE CHARACTERISTIC TO CERTAIN SIGNALS
K. I. Cherne, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 6, 1961, p. 12/21.

TRANSIENT RESPONSE OF NARROW-BAND NETWORKS TO ANGLE-MODULATED SIGNALS
J. J. Hupert, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 458/468.

. . . Network response to a step in frequency is first obtained in a convenient form; next, the response to a function other than a step is developed by the use of convolution integral with the answer represented as a sum of quasistationary response and of transient response if the network overshadows its quasistationary response or is a sizeable proportion of this response . . .

A METHOD TO REDUCE OVERSHOOT IN FILTERS (Correspondence)
F.F. Kuo, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 413/414.

. . . method to reduce the overshoot and ringing of a filter step response. The step response of a tenth order Butterworth filter is shown. . . . consider the second derivative of the step response. . . . If we add the second derivative to the step response, we will reduce the overshoot and ringing.

AN IMPULSE RESPONSE COMPARISON OF WIDE BANDPASS AMPLIFIERS
S. G. Jones, IEEE Trans. Electromagnetic Compatibility, vol. EMC-6, Jan. 1964, p. 69/75, 15 refs, A64-15079.

Comparison of the impulse response characteristics of six wide bandpass amplifiers. Each amplifier was a cascade of six single-tuned stages of maximally-flat amplitude, synchronous-tuned or flat-delay types. . . .

TRANSIENTS IN RESONANT SYSTEMS WITH PHASE-KEYED OSCILLATIONS (Translation)
V. V. Sokolov, et al., Telecommun. Radio Engng., Part 1 - Telecommunications, April 1963, p. 34/40, A64-12172.

1.623: Special Distortions Effecting Frequency Modulation Systems

Included: Nonlinear distortion of FM signals; Woodward's theorem on FM spectra; Multiple echo distortion in FM systems; Tuned circuit distortions of FM signals; Distortion of FM signals in transmission networks; Intermodulation distortion in FM systems; Distortions in angular modulation systems.

Not Included: Interchannel interference in multiplex FM systems (2); Intermodulation distortion in multichannel links (2).

Cross References: Fundamentals of frequency modulation (1.232); Nonlinear distortions in communications channels (1.625); Linear FM spread spectrum signals (1.316); Digital frequency modulation systems (Sect. 1.33); Correlated noise due to distortions (1.742); Analysis of multipath and fading channels (1.612).

Principal Publications:

EFFECTS OF TUNED CIRCUITS UPON A FREQUENCY-MODULATED SIGNAL
H. Roder, Proc. IRE, vol. 25, Dec. 1937.

A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF TUNED CIRCUIT DISTORTIONS IN FREQUENCY-MODULATION SYSTEMS
D. T. Jaffe, Proc. IRE, vol. 33, May 1945, p. 318/333.

FM DISTORTION CAUSED BY MULTIPATH TRANSMISSION
M. S. Corrington, RCA Rev., vol. 6, 1946, p. 522.

THE TRANSMISSION OF A FREQUENCY-MODULATED WAVE THROUGH A NETWORK
W. J. Frantz, Proc. IRE, vol. 34, March 1946, p. 114P/125P.

NONLINEARITY IN FREQUENCY-MODULATION RADIO SYSTEMS DUE TO MULTIPATH PROPAGATION
S. T. Meyers, Proc. IRE, vol. 34, May 1946, p. 256/265.

THE DISTORTION OF FREQUENCY-MODULATED WAVES BY TRANSMISSION NETWORKS
A. S. Gladwin, Proc. IRE, vol. 35, Dec. 1947, p. 1436/1445.

CONDITION FOR QUASI-STATIONARY RESPONSE
E. J. Bagdady, Quart. Prog. Rep., Res. Lab. Elecs. MIT, Jan. 1958, p. 65/67.

Deduction of an upper bound on the error incurred in analyzing the response of a linear system to an FM excitation on a quasistationary (or instantaneous-frequency basis).

ANALYSIS OF FM TRANSIENTS
E. J. Baghdady, et al., Quarterly Progress Report, Res. Lab Elecs. MIT, April 1958, p. 36/45.

A. Careful study of the conditions for low-distortion transmission of FM signals through linear filters suggested that, for purposes of quasistationary response, the most important characteristic of a frequency modulation is the maximum rate at which it tends to sweep the frequency of the carrier.
E. J. Baghdady

B. Experimental Study of FM Transients.
D. D. Weiner

C. Dynamic Trap for the Capture of the Weaker Signal. G. J. Rubissow

THEORY OF LOW-DISTORTION REPRODUCTION OF FM SIGNALS IN LINEAR SYSTEMS
E.J. Baghdady, IRE Trans. Circuit Theory, vol. CT-5, Sept. 1958, p. 202/214.

THE RESPONSE OF A NETWORK TO A FREQUENCY-MODULATED INPUT VOLTAGE
J. W. Head, et al., Proc. Instn. Elect. Engrs., pt. C, vol. 105, Sept. 1958, p. 509/512.

ACTION D'UN SIGNAL MODULE EN FREQUENCE SUR UN QUADRIPOLE SELECTIF (Transient of an FM Signal in a Selective Two Part Network) (In French
J. C. Simon, et al., Ann. Radioelect., vol. 13, Jan. 1958, p. 18/29.

UBER DEN DURCH UNVOLLKOMMENE BEGRENZUNG HERVORGERUFENEN KLIRRFAKTOR BEI UKW-EMPFÄNGERN FÜR FREQUENZMODULATION (On the Non-linear Distortions in UHF Frequency Modulation Receivers Caused by Imperfect Limiter Action) (In German)
E. G. Woschni, Hochfrequenztech. u. ElektAkust, vol. 67, July 1958, p. 18/25.

DISTORTION OF ANGLE-MODULATED SIGNALS IN MISALIGNED LINEAR FILTERS
J. Galejs, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 228/232.

ESTABLISHING THE FREQUENCY AT THE OUTPUT OF AN IDEAL NARROW BAND FILTER WITH FREQUENCY-PHASE MODULATION
L. I. Iaroslavskii, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 7, 1960, p. 72/83.

. . . study of transient processes, or, more accurately, the establishment of the instantaneous frequency and instantaneous amplitude at the output of a narrow band system with a frequency-phase modulated input signal . . . Purely frequency and purely phase modulation are regarded as special cases of frequency-phase modulation. . . .

FUNDAMENTAL AND HARMONIC DISTORTION OF WAVES FREQUENCY-MODULATED WITH A SINGLE TONE
R. G. Medhurst, Proc. Instn. Elect. Engrs. Part B, vol. 107, no. 32, March 1960, p. 155/164.

EXPLICIT FORM OF F. M. DISTORTION PRODUCTS WITH WHITE-NOISE MODULATION
R. G. Medhurst, Proc. Instn. Elect. Engrs., Pt. C, vol. 107, no. 11, March 1960, p. 120/126.

EXTENDED ANALYSIS FOR DISTORTION IN FM MULTICHANNEL TRANSMISSIONS
C. A. Parry, et al., Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 183/197.

OPTIMUM PASSBAND OF A FILTER IN THE RECEPTION OF FREQUENCY-MODULATED SIGNALS WITH FOLLOW-UP TUNING
Y. G. Rodionov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 9, 1960, p. 63/73.

. . . from the point of view of ensuring maximum interference resistance in reception and the highest quality reproduction of the useful signal. . . .

A COMPARISON OF FREQUENCY-SHIFT ANTI-MULTIPATH SIGNALING TECHNIQUES FOR DIGITAL COMMUNICATION SYSTEMS
W. B. Jones, Jr., IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 83/87.

ON ENERGY BAND, AND DISTORTION PRODUCED BY ATTENUATION AND PHASE CHARACTERISTICS, OF FREQUENCY-DIVISION MULTIPLEXED F. M. SIGNALS (In Japanese)
O. Shimbo, et al., J. Inst. Elect. Commun. Engrs., vol. 44, no. 3, March 1961, p. 376/383.

The energy bandwidth function of a frequency-multiplexed f. m. signal for various modulation depths is derived by approximation methods, and the function is then applied to determine the distortion due to phase and amplitude characteristics. . . .

ASYMPTOTOTIC METHOD IN LINEAR RADIO ENGINEERING (In Russian)
D. Y. Bakman, Moscow, Soviet Radio Press, 1962, 246 p.

. . . investigation of general methods for analyzing transients in FM; examination of the passage of FM pulses through lumped-constant and distributed-constant delay lines . . .

A GENERALIZATION OF WOODWARD'S THEOREM ON FM SPECTRA
N. M. Blachman, Inform. Control, vol. 5, no. 1, March 1962, p. 55/63.

Woodward's theorem asserts that the power spectral density of a slowly frequency-modulated signal is given by the first-order probability density of the modulation. It can be extended to cover the case where there is slow amplitude modulation as well—correlated or uncorrelated and deterministic or random —by weighting each frequency by the mean-square amplitude associated with it. The modulation can be regarded as slow if its bandwidth is small compared to the frequency excursion. . . .

THE VISUALIZATION OF FREQUENCY-MODULATION TRANSIENTS BY MEANS OF MECHANICAL MODELS
M. J. Golay, IRE Trans. Circuit Theory, vol. CT-9, no. 1, March 1962, p. 78/82.

A PROPERTY OF LINEAR FREQUENCY MODULATION (Correspondence)
A. J. Goldman, Proc, IRE, vol. 50, no. 7, July 1962, p. 1711.

. . . A fact useful in connection with chirp radars is that a linear FM signal of arbitrary envelope, when passed through a suitable network with linear delay characteristic, suffers a reversal of the linear FM and a Fourier

transformation of the functional form of the envelope. It is shown here that no other FM signal and delay network are related in this way. . . .

THE THEORY AND DESIGN OF F. M. RECEIVERS
D. Hess, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 11 May 1962, p. 84, incl. illus., Research rept. no. PIBMRI-1026-62, AD 282 110.

The spectrum of an F. M. wave modulated by gaussian noise is studied. . . . response of linear band-pass networks to an F. M. signal. . . The quasi static response is a modified version of the steady state response. The modification permits a very tight bound to be put on the error term and hence leads to very tight bandwidth specifications on F. M. filters. Several new and several existing F. M. demodulators are studied to establish design criteria for the demodulators. Finally the ability of a phase-lock loop to demodulate an F. M. signal is studied. . . .

TRANSMISSION OF F. M. SIGNALS THROUGH LINEAR FILTERS
D. T. Hess, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 469/476.

. . . In this paper the response of a linear filter to an F. M. signal is derived. The response is expressed as a closed form function of the instantaneous frequency of the input wave plus an error term on which a tight bound is kept. . . .

TRANSIENT RESPONSE OF NARROW-BAND NETWORKS TO ANGLE-MODULATED SIGNALS
J. J. Hupert, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 458/468.

. . . Narrow-band approximation applies but asymmetric pole pattern is admissible. Network response to a step in frequency is first obtained in a convenient form; next, the response to a function other than a step is developed by the use of convolution integral with the answer represented as a sum of quasistationary response and of transient response of the network overshadows its quasistationary response or is a sizeable proportion of this response. . . Once the natural modes of the network are known, multiple-tuned circuits may be analyzed without much more complication than a single-tuned circuit. . . .

NONLINEAR DISTORTIONS OF AN FM SIGNAL IN A CHANNEL WITH LIMITED PASSBAND
L. M. Kononovich, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 32/37.

On the basis of spectrum analysis starting from the general formulas for the shape of an FM output signal, computational formulas are given to determine the nonlinear distortion of an FM signal in a channel with a rectangular amplitude-frequency and a linear phase-frequency characteristic. . . .

INTERMODULATION NOISE IN LINEAR F. M. SYSTEMS
R. I. Magnusson, Proc. Instn. Elect. Engrs., Part C, vol. 109, no. 15, March 1962, p. 32/44.

By applying a series of detailed approximations to the Rice and Bosse theory of f. m. intermodulation noise, the recent formulae of Medhurst and Roberts for intermodulation noise/signal ratios in f. m. systems with white-noise modulation and networks of polynomial frequency characteristics are extended in three respects: (a) to the calculation of the noise ratio at any modulation frequency, (b) to network real and imaginary characteristics of eighth and seventh degree, respectively, and (c) to the case of pre-emphasis. The theory is illustrated by application to the cases of a signal with C. C. I. R. pre-emphasis passing a stagger-tuned triple without and with group-delay equalization.

MULTIPLE ECHO DISTORTION IN FREQUENCY-MODULATION, FREQUENCY-DIVISION, MULTIPLEX TRUNK RADIO SYSTEMS
R. G. Medhurst, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 61/71.

. . . concerned with intermodulation distortion in FM, FDM trunk radio systems due to a number of echoes of differing amplitudes and delay times. General formulas are developed, and applied to the case of a 960-channel system subjected to distortion due to echoes from flanges in waveguide runs. Examples considered are 100- and 200-ft. runs of RG-50/U waveguide, in 10-ft. sections, for use in the 6000 Mc band. . . .

DIE ZEIGERMETHODE. EIN ANSCHAULICHES VERFAHREN ZUR BEHANDLUNG VON VERZERRUNGEN DER KLEINHUB-FM MIT ANWENDUN AUF FM-RICHTFUNK (The Phasor Method. An Illustrative Method for the Analysis of Distortions of Small Index FM with Applications in Radio Relay Links) (In German)
M. Muller, Arch. Elekt. Ubertragung, vol. 16, no. 2, Feb. 1962, p. 93.

DISTORTION OF ANGLE-MODULATED WAVES BY LINEAR NETWORKS (Correspondence)
H. E. Rowe, IRE Trans. Circuit Theory, vol. CT-9, no. 3, Sept. 1962, p. 286/290.

. . . In a recent paper (1) Baghdady summarizes the series solutions of Carson and Fry, Van der Pol, and Stumpers for the response of a linear filter to an angle-modulated wave. He then presents bounds on the error incurred by truncating these series expansions . . . these bounds. . . are not correct in general and their use can lead to serious error in some cases. In the present paper we shall give a few counter-examples, each of which

violates one or more of the bounds. . . Finally several errors in the analysis. . . will be indicated briefly.

LA DISTORSION EN MODULATION DE FREQUENCY (FIN) (Distortions in FM Systems) (Last Part) (In French)
J. Schwob, Ann. Telecomm., vol. 17, March/April, 1962, p. 46/66., 27 refs.

INTERMODULATION NOISE IN FM TROPOSCATTER LINKS (Correspondence)
W. Sichak, et al., Proc. IRE, Vol. 50, no. 10, Oct. 1962, p. 2113.

. . . approximate formula for the intermodulation noise produced by tropospheric scattering. . . .

BINARY DATA TRANSMISSION BY FM OVER A REAL CHANNEL
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2387/2426.

Formulas are derived for probability of error in the detection of binary FM signals received from a channel characterized by arbitrary amplitude- and phase-vs-frequency distortion as well as additive Gaussian noise. The results depend on the signal sequence and can be presented in terms of averages over all signal sequences or as bounds for the most and least vulnerable ones. Illustrative examples evaluated include Sunde's method of suppressing intersymbol interference in band-limited FM. . . It is found that a performance from 3 to 4 db poorer than that theoretically attainable from binary PM is realizable over a variety of filtering situations.

A COMMON ERROR IN FM DISTORTION THEORY (Correspondence)
L. H. Enloe, et al., Proc. IEEE, vol. 51, no. 5, May 1963, p. 846.

. . . exists in many published procedures for computing the intermodulation distortion which occurs when an angle modulated wave is passed through a linear filter. The error consists in using a first-order approximation to determine the difference between the angles of the input and output waves. . . . when attempting to determine the second- and higher-order intermodulation products which are of primary interest. For instance, the error for a simple-tuned circuit is 10 db for the small distortion case. . . .

ON THE PREDICTION OF THE INHERENT BANDWIDTH CAPABILITY OF THE TROPOSPHERIC SCATTER LINK
C. A. Parry, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 215/232, 27 refs.

. . . It is pointed out that these bandwidth definitions have little meaning when applied to FM type transmissions since they do not indicate the level of the intermodulation noise introduced into the system by the multipath behaviour, and this may be a significant factor in system performance. So far, no satisfactory procedure for the evaluation of bandwidth in such terms has been described, and both experimental and analytic data are extremely limited. . . .

THE STATISTICAL DISTRIBUTION OF INTERMODULATION DISTORTION DUE TO THE PROPAGATION MEDIUM IN THE FM TROPOSPHERIC SCATTER SYSTEM
H. Prescott, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 248/267, 20 refs.

During the past decade, tropospheric systems have been installed on a world-wide basis. . . . the expansion of existing systems and the maximum utilization of new systems is being given careful attention. . . this paper is to present a method for predicting the statistical distribution of intermodulation distortion due to the propagation medium. . . An understanding of the IM distortion due to the propagation medium is needed in order to determine the available bandwidth, and hence the number of voice channels, teletype circuits and other types of data devices that can be utilized. . . .

K TEORII PROKHOZHDENIIA SHIROPOLOSNYKH SIGNALOV V SISTEMAKH NAZEMNOI KOSMICHESKOI SVIAZI (Contribution to the Theory of Wide-Band Signal Transmission in Ground-Based Space Communications Systems) (In Russian)
A. V. Prosin, Radiotekhnika i Elektronika, vol. 8, Nov. 1963, p. 1822/1833, A64-12029.

Theoretical investigation of distortions due to dispersion that arise in the passage of FM signals through a dispersing medium. Developed is a method for calculation cross noise created by the dispersion-induced distortions in multichannel multiplexed FM communications systems based on the use of artificial Earth satellites.

PARAMETER OPTIMIZATION OF AN FM/FM MULTICHANNEL TELEMETRY SYSTEM
D. H. Sapp, RCA Rev., vol. 24, no. 3, Sept. 1963, p. 381/390.

. . . The various sources of distortion in FM systems are discussed and graphs are given to show typical saddle points by means of which parameters can be selected to maximize the channel signal-to-noise rations. . . .

DISTORTION OF MULTITONE FM SIGNALS DUE TO PHASE NONLINEARITY
P. D. Shaft, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 25/35.

An equation is developed for the distortion of multitone FM signals caused by transmission through a network with nonlinear phase characteristics. A simplified form involving only one term is also given and the conditions of its applicability are discussed. The power spectrum of the distortion is derived for the case

where the simpler form is valid. Thus, the distortion-to-signal ratio in any frequency band may be obtained. Applications are presented where the results are used to determine equipment linearity specifications and to determine the distortion which results from propagation through the ionosphere. . . . Previous work has dealt with the harmonic distortion of a sine wave and intermodulation distortion of two sine waves. Here, the modulation will be an ensemble of sine waves which is similar to a band of white noise. This is a practical case because frequency-division multiplex signals can often be represented in this manner. . . .

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS-COMMUNICATION TYPE
C. W. Stuckey, et al., Georgia Inst. of Tech. Engineering Experiment Station, Atlanta, Quarterly rept., no. 3, 15 Aug.-15 Nov. 1963, 15 Nov. 1963, p. 56, Rept. no. 24, AD 433 705.

The effects of multipath interference on the intelligibility of speech transmitted over an FM system employing time division multiplexing are reported. Predicted intelligibility measurements based on audio output S/N ratios indicate that significant degradation in intelligibility will exist for the FM/TDM system tested when multipath signals of equal strength are received over paths which differ in length by as little as 0.15 mile. . . .

Related Publications:

DISTORTION IN FREQUENCY-DIVISION-MULTIPLEX F. M. SYSTEMS DUE TO AN INTERFERING CARRIER
R. G. Medhurst, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 105, May 1958, p. 282/292.

THEORETICAL ERROR PROBABILITIES FOR FREQUENCY-SHIFTKEYED TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague (Netherlands), Sept. 1959, p. 65, AD 226 924.

INTERMODULATION DISTORTION IN MULTI-CHANNEL LINKS WITH FM IN USW SCATTER PROPAGATION
A. V. Prosin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 1/17.

. . . intermodulation distortions. . . owing to multi-path scatter propagation. . . Formulae are produced for determining the power of transient noise. The author establishes the dependence of intermodulation distortions on the length of the path, the beam-width of the aerial, and a number of other factors. . . .

INTERCHANNEL INTERFERENCE IN FM SYSTEMS PRODUCED BY CONTINUOUS RANDOM MODE CONVERSION IN CIRCULAR ELECTRIC WAVEGUIDE
L. H. Enloe, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2765/2786.

AM TO PM CONVERSION IN TUNNEL DIODE AMPLIFIERS (Correspondence)
R. M. Kurzrok, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 377/378.

. . . can be a source of distortion in frequency-modulated systems. . . .

FREQUENCY-MODULATED SIGNALS AND THEIR POWER SPECTRA
G. H. Nitta, Naval Ordnance Lab., Corona, Calif., Feb. 1964, p. 139, NOLC TM74 208, AD 436 407.

INTERMODULATION DISTORTION ON TROPOSPHERIC SCATTER SYSTEMS (CORRESPONDENCE)
H. Prescott, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1244.

1.624: Special Distortions Effecting Amplitude Modulation and Other Modulation Systems.

Included: Distortions effecting random signal processes; Distortions in SSB systems; Distortions due to asymmetrical sideband transmission.

Not Included: Distortions in vestigial sideband TV systems.

Cross References: Signal representations (1.142); Single sideband modulation methods (1.223); Vestigial sideband modulation methods (1.224); Vestigial sideband data transmission systems (1.324).

Principal Publications:

BEEINFLUSSUNG EINES NACHRICHTENBANDES BEI AMPLITUDENMODULATION DURCH UNSYMMETRISCHE HOCHFREQUENZKREISE (Influence of Unsymmetrical rf Circuits on AM Signals) (In German)
R. Hofer, Entwicklungs-Berichte, vol. 21, Dec. 1958, p. 288/300.

PHASE-COMPENSATION METHODS OF SHAPING A SINGLE-SIDEBAND SIGNAL (In Russian)
A. Semenov, et al., Radio, Moscow, June 1958, p. 27/29.

PULSE PHASE-CHANGE SIGNALING IN THE PRESENCE OF IONOSPHERIC MULTIPATH DISTORTION
S. G. Lutz, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 102/110.

CROSS MODULATION AND MODULATION DISTORTION IN AM RECEIVERS EQUIPPED WITH TRANSISTORS
Electronic Applic., vol. 20, no. 3, 1959-1960, p. 107/128.

The causes of cross-modulation and modulation distortion in transistorized am receivers are examined. Design consideration to reduce these effects are indicated. . . .

ON THE PROBABILITY DENSITY OF THE OUTPUT OF A LOW-PASS SYSTEM WHEN THE INPUT IS A MARKOV STEP PROCESS
W. M. Wonham, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 539/544.

. . . As examples, the joint probability densities of input and output are found for a symmetric three-level signal smoothed by an RC low-pass filter, and partial results are obtained for a doubly integrated Rice telegraph signal.

THE PROBABILITY DISTRIBUTIONS OF THE OUTPUTS OF FIRST-ORDER AND TUNED SECOND-ORDER FILTERS WITH COIN-TOSS SQUARE WAVE INPUTS
A. R. Cohen, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 371/377, AD 407 272.

. . . The input is a binary process in which axis crossings can occur only on a set of equally spaced sample points . . .

RECOVERY OF INFORMATION TRANSFERRED INTO PHASE MODULATION IN IONOSPHERIC WAVE PATHS
Mario Mancianti, et al., Pisa U. (Italy) Final rept., 1 Feb. 1961-31 Jan. 1962, Feb. 1962, 37 p. incl. illus., 11 refs. (AFCRL 62-547), AD 282 960.

. . . information . . . originally impressed onto a signal as amplitude modulation, has been changed to phase modulation by travelling through the ionosphere . . . at least partial recovery . . . by means of a double homodyne detector was studied . . .

RECTANGULAR PULSE DISTORTION DUE TO A NONLINEAR COMPLEX TRANSMISSION PROPAGATION CONSTANT
R. D. Wanselow, J. Franklin Inst., vol. 274, no. 3, Sept. 1962, p. 178/184.

A theoretical analysis of the waveform distortion of a rectangular r.f. pulse propagating through a guided uniform microwave transmission medium is presented. A nonlinear complex propagation constant as a function of frequency is assumed where the attenuation and phase constants are approximated by a quadratic. By applying Fourier transformation, an expression is derived for the exit waveform as a function of the propagation distance, attenuation, dispersion and input pulse width. . . .

BETTER SUPERHETS FOR SIDEBAND RECEPTION
W. Bruene, et al., Electronics, vol. 36, May 10, 1963, p. 39/45, A63-16926.

. . . single-sideband (SSB) receivers for improving HF communications. . . . sensitivity . . . the noise factor . . . blocking and cross modulation . . . RF amplifier . . . mixing . . . IF amplifiers . . . automatic gain control . . . sideband selection . . . SSB demodulations. . . .

DISTORTION OF SINGLE SIDEBAND TRANSMISSION DUE TO AM/PM CONVERSION IN TRAVELING WAVE AMPLIFIERS
R. G. Medhurst, et al., General Electric Co., Ltd. (Gt. Brit.) 13 June 1963, lv., Rept. no. 14374C, AD 417 949.

Intermodulation distortion of a single-sideband, amplitude modulated signal will be generated by am/pm conversion effects present in amplifiers (such as traveling wave tubes) as well as by output/input non-linearity. When the s.s.b.a.m. signal is carrying multi-channel telephony this can be an important source of distortion. A formula is developed relating intermodulation distortion to am/pm conversion level . . .

Related Publications:

A MARKOFF ENVELOPE PROCESS
J. N. Pierce, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 163/166.

It is shown that the envelope of a narrow-band Gaussian noise constitutes a first-order Markoff process if the power spectrum of the noise is the same as would be obtained from a singly tuned RLC filter with white noise at the input.

EFFECTS OF FREQUENCY CUTOFF CHARACTERISTICS ON SPIKING AND RINGING OF TV SIGNALS
A. D. Fowler, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 173/179.

The spiking and ringing of TV signals depend upon amplitude and delay characteristics associated with frequency cutoff of transmission. The effects of a variety of cutoff characteristics of both ideal and practical systems on rectangular and sine-squared pulses are illustrated by computed waveforms. . . .

THE PROBABILITY DENSITY OF THE OUTPUT OF AN RC FILTER WHEN THE INPUT IS A BINARY RANDOM PROCESS
J. A. McFadden, IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 174/178.

NOISE IMMUNITY OF AMPLITUDE-KEYED SIGNALS IN THE PRESENCE OF FADING
M. F. Bakhareva, et al., (Radiotekhnika i Elektronika, vol. 8, April 1963, p. 539/545, In Russian) Radio Engng. Electronic Phys., vol. 8, April 1963, p. 585-590, 5 refs., Translation, A64-15211.

1.625: Nonlinear Distortions in Communications Channels

Included: Intermodulation distortions; Harmonic distortions; Distortions due to propagation in nonlinear media; Amplitude distortions; Cross modulation due to nonlinear characteristics; Nonlinear distortions in companding devices; Distortions in limiters.

Not Included: Nonlinear amplifiers; Logarithmic amplifiers; Nonlinearities in receiving equipment; Fundamentals of compandors (2); Nonlinear distortions in detection circuits; Design of limiter circuits; Intermodulation distortion in multiplex systems (2).

Cross References: Correlated noise due to interchannel interference (1.742); Nonlinearities in plasma interaction media (1.635); Echo distortions in FM systems (1.623).

Principal Publications:

NONLINEARITY IN FREQUENCY-MODULATION RADIO SYSTEMS DUE TO MULTIPATH PROPAGATION
S. T. Meyers, Proc. IRE, vol. 34, May 1946, p. 256/265.

EIN BEITRAG ZUM ADDITIONSGESETZ: KLIRRSPANNUNGEM IN WEITVERKEHRS-SYSTEMEN MIT AMPLITUDENMODULATION (A Contribution to the Superposition Law: Non-Linear Distortion Products in Long Distance Circuits with AM) (In German)
H. Zuhrt, Nachrichtentech. Z. (NTZ), vol. 11, Aug. 1958, p. 424/428.

INTERMODULATION DISTORTION AND EFFICIENCY ANALYSIS OF MULTICARRIER REPEATERS
F. Assadourian, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 68/71.

CROSSTALK DUE TO FINITE LIMITING OF FREQUENCY-MULTIPLEXED SIGNALS
C. R. Cahn, Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 53/59.

EFFECTS OF NONLINEARITY ON PROPAGATION IN IONIZED MEDIA
G. I. Cohn, Commun. and Electronics, no. 46, Jan. 1960, p. 942/949.

INTERMODULATION ON AMPLITUDE-MODULATED MULTI-CHANNEL LINE LINKS
J. C. Davis, et al., Proc. Instn. Elect. Engrs. Part C, vol. 107, no. 12, Sept. 1960, p. 342/352, 13 refs.

. . . a method for estimating the total intermodulation noise power falling into any channel in the transmission band of an a.m. multi-channel line system with many repeater sections in tandem. These sections may be composed of widely varying lengths of cable imperfectly equalized by non-identical amplifiers whose in-band feedback, output load impedance and output network response all vary with frequency. . . .

COMPANDOR EFFECTS ON DATA SIGNALS
E. Enriques, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 220.

Abstract only.

V. H. F. SOUND BROADCASTING, SUBJECTIVE APPRAISAL OF DISTORTION DUE TO MULTIPATH PROPAGATION IN FM RECEPTION
R. V. Harvey, Proc. Instn. Elect. Engrs., Part B, vol. 107, no. 35, Sept. 1960, p. 412/422.

AN INTERSYMBOL ADJUSTMENT METHOD OF DISTORTION COMPENSATION
E. D. Gibson, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 196/207.

This paper describes a device capable of simultaneously compensating for both amplitude and delay distortion. Within wide limits, any amplitude-versus-frequency curve and any differential-delay-versus-frequency curve can be obtained simultaneously from this device, called the ISIC (Intersymbol Interference Corrector) is well suited for use as an equalizer of digital or analog transmission systems, a highly adjustable filter, or a laboratory instrument. The ISIC is continuously and easily adjustable, stable and reliable. . . .

OPTIMIZATION OF SOME NOISY NONLINEAR SYSTEMS
R. O. Harger, Institute of Science and Tech., U. of Michigan, Ann Arbor, Oct. 1961, 82 p. (Rept. 2900-290-T), AD 265 554.

The presence of noisy nonlinearities in the transmission of signals in a system whose function is either signal recovery (estimation) or signal detection is considered. The system is composed of a nonlinear operator followed inseparably by an additive stochastic noise source and interspersed between two linear time-invariant filters. For the estimation function, two types of signal are considered: a sinusoidal signal of random phase; and a more general stochastic signal of second-order stationarity . . . The postfilter gain is determined by matched-filter theory, and it is shown that prefilter gain should be infinite.

EVALUATION OF THE COMBINATIONAL FREQUENCY LEVEL AND OF THE PERMISSIBLE LEVEL FLUCTUATION OF CODED REMOTE CONTROL FREQUENCY SIGNALS DURING THEIR SIMUTANEOUS TRANSMISSION
V. L. Inosov, et al., (Avtomat i Telemekh., In Russian, vol. 23, no. 2, Feb. 1962, p. 214/221), Automat. Remote Control, English translation, vol. 23, no. 2, July 1962, p. 191/198.

Investigates analytically the method of estimating the amplitudes of combinational components from the form of the oscillation envelope of two frequencies after these frequencies have passed through a nonlinear element. Also investigates the method of determining the permissible level of fluctuation for the remote control signal frequencies as a function of the changes in communication channel attenuation.

CROSS MODULATION IN RESONANCE TRANSISTOR AMPLIFIERS
M. Ye. Movshovich, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 5, May 1962, p. 71/78.

. . . in the present paper, only the fundamental relationships between the cross-modulation coefficient . . . and interference are determined, by an analysis of the simplest theoretical models of transistors; subsequently, the correctness of these relationships and their values for real transistors are evaluated experimentally. All the investigations are carried out for the case when there is no impedance in the common electrode circuit of the transistor that may cause feedback at the signal frequencies and no products arise due to nonlinearity of the input loop. . . .

MODULATION, INTERMODULATION, BALANCED MODULATORS FOR COLOUR TELEVISION (In French)
J. Tasso, Onde Electr., vol. 42, no. 429, Dec. 1962, p. 992/1013.

. . . defining as precisely as possible intermodulation and modulation . . . account of the principal methods of calculation which can be used for the study of intermodulators . . .

PROGRAM TO COMPUTE INTERMODULATION PRODUCTS
D. Wiggert, et al., Lincoln Lab., Mass. Inst. of Tech. Lexington, Nov. 16, 1962, 18 p., N63-21725.

. . . written in the SHARE 709 system (SOS) for the IBM 7090 computer to calculate all intermodulation products up to and including sixth order for any number of input frequencies and bandwidths consistent with core storage limitations. Interfering products are written out using OUTRAN as they are calculated and detected.

HARMONIC DISTORTION ANALYSIS IN HIGH-FREQUENCY TRANSISTOR AMPLIFIERS
F. H. Zander, Arizona State U., Tempe, 1962, 47 p., AD 405 141.

. . . extensions to J.G. Linville's two-port harmonic distortion analysis. A more effective use of two-port network theory is developed in order that "building-block" techniques be applied to Linville's method. . . . facilitates the design of feedback circuitry.

PASSAGE OF SIGNALS THROUGH A NONLINEAR FOUR-TERMINAL NETWORK
O. Ye. Antonov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 11/18.

The problem of determining the structure of a signal at the output of a zero-delay four-pole network with a nonlinear univalued characteristic is considered. By representing the characteristic of the nonlinear four-terminal network by an exponential Fourier series . . .

A METHOD FOR PREDICTING INTERCHANNEL MODULATION DUE TO MULTIPATH PROPAGATION IN FM AND PM TROPOSPHERIC RADIO SYSTEMS
C. D. Beach, et al., Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 1/36.

. . . interchannel modulation due to multipath propagation on angle-modulated tropospheric scatter radio systems. Values of signal-to-intermodulation ratio, S/I, are calculated for various pairs of signal reflections in the troposphere, taking into account the base bandwidth and frequency deviation of the system, the antenna patterns, the path geometry, and climatic conditions during the "worst month" of propagation. The lowest value of S/I (worst intermodulation) computed for such pairs of signal reflections is then corrected empirically to account for multiple reflections. The result represents the median value of S/I expected during the worst month of transmission on a specified path. . . .

WAVE PROPAGATION IN NONLINEAR ELECTROMAGNETIC MEDIA
N. Bloembergen, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 124/131.

. . . tutorial review . . .

INTERCHANNEL INTERFERENCE IN FM SYSTEMS PRODUCED BY CONTINUOUS RANDOM MODE CONVERSION IN CIRCULAR ELECTRIC WAVEGUIDE
L. H. Enloe, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2765/2786.

ANALYSIS OF SIGNAL INTERFERENCE GENERATED WITHIN A LIMITER
R. L. Greenspan, et al., Mitre Corp., Bedford, Mass., Aug. 1963, 12 p., Rept. no. W5369, ESD TDR63 257, AD 415 188.

. . . modeled as an ideal clipper cascaded with a bandpass filter. The nonlinear clipper characteris analyzed as a linear sum of sinusoids in order to determine signal modulation frequencies generated within the clipper and which pass through the filter. The representation leads to evaluation of modulation component amplitudes as sums of Bessel Functions, or equivalently, as integrals of Bessel Functions. The cases of a single narrowband input, and two interfering sinusoids, are considered in detail. . . . literature concerning signal-to-noise ratio calculations in systems using a limiter . . .

A GENERAL METHOD OF MEASURING THE NONLINEARITY OF PULSED DEVICES (Translation)
I. F. Ivanov, et al., Telecommun. Radio Engng., Part II-Radio Engineering, vol. 18, Feb. 1963, p. 51/60, A63-20644.

. . . three different nonlinearity criteria of the nonlinearity of typical amplitude characteristics tabulated . . . they can be used with the comparison method suggested previously by Ivanov.

MOP-UP EQUALIZER FOR AMPLITUDE AND DELAY DISTORTION IN IF BAND FOR 6GC 1800 CHANNEL SYSTEM
T. Kawahashi, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 163/176.

. . . To accomplish high capacity radio transmission, that is, a multi-channel radio relay system capable of carrying 1800 telephone channels. . . . it has become necessary to equalize the 3rd and 4th order distortion components of the amplitude-frequency response in the IF stage, not to speak about the residual delay distortion in the FM transmission path.

In order to meet the said requirement . . . we have developed two types of the IF mop-up equalizer: one is the amplitude equalizer . . . and the other is the delay equalizer . . .

When operated as part of the IF stage of the existing Tokyo - Osaka 6GC-1200 channel system, these equalizers have proved to be effective enough to convert the existing system into a 1800 channel system conforming to the CCIR Recommendation . . .

ON THE MEASUREMENT AND INTERPRETATION OF NON-LINEARITY IN A TELEVISION SYSTEM
J. B. Potter, J. Brit. Instn. Radio Engrs., vol. 26, no. 2, Aug. 1963, p. 141/147.

A mathematical description of a general nonlinear system is used to illustrate the scope of presently defined non-linearity measurements and to indicate how these may be extended. . . .

THE STATISTICAL DISTRIBUTION OF INTERMODULATION DISTORTION DUE TO THE PROPAGATION MEDIUM IN THE FM TROPOSPHERIC SCATTER SYSTEM
H. Prescott, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 248/267, 20 refs.

During the past decade, tropospheric systems have been installed on a world-wide basis. . . . the expansion of existing systems and the maximum utilization of new systems is being given careful attention . . . this paper is to present a method for predicting the statistical distribution of intermdoulation distortion due to the propagation medium . . . An understanding of the IM distortion due to the propagation medium is needed in order to determine the available bandwidth, and hence the number of voice channels, teletype circuits and other types of data devices that can be utilized. . . .

SIGNAL DISTORTION IN NONLINEAR FEEDBACK SYSTEMS
I. W. Sandberg, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2533/2550.

. . . plays a central role in the theory of signal transmission through a general physical system containing linear time-invariant elements and a single time-variable nonlinear element. . .

As a direct application, we consider the range of validity of two simple cascade flow graphs (i.e., flow graphs without feedback loops) for approximately determining the signal distortion in nonlinear feedback systems when the distortion is small. Our discussion is not restricted to specific types of nonlinear characteristics.

INTERMODULATION DISTORTION IN GaAs INFRARED EMITTERS (Correspondence)
L. M. Vallese, et al., Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1252.

Related Publications:

THE FOURTH PRODUCT MOMENT OF INFINITELY CLIPPED NOISE
J. A. McFadden, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 159/162.

ECHO-DISTORTION IN FREQUENCY-MODULATION FREQUENCY-DIVISION-MULTIPLEX TRUNK RADIO SYSTEMS
R. G. Medhurst, Electronic Radio Engr., vol. 36, July 1959, p. 253/259.

The level of intermodulation distortion generated in f.m., f.d.m. trunk radio system by a small echo depends on the echo amplitude and delay, on the phase relation between the wanted carrier and the echo carrier, and on the parameters of the modulation; i.e., the maximum and minimum modulating frequencies, the r.m.s. deviation and the base-band spectral distribution. Numerical evaluation for the important case of top channel distortion has been carried out on a Hollerith Hec. 2M digital computer . . .

CROSS MODULATION AND MODULATION DISTORTION IN A.M. RECEIVERS EQUIPPED WITH TRANSISTORS
Electronic Applic., vol. 20, no. 3, 1959-1960, p. 107/128.

The causes of cross-modulation and modulation distortion in transistorized a.m. receivers are examined. Design consideration to reduce these effects are indicated. . . .

EXPLICIT FORM OF FM DISTORTION PRODUCTS WITH WHITE-NOISE MODULATION
R. G. Medhurst, Proc. Instn. Elect. Engrs., Part C, vol. 107, no. 11, March 1960, p. 120/126.

PSEUDO-RECTIFICATION AND DETECTION BY SIMPLE BILATERAL NONLINEAR RESISTORS
J. E. Bridges, Proc. IRE, vol. 49, Feb. 1961, p. 469/478.

. . . Ordinary carbon resistors . . . and to a more marked degree, certain symmetrical or bilateral nonlinear resistors containing no unilateral elements, can, when a pulse-type ac waveform is impressed upon them, perform a rectification process; this process may be considered solely as a circuit effect. Four basic ac-to-dc converting circuits, some of which are largely independent of temperature, and which employ symmetrical nonlinear resistors, are analyzed.

BANDWIDTH LIMITING EFFECTS OF FREQUENCY SELECTIVE FADING OVER TROSPHERIC SCATTER PATHS

P. D. Shaft, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., Master's thesis, 12 Dec. 1961, 105 p., incl. illus, tables, 28 refs. (Research rept. no. PIBMRI-976-61), AD 281 967.

A set of design curves of intermodulation distortion due to frequency selective fading . . .

A NOTE ON POWER-LAW DEVICES AND THEIR EFFECT ON SIGNAL-TO-NOISE RATIO

C. N. Berglund, Queen's U., Belfast (Gt. Brit.), Aug. 1962, 21 p., incl. illus., 5 refs., AD 291 427.

. . . used as either band-pass non-linear amplifiers or enveloped detectors. . . determined for both limiting cases of very large and very small input signal-to-noise ratios. . . . The results are general . . .

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS

C. E. Cook, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 174/184.

. . . Paired-echo theory has been used to describe the effects of network and time-function distortions (both amplitude, and phase) of pulsed signals. The advent of coded-waveform techniques (e.g., pulse compression) that generate waveforms having sidelobes extending in time has led to the application of paired echo theory in the establishment of design criteria for modern radar techniques. This paper introduces somewhat more general conditions into the paired echo analysis as a basis for conducting experimental work on the effects of phase-error modulation of the time signal in a pulse compression system. . . .

LINEARITY AND INTERMODULATION IN HIGH-POWER TUNED AMPLIFIERS (Correspondence)

R. C. Cumming, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 219/220.

PROBABILITY DISTRIBUTION AT THE OUTPUT OF A LOGARITHMIC RECEIVER

S. Gelston, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., 4 Oct. 1962, 102 p., (Research rept. no. PIBMRI-1087-62), AD 298 294.

DAS NICHTLINEARE VERHALTEN VON TRANSISTOREN BEI GRORER AUSSTEUERUNG (The Non-Linear Behavior of Transitors for Large Signals) (In German)

W. Hilberg, Arch. Elekt. Uebertragung, vol. 16, Nov. 1962, p. 553/564.

An exact mathematical treatment of the nonlinearity problem under large signal conditions appears very difficult and above all unwieldy. On the other hand approximate calculations such as those of Sparkes and Beaufoy, which start from a change control of the transistor present the controlling conditions in the transistor only within such broad lines that no information can be gathered as to the details of the dynamic processes and the nonlinear behavior of the transistor. . . . The present paper attempts to show a simple approach for discussing by calculation in an approximate and clear fashion transient phenomena and the nonlinear behavior which makes itself strongly felt under large signal conditions. This is effected with the aid of the given function of the current amplification and a constant effective lifetime. . . .

TRANSMISSION OF MULTI-LEVEL DIGITAL SIGNALS THROUGH NOISE-FREE DISTORTING CHANNELS

L. W. Hill, Proc. Instn. Elect. Engrs., London (Part B), vol. 109, no. 44, March 1962, p. 165/173.

. . . The case of a channel with an exponentially decaying impulse characteristic, for which the maximum rate is independent of the number of levels, is of special interest as a large class of passive linear networks has this characteristic at least asymptotically. . . .

DEPENDENCY OF CROSSTALK ON UPPER AND LOWER CUTOFF FREQUENCIES IN PAM TIME-MULTIPLEXED TRANSMISSION PATHS

H. M. Straube, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 263/276.

INVESTIGATION OF MODULATIONS ARISING FROM INTERACTION OF ELECTROMAGNETIC WAVES WITH A PLASMA

S. Tetenbaum, et al., General Telephone and Electronics Labs., Inc., Palo Alto, Calif., Rept. for 30 March 1961-31 Oct. 1962, 15 Nov. 62, 118 p., (RADC TDR 62-613), AD 297 479.

INPUT AND OUTPUT IMPENDANCE CONCEPTS IN NONLINEAR AM DETECTORS

B. G. Whitford, National Research Council of Canada, Aug. 1962, 34 p., (Rept. no. ERB-617, AD 299 012.

A VARIABLE GAMMA AMPLIFIER (Correspondence)

P. Kundu, et al., Proc. IEEE, vol. 51, no. 5, May 1963, p. 867/868.

. . . non-linear device which yields an output varying directly or inversely as the nth power or root of an input signal, where n may be an integer or a fraction. . . .

ON THE EVALUATION OF SPURIOUS RESPONSE LEVELS (Correspondence)
F. McManus, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1264.

A classical problem in the design and analysis of receiving systems is the calculation of spurious response levels attributable to intermodulation (IM) products generated in the mixer. The traditional approach to this problem has been to represent the mixer characteristic by a power series and laboriously compute the IM products. The increasing use of nonlinear devices in advanced radar and communications systems has motivated a search for different approaches to this problem. One approach that has been found useful is described. . . .

1.626: Phase and Delay Distortions in Communications Channels

Included: Delay distortion characteristics in long distance systems; Effects of echo and time delay on telephone conversations; Delay variation and influence on data transmission; Delay distortion in multi-mode transmission systems; Fundamentals of automatic phase equalization systems; Phase difference fluctuations in turbulent media; Phase variations on VLF propagation; Phase variations in microwave line-of-sight channels; Echo distortions.

Not Included: Echo effect in satellite communications (4A); Design of equalizers; Adaptive operations in communications systems (2); Diversity reception systems (2).

Cross References: Impulse response of communications channels (1.622); Phase fading in ionospheric propagation (1.632); Phase equalization of lines (1.652); Characteristics of microwave multimode systems (1.655); Characteristics of ionospheric channels (1.632); Characteristics of plasma channels (1.635); Characteristics of VLF channels (1.642); Characteristics of microwave radio channels (1.646); Theory of multipath distortions in general (1.612); Aircraft reflections (1.635).

Principal Publications:

PHASE-COMPENSATION METHODS OF SHAPING A SINGLE-SIDEBAND SIGNAL
A. Semenov, et al., Radio. Moscow, June 1958, p. 27/29.

ASSESSING DELAY DISTORTION EFFECTS IN DATA SYSTEMS
A. D. Fowler, et al., Commun. Electronics, Jan. 1959, p. 918/923, Elect. Engng., vol. 78, Nov. 1959, p. 1085.

. . . Phase characteristics of a system, which can generally be neglected in voice transmission, become important in pulse systems, because the shape of a pulse is influenced greatly by the relative phase of the spectrum components. A quantity frequency used to describe this influence is enveloped delay distortion. . . . object of this article is to illustrate a method for assessing the effects of delay distortion on data-transmission systems, based on experimental tests. . . .

ECHO-DISTORTION IN FREQUENCY MODULATION (Correspondence)
R. Hamer, Electronic Radio Engr., vol. 36, Sept. 1959, p. 353.

VLF PHASE CHARACTERISTICS DEDUCED FROM ATMOSPHERIC WAVEFORMS
A. G. Jean, et al., IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

PHASE INTERCEPT DISTORTION IN FREQUENCY, PHASE, PULSE AMPLITUDE, AND PULSE TIME MODULATION SYSTEMS
C. May, et al., Dunham Lab., Yale U., Quarterly Progress Report No. 7 for the period ending 4 Sept. 1959, 26 p., AD 226 643.

The effects of a phase intercept angle upon the information that is conveyed by frequency, phase, pulse amplitude, and pulse time modulation systems are considered.

FLUCTUATIONS OF PHASE-FRONTS IN THE PROPAGATION OF TEN-CENTIMETRE RADIO-WAVES OVER THE SEA-SURFACE (In Russian)
A. V. Men', et al., Dokl. Akad. Nauk, SSSR, vol. 125, no. 5, April 1959, p. 1019/1022.

MEASUREMENTS OF PHASE STABILITY OVER A LOW-LEVEL TROPOSPHERIC PATH
M. C. Thompson, Jr., et al., J. Res. Nat. Bur. Stand., vol. 63D, July-Aug. 1959, p. 45/51.

WAVE PROPAGATION AND GROUP VELOCITY
L. Brillouin, New York, Academic Press, 1960, 154 p.

MEASUREMENTS OF CHANGES IN THE PHASE PATH OF RADIO WAVES REFLECTED FROM THE IONOSPHERE AT NORMAL INCIDENCE
R. W. McNicol, et al., Austral. J. Phys., vol. 13, no. 2, June 1960, p. 120/131.

Fixed-frequency measurements were made at Brisbane, using pulse transmissions, of the changes in phase of radio waves received after reflection at normal incidence from the various ionospheric layers. . . .

THE PASSAGE OF HIGH-FREQUENCY PULSES THROUGH LINEAR SYSTEMS WITH DELAY FEEDBACKS
A. I. Nedeshev, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 36/40.

A study is made of the variation in the high-frequency content of a rectangular pulse during circulation through a closed system containing an off-tune amplifier with a delay feedback. The dependence of the variation in the frequency content on the initial de-tuning and transmission band of the system is elucidated. . . .

EXPERIMENTAL RELATIONS BETWEEN IONOSPHERIC TRUE HEIGHT, GROUP HEIGHT, AND PHASE HEIGHT
J. A. Thomas, et al., Austral. J. Phys., vol. 13, no. 2, June 1960, p. 132/138.

. . . Temporal changes in these computed values agreed well with experimentally measured changes of phase path both in the case of regular diurnal variations and during an eclipse. . . .

MAINTAINING FIXED PHASE DIFFERENCES BETWEEN MICROWAVE SIGNALS GENERATED AT REMOTE SITES
S. B. Boor, et al., IRE Internat. Conv. Rec., vol. 1, March 1961, p. 123/134.

A relatively simple solution has been developed using closed-loop compensation of transmission medium irregularities to maintain fixed phase relationships between remote sites.

RECOVERY OF INFORMATION TRANSFERRED INTO PHASE MODULATION IN IONOSPHERIC WAVE PATHS
M. Mancianti, et al., Pisa U., Italy, Final rept., Feb. 1962, 37 p. incl. illus., 11 refs., AFCRL 62-547, AD 282 960.

. . . information . . . originally impressed onto a signal as amplitude modulation, has been changed to phase modulation by travelling through the ionosphere . . . at least partial recovery . . . by means of a double homodyne detector was studied . . .

PULSE TRANSMISSION BY AM, FM AND PM IN THE PRESENCE OF PHASE DISTORTION
E. D. Sunde, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 353/422.

PHASE DISTORTION IN HIGH FREQUENCY TRANSISTOR AMPLIFIERS
T. A. Seliga, Ionosphere Research Lab., Pennsylvania State U., University Park, 1 Dec. 1961, 77 p. (Scientific rept. no. 153), AD 268 328.

. . . resulting from the application of automatic gain control. . . . Verification of the theory is made by comparing calculated and measured phase shifts in single amplifiers and a receiving system. The problems of choosing the most suitable type of automatic gain control system, and transistor, based on a minimum phase distortion criteria are also considered.

DELAY VARIATIONS IN TELEMETRY FILTERS
K. L. Berns, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 199/204.

. . . significance of filter delay characteristics in telemetry applications . . . methods of delay measurement . . . experimental results . . . Recommendations . . . regarding filter specifications. . . . Although the study and investigations were conducted with FM/FM telemetry subcarrier discriminators, the results can also be applied to other filter networks such as those used in telemetry transmitting systems. . . .

RAPID PROCESSES IN THE IONOSPHERE
N. D. Bulatov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 25/30.

. . . The rate of phase change in radio waves reflected from the ionosphere, caused by fluctuations in the height of the reflecting layers, is determined. Quantitative data on the phase shifts are obtained. . . .

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS
C. E. Cook, IRE Internat. Conv. Rec., Pt. 4, vol. 10, no. 9, March 1962, p. 174/184.

. . . Paired-echo theory has been used to describe the effects of network and time-function distortions (both amplitude, and phase) of pulsed signals. The advent of coded-waveform techniques (e.g., pulse compression) that generate waveforms having sidelobes extending in time has led to the application of paired echo theory in the establishment of design criteria for modern radar techniques. This paper introduces somewhat more general conditions into the paired echo analysis as a basis for conducting experimental work on the effects of phase-error modulation of the time signal in a pulse compression system. . . .

A TECHNIQUE FOR EQUALIZING PARABOLIC GROUP DELAY (Correspondence)
R. M. Kurzrok, Proc. IRE, vol. 50, no. 8, Aug. 1962, p. 1840.

DIVERSITY RECEPTION AND AUTOMATIC PHASE CORRECTION
L. Lewin, Proc. Instn. Elect. Engrs., Part B, vol. 109, no. 46, July 1962, p. 295/304.

MULTIPLE ECHO DISTORTION IN FREQUENCY-MODULATION, FREQUENCY-DIVISION, MULTIPLEX TRUNK RADIO SYSTEMS
R. G. Medhurst, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 61/71.

. . . due to a number of echoes of differing amplitudes and delay times. General formulas are developed . . . Examples considered are 100- and 200-ft. runs of RG-50/U waveguide, in 10-ft. sections, for use in the 6000 Mc band. . . .

DIGITAL TRANSMISSION IN MEDIA OF VARIABLE TIME DELAY

E. M. Bradburd, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 438/442.

. . . requires suitable techniques for bit synchronization, bit identification and time division multiplexing. Increasing refinements in these techniques are needed in the progression from networks of two nodes connected by a single link to a number of nodes joined by tandem links and thence to networks of higher connectivity. The addition of link encryption and multiplexing of information imposes even more severe constraints. . . . the three key terms in this analysis. . .

THE NORMAL PHASE VARIATIONS OF THE 18 KC/S SIGNALS FROM NBA OBSERVED AT BOULDER, COLORADO, U. S. A.

A. H. Brady, et al., Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., 10 April 1964, 27 p., NBS CRPL TN206 3, AD 435 848.

. . . given in the form of monthly averages and standard deviations at five minute intervals. The relations between the diurnal phase variations and the diurnal variation in the length of sunlit path are shown. . . . Values of the short term phase differences are also given.

ON THE LONG TERM PHASE STABILITY OF THE 19.8 KC/S SIGNAL TRANSMITTED FROM HAWAII, AND RECEIVED AT BOULDER, COLORADO

A. H. Brady, Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., 31 Oct. 1963, 7 p., Rept. no. P68D3 343, AD 435 897.

The use of VLF signals for intercontinential frequency comparison is now popular, and it was shown that a precision of about 2 parts in 10 to the 11th can be achieved with measurements over a 24-hr period. Phase records made at Boulder, Colo., of the NPM, Hawaii, 18.6 kc/s transmission. . . of nearly two weeks duration in 1962. . . . show an attainable precision of 2.5 parts in 10 to the 11th in a 24-hr observation, extending to 3.1 parts in 10 to the 12th in a 192 hr observation. . . .

ARBITRARY DELAY EQUALIZATION UTILIZING DIGITAL COMPUTER IBM 704

L. S. Cheo, Electronics Research Lab., U. of Calif, Berkeley, 5 July 1960, 43 p., Rept. no. 106, AD 418 407.

PHASE VARIATIONS IN V.L.F. PROPAGATION

C. J. Chilton, et al., In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, p. 257/290, refs, (See N64-19676) Pergamon Press and MacMillian Co., N64-19695.

The experimental work describing the variation in phase of VLF signals received after ionospheric reflections at small and large distances is reviewed. . . At all distances, regular systematic variations in phase occur when the path changes from day to night. . .

SOME PARTICULAR OBSERVATIONS ON DIURNAL PHASE VARIATIONS OF VLF TRANSMISSIONS RECEIVED IN PARIS

B. Decaux, et al., (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-312), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 21/25, 7 refs., A64-14686.

Examination of observed VLF transmission variations during particular geographic situations and ionospheric phenomena. It is noted that a quick phase change has been observed at sunrise, remaining nearly constant during the day, and changing again more slowly at sunset . . . amplitude also varies slightly with the seasons. . . .

REAL-TIME MEASUREMENT AND CORRECTION OF PHASE DISTORTION IN HIGH-FIDELITY RADARS

J. DeLorenzo, et al., IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 96/103.

. . . Phase distortion causes variations in the radar uncertainty function, that, in many cases, degrade the resolution capability of the system. This paper briefly describes the characteristics of the common forms of distortion in practical systems and deals with the analytical and experimental results of phase measurements using a multiplier-type phase-error detector. The relationship of this device to active correlators and uncertainty function plotters will be described. A discussion of real-time correction of phase distortion with experimental results also is included. . . .

THE INFLUENCE OF RANDOM PHASE ERRORS ON THE ANGULAR RESOLUTION OF SYNTHETIC APERTURE RADAR SYSTEMS

J. A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., 20 June 1963, 40 p. Rept. no. TDR169 3250 43TN4, AD 408 761.

THE EFFECTS OF TIME DELAY AND ECHOES ON TELEPHONE CONVERSATIONS

J. W. Emling, et al., Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2869/2891.

. . . brief history. . . Actual delays involved in typical circuits. . . discussion of the effects of delay only on typical conversations. . . sources of echo . . . measures . . . to reduce echo by improving return loss. . . introduction to echo suppressors and some of the new problems they introduce.

TIME-VARYING CHANNELS WITH DELAY SPREAD

P. E. Green, Jr., IN: RADIO WAVES AND CIRCUITS; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 208/224; Discussion, p. 225/226, 21 refs., A64-10835.

. . . results on two topics, (1) the characterization of time-varying linear communication channels (or radar targets) having a spread of propagation delays, (2) the design of optimum receivers for detecting or distinguishing between signals propagated by such media. It has proved useful to model the channel as a tapped delay line in which each individual tap output undergoes a random time variation before being added to the other tap outputs to form the channel output. . . . particular emphasis on Price's formulation of a class of receivers that are optimum at small input signal-to-noise ratios.

AN EXPERIMENTAL STUDY OF THE PHASE STABILITY OF VLF SIGNALS

D. E. Hampton, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-311), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 19/20, A64-14685.

Examination of diurnal phase variation records. Phase and amplitude of VLF signals have been shown to be stable from day to day. For distances exceeding 4000 km, phase difference is linearly dependent on distance. In cases of paths part in light and part in dark, a "step" is assumed in the ionosphere height at the dawn and dusk points, and phase velocity is discontinuous across these points. . . .

A RELATIONSHIP BETWEEN IMPULSE RESPONSE OVERSHOOT AND PHASE RIPPLE (Correspondence)

D. S. Humphreys, IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 450/452.

THEORY OF THE MEASUREMENT OF RELATIVE DELAY BETWEEN TWO SAMPLES OF AN UNKNOWN SIGNAL

P. W. James, Royal Aircraft Establichment (Gt. Brit.), March 1963, 22 p., RAE TN no. Rad 834, AD 410 362.

. . . It will be supposed that we are receiving a signal from a source simultaneously through two similar channels. Each channel imposes a time delay on the signal. We wish to measure the difference between these two delays. . . reception of the signal from a radio transmitter at two spaced receivers. Formulae are obtained for the mean and standard deviation of the measured delay, both in the absence of and in the presence of additive noise. It is shown how the probable error is related to the statistical properties of the signal and the noise.

CORRELATION OF THE PHASE OF MICROWAVE SIGNALS ON THE SAME LINE-OF-SIGHT PATH AT DIFFERENT FREQUENCIES

H. B. Janes, IEEE Trans. Antennas Propagation, vol. AP-11, Nov. 1963, p. 716/717, A64-11819.

. . . experiments conducted to measure the relative phase and amplitude variations of two microwave signals sent over the same line-of-sight path at slightly different frequencies. Diagrams showing phase variations and phase difference variations of 9.4 and 9.2 Gc signals are included.

A FUNCTIONAL ANALYSIS RELATING DELAY VARIATION AND INTERSYMBOL INTERFERENCE IN DATA TRANSMISSION

R. W. Lucky, Bell Syst. Tech., vol. 42, no. 5, Sept. 1963, p. 2427/2483.

A relationship is derived between the delay characteristic in a data transmission system and the distortion in the form of intersymbol interference created by the delay variation. The relationship is valid for small delay and involves a sequence of linear functionals, each of which has a particular significance. . . .

METODA FAZOVYKA IZMERENII IZMERENE V SLUCHAE NEKOGERENTNYKA SIGNALOV (Investigation of the Phase Method in Application to Incoherent Signals) (In Russian)

V. I. Medvedev, Moskovskii Universitet, Vestnik, Seriia III - Fizika, Astronomiia, Nov.-Dec. 1963, p. 77/84, 15 refs., A64-15470.

. . . a stroboscopic method for measuring the change in phase difference of signals stable with respect to frequency and of appreciable frequency separation. . . .

AUTOCORRELATION CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS (Translation)

A. V. Men', Telecommun. Radio Engineering, Part II - Radio Engineering, vol. 18, Feb. 1963, p. 26/35, 16 refs., A63-20641.

. . . which occur in the propagation of waves in a turbulent medium. Using a phenomenological description of the medium by means of a correlation function of Gaussian form, the autocorrelation coefficients for various paths are determined by taking into account the effect of transport both of "frozen" and "unfrozen" turbulence.

SPECTRAL CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS (Translation)
A. V. Men', Telecommun. Radio Engineering, Part 2 - Radio Engineering, July 1963, p. 24/32, 10 refs., A64-15463.

. . . spectral characteristics of phase-difference (amplitude) fluctuations for waves propagating in a turbulent medium. . . It is noted that when measurements are carried out over large bases, the phase-difference fluctuation spectrum has, independently of the path type, an oscillatory behavior. . . .

THE NATURE OF AND SYSTEM INFERENCES OF DELAY DISTORTION DUE TO MODE CONVERSION IN MULTIMODE TRANSMISSION SYSTEMS
S. E. Miller, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2741/2760.

. . . For PCM in an all-helix waveguide, it is concluded that a pulse rate up to 5000 megabits and up to 746 miles between regenerators is permitted by mode conversion effect. . .

For transmission of frequency division multiplex via a frequency-modulated carrier (FDM-FM), estimates based on the discrete-echo theory of Bennett, Curtis and Rice suggest that 4000-mile transmission of 2000 channel groups is possible in all-helix waveguide. . .

AUTOMATIC TIME-DOMAIN EQUALIZATION
W. S. Mohn, Jr., et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 1/9.

. . . a method of reducing intersymbol interference in data-communication systems. . . . will operate as a predistortion device at the transmitter or as a post-distortion device at the receiver. The equalizer will adapt or train to a given communication system either manually or automatically. . . . digital approach which stores sixteen samples to provide the necessary history of the data transmitted. . . .

THEORY OF STOCHASTIC DELAYS
C. J. Palermo, Institute of Science and Tech., U. of Michigan, Ann Arbor, July 1963, 57 p., AD 411 397.

. . . The effects of stochastic delay on power spectra and correlation functions are described; system performance is considered in terms of least squares filtering, doppler and range estimation, signal to noise ratio and the probability of detections and false alarms. . . special cases are considered, such as small and large variance delays, narrow and broad bandwidth delays, Gaussian delays, and delays in narrowband systems.

EXPERIMENTAL MF/HF PHASE PATH STUDIES
H. E. Petrie, et al., National Bureau of Standards, Boulder, Colo., 14 Aug. 1963, 1v., AD 416 335.

. . . experimental measurements on phase path changes and group path time delays of MF and HF signals reflected from the ionosphere at vertical and oblique incidence are discussed and analyzed with a view to the value of these types of measurements in detection of deep space nuclear detonations.

PROPAGATION DELAY FROM WWV
D. W. Proctor, Sperry Gyroscope Co., In its Minimum Variance Orbit Determination Program, 8 Nov. 1963, p. 56/60, N64-18229.

The raw data from the range-and-range rate system are related to the time of the measurement at the ground station. These times are synchronized to WWV and include the time delay from WWV to the ground site. . . propagation-delay corrections from WWV to the site must be included . . . Since only three stations are involved, these corrections can be precomputed and stored as program constants for each station location. An equation is derived for computing timing-signal delay from WWV to a range-and-range-rate tracking station. . .

AN AUTOMATIC PHASE-CORRECTION SYSTEM
P. Rademacher, et al., IEEE Internat. Conv. Rec., vol. 11, no. 3, March 1963, p. 179/186.

In recent years the requirement for high-fidelity signal reproduction in microwave systems has led to increasing efforts toward minimizing system phase nonlinearities. Such a requirement is present in pulse compression radar systems where phase nonlinearities in the transmitter or receiver lead to the generation of paired echoes from the target. . . .phase nonlinearities no greater than $\pm$ 1 degree for complete system are desirable. . . .

RECENT V. L. F. WORK AT THE U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
F. H. Reder, et al., In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, p. 335/338, refs., Pergamon Press and Mac Millan Co., N64-19698.

. . . propagation studies and long-distance clock synchronization experiments that have been conducted. . . since 1959. Atomic Cs beam frequency standard, type NC 1001, was used for driving transmitters and clocks, and for providing local references for VLF and LF receivers. Measured values of the depth of the phase trapezoid patterns for various VLF transmission paths are included.

ANALYSIS OF AN OPTIMIZING SYSTEM USED FOR MEASUREMENT OF PARAMETERS OF AN UNKNOWN SYSTEM
W. B. Roeca, Antenna Lab., Ohio State U. Research Foundation, Columbus, 30 Nov. 1960, 69 p., AD 409 282.

Analysis is made of the convergence of a model transfer function's parameter values when they are adjusted by adaptive control systems to approximate an unknown transfer function. Convergence depends on the adaptive loops' velocity constants and on the operating signal's parameters. . .

TROPOSPHERIC PHASE FLUCTUATIONS AT S-BAND
H. A. von Biel, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Oct. 1963, 21 p., Rept. no. UB1725 1, RADC TDR63 408, AD 423 223.

A tropospheric propagation experiment to obtain the mean square phase fluctuations at 2250 mc over a 48-mile path is described. Experimental data pertain to a 10-minute time interval on a meteorologically quiet day . . . The experimental equipment used in this experiment consisted of four phase-locked interferometers having baselines of 100 m and 100 m north-south and east-west. The 2250-mc signal source was carried on board a B-57 aircraft at a mean altitude of 40,000 ft.

INVESTIGATION OF PHASE INTERACTION AS A MEANS FOR THE STUDY OF THE LOWER IONOSPHERE
S. Weisbrod, Ionosphere Research Lab., Penn. State U., University Park, 1 March 1964, AD 435 736.

. . . a new technique. . . based on the simultaneous observations of phase and amplitude wave interaction. . . . To measure, or even to detect . . . minute changes in the phase of ionospherically reflected echoes, which are subject to rapid amplitude fading and phase tumbling, required the development of special techniques and instrumentation. The scheme is based on the extension of the Fejer pulse technique which has been used in the past by a number of investigators in the study of the amplitude interaction. The theory of interaction is extended and generalized by the introduction of the complex coefficient of interaction, which embodies both amplitude and phase effects. . . . On the average, below 75 or 80 km., the phase perturbations, measured in radians, are stronger than the amplitude perturbations.

Related Publications:

THE OPTIMAL DISTRIBUTION OF SIGNAL POWER IN A TRANSMISSION LINK WHOSE ATTENUATION IS A FUNCTION OF FREQUENCY (Correspondence)
G. Raisbeck, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 129/130.

EFFECTS OF FREQUENCY CUTOFF CHARACTERISTICS ON SPIKING AND RINGING OF TV SIGNALS
A. D. Fowler, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959. p. 173/179.

The spiking and ringing of TV signals depend upon amplitude and delay characteristics associated with frequency cutoff of transmission. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS (PHASE 2 REPORT).
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Rept. for Jan. 1961 - Jan. 1962, 20 Feb. 1962, 311 p., incl. illus., refs. (Rept. no. UA-1420-S-2), RADC TDR 62-134, AD 276 847.

. . . The optimization of systems operating over dispersive channels in the presence of nonwhite, gaussian noise is treated and the effects of medium phase perturbations on the performance of digital systems are analyzed. . . .

SYSTEM PERFORMANCE IN THE PRESENCE OF STOCHASTIC DELAYS
W. M. Brown, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 206/214.

A STUDY OF PHASE FADING OF IONOSPHERIC REFLECTIONS
P. E. Monro, Austral. J. Phys., vol. 15, no. 3, Sept. 1962, p. 387/404.

Pulsed 2.28 Mc/s radio waves were transmitted and measurements were made on the first-hop, vertically - incident reflections from the ionosphere. A method of continuously recording the changes of phase difference between the signals at two aerials is described. . . . it is shown that the quasi-periodic type of fading can be explained in terms of two component rays being reflected from two reflecting areas of the ionosphere and interfering at the receiving aerials. The horizontal separation of the two regions is about 50 km in the case analysed. . . .

DEPENDENCY OF CROSSTALK ON UPPER AND LOWER CUTOFF FREQUENCIES IN PAM TIME-MULTIPLEXED TRANSMISSION PATHS
H. M. Straube, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 268/276.

SLOZHENIE SINUSOIDAL'NYKH KOLEBANII S NARASTAIUSHCHIM SLUCHAINYM RAZBROSOM FAZY (Addition of Sinusoidal Oscillations with a Growing Random Phase Scatter) (In Russian)
I. K. Barsukov, Radiotekhnika i Eletronika, vol. 8, July 1963, p. 1106/1110, A63-24399.

EFFECTS OF PHASE ERRORS ON THE AMBIGUITY FUNCTION
W. M. Brown, et al., IEEE Intern. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 118/123.

. . . The lack of perfect coherence (specifically, phase errors) in a radar or sonar system limits system accuracy and resolution. Two types of phase errors are considered here: (1) Time phase errors which appear as a multiplicative factor . . . on the received pulse; local oscillator drift is a typical source of such a phase error. (2) Frequency phase errors (or dispersion) which appear as a multiplicative factor. . . on the Fourier transform of the received pulse; such phase errors appear if propagation "constants" or reflection characteristics change as a function of frequency over the bandwidth of the transmitted pulse. . . .

THE PROPAGATION TIME OF A RADIO PULSE
J. R. Johler, IEEE Trans. Antennas and Propagation, vol. AP-11, Nov. 1963, p. 661/668., 13 refs., A64-11806.

. . . propagation of the ground wave over finitely conducting ground which modifies the propagation time of the tagged point-in-time on the envelope by amounts which may be sufficiently large as to cause cycle ambiguity $\pm \pi$ radians at the carrier or characteristic frequency of the pulse. . . .

MOP-UP EQUALIZER FOR AMPLITUDE AND DELAY DISTORTION IN IF BAND FOR 6GC 1800 CHANNEL SYSTEM
T. Kawahashi, et al., IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 163/176.

NOTE ON THE ELIMINATION OF DELAY DISTORTION IN BROAD-BAND LONG DISTANCE SYSTEMS (Correspondence)
E. J. Post, Proc. IEEE, vol. 51, no. 4, April 1963, p. 627/628.

. . . The slope of the attenuation in the neighborhood of the edge of the pass band is very steep; in the limit, it may be conveniently represented by two impulse functions of opposite sign at ω_1 and ω_2, the limit points of the pass band. . . .

PHASE DISTORTION IN L. F. RADAR AMPLIFIERS (In French)
G. Thomas, Onde Electr., vol. 43, no. 433, April 1963, p. 400/407.

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 19, 1963, 51 p., 9 refs., N63-23350.

. . . Specifically considered is a binary symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise . . .

UBER PHASE UND GRUPPENLAUFZEIT (On Phase and Group Transmission Time) (In German)
H. Wolf, Nachrichtentech. Z., vol. 16, Sept. 1963, p. 457/460, A63-24421.

. . . The conditions for distortion-free transmission of instantaneous values and modulation products, and the concept of signal delay, are explained by means of an idealized phase curve of a bandpass filter, and are illustrated by a model example. Quantities important for the determination of distortions are indicated.

RESEARCH STUDY OF SYNCHRONIZATION IN DIGITAL SWITCHING SYSTEM
ITT Federal Labs., Nutley, N. J. Quarterly rept. no. 2, 1 July 1962 - 1 March 1963, 1 March 1963, 52 p., AD 407 314.

. . . various methods of providing synchronization in a switching system using time division multiplex transmission between exchanges. . . . study of . . . long-term propagation delay variations in microwave radio and cable systems.

1.628: Various Other Distortions

Included: Polarization distortions; Frequency shift distortions; Frequency translation distortions in carrier transmission systems; Antenna distortions; Distortions in storage media; Polarization system analysis; Faraday polarization rotation; Bit loss or bit gain distortion in data systems.

Not Included: Polarity coincidence detectors (2); Physics of ionospheric propagation; Polarization characteristics of antennas; Transpolarizer circuits.

Cross References: Characteristics of ionospheric channels (1.632); Multi-mode distortions in waveguides (1.655).

Principal Publications:

ALTITUDE VARIATION OF FIELD STRENGTH FOR VERTICALLY POLARIZED LOW AND BROADCAST FREQUENCY RADIATION
J. R. McGonegal, et al., IRE Trans. Antennas Propagation, vol. AP-6, July 1958, p. 278/281.

THE USE OF VERTICAL POLARIZATION TO SOLVE UHF TELEVISION "GHOSTING" PROBLEMS IN A SHADOWED VALLEY
D. W. Peterson, RCA Rev., vol. 19, no. 2, June 1958, p. 208/215.

UHF Television broadcasting in hilly or mountainous terrain suffers from "ghosting" or multi-path reception in shadowed valleys. An experimental study of the ghosting problem has led to the conclusion that vertically polarized co-channel amplifier boosters and passive boosters will solve the problem of serving shadowed valleys. New service can be rendered without denying any existing service resulting from creation of a "mush" area. . . .

POLARIZATION OF ATMOSPHERIC PULSES DUE TO SUCCESSIVE REFLECTIONS FROM THE IONOSPHERE
A. P. Tantry, et al., J. Geophys. Res., vol. 63, Sept. 1958, p. 527/538.

SPIN VARIATIONS OF SATELLITE RADIO EMISSION
P. R. Arendt, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 407/412.

Most of the propagation effects observed from the radio emissions of earth satellites are related to their translatory movement. . . . the rotational and tumbling movements of the satellites were causing similar changes in the amplitude of received radio emissions. These variations or spin-type fadings are due to the changing position of the spatial pattern of the satellite's antenna with respect to the also-changing ray path from the satellite to the ground observation point. . . .

POLARIZATION COMPUTATIONS BY MEANS OF THE MULTISLAB APPROXIMATION
A. J. Ferraro, et al., J. Atmos. Terr. Phys., vol. 16, Oct. 1959, p. 136/144.

EFFECT OF ANTENNA PHASE PATTERN ON DOPPLER SYSTEM OPERATION
H. S. Rothman, et al., Conf. Proc. Nat. Conf. Mil. Electronics, vol. 4, June 1960, p. 503/509.

DOPLOC SYSTEM STUDIES
W. E. Scharfman, et al., Stanford Research Inst., Menlo Park, Calif., Final rept., pt. B., July 1960, 70 p., Rept. no. 10., AD 419 771.

. . . A number of effects are discussed that are associated with the propagation of electromagnetic waves from the ground to a satellite and back to the ground again. . . .

THE CHANNEL CAPACITY OF ONE- AND TWO-PATH COMMUNICATION CHANNELS WITH POLARIZATION (In Russian)
L. Khai-Tsyuan', Radiotekhnika i Elektronika, vol. 6, no. 2, Feb. 1961, p. 200/203.

The channel capacity of the received signal is calculated for a uniform distribution of the angle between the electric field and a horizontal vibrator, with additive Gaussian noise. Particular cases given are for small signal to noise power ratios and for a high signal to noise power ratio. . . .

ON THE DYNAMIC RANGE OF A MAGNETIC RECORDING CHANNEL
M. V. Gitlits, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 4, April 1962, p. 65/75.

The effect of irregularities in efficiency of ferromagnetic recording media and of tape-transport flutter on the dynamic range of a channel during direct magnetic recording of signals is analyzed as is the use of amplitude, frequency and pulse-width modulation. . . .

EFFECT OF PROPAGATION FADING AND ANTENNA FLUCTUATIONS ON COMMUNICATION SYSTEMS IN A JAMMING ENVIRONMENT
A. B. Glenn, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 43/60.

. . . The results are plotted for a large variety of fading conditions for both the desired and undesired signals and antenna fluctuations. . . .

ON THE RECEPTION OF QUASI-MONOCHROMATIC, PARTIALLY POLARIZED RADIO WAVES
H. C. Ko, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1950/1957.

The response of an elliptically polarized antenna to a quasi-monochromatic, partially polarized radio wave is treated from the standpoint of coherence theory. A general formula is derived for the available power at the terminals of a receiving antenna in terms of appropriately chosen coherency matrices for the antenna and the incident wave. . . .

FAR-FIELD WIDE-BAND DISTORTION PATTERNS OF ANTENNAS
D. J. Lewinski, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 132/138.

COORDINATING ANTENNA PERFORMANCE OF COMMUNICATION CIRCUIT REQUIREMENTS
S. Perlman, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 179/183.

. . . for HF signals beyond the horizon, complex changes in propagation phenomena affect in particular, the vertical (elevation) angle of the ray path with the passing hours of the day, season, and portion of the sun-spot cycle. More than one mode of propagation ray is possible and sometimes exist simultaneously. . . . "Angle of Arrival" studies . . . for a particular point-to-point circuit over the period of a sun-spot cycle. The results have been used in selecting the performance requirements of the antennas when the frequency assignments are known. . . .

BIT LOSS AND GAIN CORRECTION CODE
F. F. Sellers, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 35/38.

A block code is presented that will correct an error consisting of the gain or loss of a bit (binary digit) within the block. The code can be generalized to correct the loss or gain of a burst of bits. A further feature is the possibility of correcting additive errors appearing in the vicinity of the bit loss or gain. . . . a received message has a different number of bits (binary digits) than the transmitted message had. One cause of such errors is the temporary loss of synchronization between the transmitter and the receiver. . . . Even the self synchronizing comma-free codes are not able to decode a character containing a bit loss or gain error. . . .

THE SIGNAL/NOISE GAIN OF IDEAL RECEIVING ARRAYS
V. G. Welsby, Proc. Instn. Elect. Engrs, (Part C), vol. 109, no. 15, March 1962, p. 108/116.

SATELLITE MEASUREMENTS OF RADIO BREAKTHROUGH
E. A. Atkins, et al., Canadian Journal Physics, vol. 41, Aug. 1963, p. 1388/1393, A63-22887.

. . . of a signal identified as "breakthrough from the ground" received by Transit 2A . . . appears as a rectified sinusoid with noise superimposed . . . The period of the variation in amplitude is appropriate to the spin rate of the satellite . . . The precise times of observation of breakthrough are supplied.

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING
R. S. Berkowitz, et al., Moore School of Electrical Engineering, U. of Penn., Philadelphia, Interim rept., Rept. no. 64 08 2., AD 431 882.

. . . Three different aspects . . . First a study of propagation properties of the troposphere scatter communication is concluded. . . . all available evidence indicates that transmitted polarization properties will be essentially preserved through the medium up to the point of reception. . . . second study . . . has to do with construction of a statistical model of the propagation medium consistent with our knowledge of scatter propagation characteristics that can be used as the basis of system design. Such a channel model incorporating random fading statistics has been set up.

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING VOLUME II POLARIZATION SYSTEMS ANALYSIS
R. S. Berkowitz, et al., Moore School of Electrical Engineering, U. of Pennsylvania, Philadelphia, Jan. 1964, 74 p., Rept. no. 64 02, RADC TDR63 396, vol. 2, AD 430 249.

. . . The choice of frequency range based upon preservation of polarization is discussed and a few factors which can lead to depolarization at higher frequencies are mentioned. . . . polarization effects that take place in propagation via the ionosphere . . . future applications to satellite communication. The troposcatter propagation factors affecting a polarization programming system are presented. . . . Two appendices discuss a statistical model of a fading channel and a specific system incorporating one of the given design philosophies, respectively. The application of polarization programming to an over-the-horizon troposcatter link seems to be feasible, it should lie in the range of 1 to 10 kilomegacycles per second.

OWENS VALLEY RADIO OBSERVATORY. 7. LINEAR POLARIZATION MEASUREMENTS OF THE DECIMETER WAVELENGTH RADIATION FROM SMALL DIAMETER RADIO SOURCES
G. A. Seielstad, et al., California Inst. of Tech., Pasadena, 1963, 8 p., AD 422 681.

The two 90-foot antennas at Caltech's Owens Valley Radio Observatory have been used as an interference polarimeter in an extensive investigation of the linear polarization properties of a number of discrete radio sources . . the distribution of polarization over the source became significant and necessitated a completely different type of analysis. Such an analysis is being carried out on the resolved sources and will be reported elsewhere. We report here only the measurements made between July and November, 1962 . . .

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab. Mass. Inst. of Tech., Lexington, 19 Feb. 1963, 44 p., TR 301, AFESD TDR 6368, AD 406 882.

. . . in a binary, symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise. . . .

IONOSPHERIC RESEARCH AND PROPAGATION STUDIES
H. D. Webb, et al., Electrical Engineering Research Lab., U. of Illinois, Urbana., Quarterly progress rpt. no. 11, 1 Jan.-31 March 1963, 13 June 1963, 27 p., AD 419 683.

Observations of moon reflected signals were made on 40 days for a total of over 322 hours. The relative polarization angles have been read out from all of the data. . . .

POLARIZATION OF RADIO WAVES PASSING THROUGH A TRANSVERSE MAGNETIC FIELD REGION IN THE SOLAR CORONA
V. V. Zhelezniakov, et al., (Astron. Zh., vol. 40, July-Aug. 1963, p. 633/642.), In Russian, Soviet Astronomy, vol. 7, Jan.-Feb. 1964, p. 485/491, 11 refs., Translation, A64-13264.

Related Publications:

THE TRANSPOLARIZER: AN ELECTROSTATICALLY CONTROLLED CIRCUIT IMPEDANCE WITH STORED SETTING
C. F. Pulvari, Proc. IRE, vol. 47, June 1959, p. 1117/1123.

This new device operates by the controlled transfer of polarization through two or more ferroelectric dielectric sections in series and therefore is named "transpolarizer." It represents a new basic means for storing and gating electrical signals and, in general, means to control circuit impedance in any predetermined manner according to a stored setting.

AN ULTRA-HIGH FREQUENCY CW REFLECTION MEASURING SYSTEM
S. Mikuteit, Ohio State U. Research Foundation, Columbus Antenna Lab., June 30, 1963, 85 p., 21 refs, N63-21264.

. . . For the study of echo-area control, a CW radar facility operating at a frequency of 422 Mc. with a variable range from 30 to 103 ft. and the capability to vary the polarization of transmitting and receiving antennas continuously through 90 deg. has been constructed and calibrated . . .

UTILIZATION OF THE FARADAY EFFECT IN IONOSPHERIC STUDIES
B. C. Potts, Ohio State U. Research Foundation, Columbus, Bedford, Mass. A. F. Cambridge Res. Labs., March 15, 1963, 173 p., 59 refs, (Rept. 1116-28; AFCRL-63-109), N63-23110.

. . . When a linearly polarized antenna is used to receive continuous wave radio transmissions from an artificial earth-satellite, the amplitude of the radio signal exhibits a quasi-periodic fading due to the Faraday polarization rotation of the down-incoming wave. This fading may be used to ascertain the electron density as a function of height in the ionosphere by synthesizing the actual conditions that produced the observed rate of fading . . .

DESIGN AND PERFORMANCE OF A POLARITY COINCIDENCE DETECTOR
M. Raether, et al., Coordinated Science Lab., U. of Illinois, Urbana, Aug. 1963, 25 p., Rept. no. R 178, AD 418 173.

. . . The present instrument works in the range of 20 c/sec to 20 Kc/sec and is capable of measuring signal-to-noise ratios as low as 10 to the -4th power . . . very reliable tool for the synchronous measurement of small ac signals.

POLARIZATION CONSIDERATIONS FOR A DUAL CHANNEL RECEIVING ELEMENT
E. J. Christopher, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., June 1963, 14 p., AD 409 153, N63-18377.

A means of optimumly receiving electromagnetic energy from a wave whose polarization is not necessarily constant or known is discussed . . .

THE USE OF AN HF LUNAR REFLECTION CIRCUIT IN THE STUDY OF IONOSPHERIC ELECTRON DENSITY
J. R. Davis, et al., Naval Research Lab., Washington, D. C., 19 July 1963, 12 p., NRL rept. 5968, AD 414 850.

. . . The received moon echoes were subjected to a high degree of predetection bandwidth narrowing and were analyzed to yield information regarding the possible extent of polarization-rotation undergone by radio waves traversing the ionosphere.

ORIENTATION OF LINEARLY POLARIZED HF ANTENNAS FOR SHORT-PATH COMMUNICATION VIA THE IONOSPHERE NEAR THE GEOMAGNETIC EQUATOR
G. H. Hagn, Stanford Research Inst., Menlo Park, Calif., Aug. 1963, 26 p., Research Memo no. 5, AD 418 497.

There is an optimum orientation for linearly polarized antennas used on short ionospheric paths near the geomagnetic equator. Consideration of the magneto-ionic theory and its application to antenna-to-medium coupling problems indicates that aligning such antennas parellel to the earth's magnetic field will maximize signal strength while minimizing polarization fading. Such orientations may intercept less interference than vertically polarized antennas . . .

GROUNDWAVE PROPAGATION EFFECTS ON MICROSECOND PULSES AT 141 MCS
R. W. Heffner, IEEE Intern. Conv. Rec., pt. 8, vol. 11, March 1963, p. 182/196.

. . . A test program was performed to investigate the propagation effects around 141 mcs using microsecond pulses of different carrier frequencies. These investigations used omnidirectional antennas at the transmitter and receiver locations. Antenna height at both locations was twelve feet. The results to be discussed are: a) propagation attenuation contour; b) pulse stretching; c) selective fading and enhancement of pulses within the time-frequency matrix frame; d) backscatter pulse stretching, and; e) polarization dependence. . . . only limited information was applicable to the special wide band multiple pulse system requirements of RACEP. . . .

DETECTION OF SOLAR PARTICLE STREAMS USING HIGH-FREQUENCY RADIO WAVES
B. B. Lusignan, Stanford U., Stanford Electronics Labs., Calif., April 1963, 39 p., 9 refs, (Tech. rept. 1403-3; SEL-63-041; AFCRL-62-7994), N63-17573.

Interactions between radiowaves and charged particles change their character when the particles have high average velocities. The nature of such interactions is investigated, assuming no collisions, no external magnetic field, and low particle densities. A stream of such particles make the medium anisotropic. As a result, the medium propagates two waves of unchanging (characteristic) polarization, one linearly polarized perpendicular to the particle stream, and a second at right angles to the first.

CROSS-POLARIZATION WITH REFERENCE TO TELEVISION PLANNING
D. E. MacDonald, et al., Proc. Instn. Radio Engrs. Australia, vol. 24, no. 7, July 1963, p. 570/582.

. . . describes measurements taken of the horizontally polarized component (E_H) and the vertically polarized component (E_V) of the emissions of existing TV stations. In the analysis, it is shown that the statistical distribution with location of the parameter E_H/E_V from one station, although currently used, does not provide a valid means of estimating the improvements to be expected when using cross-polarized transmitters as a means of reducing interference. . . . Cross-polarization should be of greatest use . . . where the receiving location lies between the wanted and unwanted stations. The analysis relates to the effects of propagation and does not take into account the problems of domestic receiving aerial installations. . . .

POLARIZATION MEASUREMENTS DURING SCINTILLATION OF RADIO SIGNALS FROM SATELLITES
J. P. McClure, Journal of Geophysical Research vol. 69, April 1, 1964, p. 1445/1447, A64-16803.

Brief review of measurements obtained from Transit 4A Charts are given which show segments of satellite records, including dipole, turnstile, and polarimeter (antenna-goniometer-receiver combination) signal strength channels . . . The random polarization angle variations observed were never large enough to obscure the regular Faraday effect at 54 Mc during the period March through June 1963. . . .

ACHIEVING EFFICIENT WIDE-BAND OPERATION WITH SHORT ANTENNAS
A. Macovski, Proceedings, IEEE, vol. 51, May 1963, p. 863/864, A63-16790.

Section 1.63
Natural Propagation Media and Their Characteristics

To date space communications systems must use electromagnetic waves of one kind or another. These waves transverse a variety of regions around the Earth and in space which effect their mode of propagation in many ways. This in turn causes distortions of the communications signals or may even interrupt communications completely.

This section contains a combination of references to papers describing our increasing understanding of the natural phenomena which enable or impede electromagnetic wave propagation. The further sections in this division refer to publications which demonstrate how engineers convert this increased understanding into practical results when establishing improved communications links.

The present section is arranged in nine subdivisions. The first subdivision is devoted to analytical models of natural media. The next seven subdivisions deal with special regions in space and around the Earth. These subdivisions start with the regular (1.632) and irregular characteristics (1.633) of the ionosphere and continue with the troposphere (1.634), the lower atmosphere and the Earth surface (1.635) to subterraneous propagation (1.636). The subdivision 1.637 contains references on propagation media in special geographical regions of the Earth and 1.638 is a collection of all other references, primarily of discussions about extraterrestrial propagation phenomena.

The last subdivision 1.639 brings a review of experimental techniques for the systematic evaluation of all these natural media.

It is important to recognize that in all these subdivisions the selections are largely restricted to publications which may contribute ultimately to the problems of practical communications systems.

Astrophysical and geophysical research results are excluded from this section, as are results from operational communications systems and equipment descriptions, except those referring to experimental installations. Results from ionospheric satellites and from observations of satellite transmissions are included on a selective basis when they meet the above selection criteria. The reader is invited to check in volume 4B for further reports on ionospheric research satellites.

Disturbances originating within these natural media, such as atmospheric noise, will be discussed in section 1.7.

1.631: Analytical Background for the Description of Natural Propagation Media

Included: Books and surveys on propagation media; Definitions of propagation terms; Mathematical models of propagation media; Calculation of ionospheric propagation paths; Perturbation methods in path evaluation; Ionospheric ray tracing; Fresnel surface integral.

Not Included: Electromagnetic wave theory; Propagation prediction services; Faraday rotation as a geophysical effect.

Cross References: General theory of time-variant communications channels (1.611); Analysis of multipath and fading channels (1.612); Simulation of time-variant communications channels (1.619); Practical propagation results in various wavebands (Sect. 1.64); Experimental evaluation of propagation media (1.639).

Principal Publications:

STATISTICS OF A RADIO WAVE DIFFRACTED BY A RANDOM IONOSPHERE
S.A. Bowhill, J. Res. Nat. Bur. Stand., vol. 65D, no. 3, May-June 1961, p. 275/292.

For some purposes, particularly in connection with the study of the random structure of the lower ionosphere, using very low frequencies, it is necessary to find the detailed statistical properties of a random signal diffracting in free space. Mathematical tools for evaluating these parameters have been developed, and are applied in this paper. . . . The case of oblique incidence of a wave of the ionosphere is also considered.

TRANSMISSION CURVES FOR THE CURVED IONOSPHERE
T. Kobayashi, J. Radio Res. Lab., vol. 8, no. 40, Nov. 1961, p. 395/411.

An equivalence theorem for the curved ionosphere and curved earth is derived and two types of transmission curves are developed, the difference between virtual height and real height being used as a parameter. . . . recordings . . . showing the relation between the frequency and the time of propagation over the 5300 km path between Slough and Ottawa, to confirm the one-hop mode of propagation for frequencies in the 27-33 Mc/s range. . . .

H-F PROPAGATION SIMULATION
R. Mather et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., Nov. 1962, 21 p. incl., 6 refs., (Rept. no. RADC TDR 62-473) AD 288 924.

. . . to be simulated on an analog computer and compared with experimental data collected over a 3800-km path. The experimental complex consists of a transmitter site located in the Panama Canal Zone and a receiver site at Stockbridge, N.Y. Vertical ionospheric sounders are located along the transmission path and are used to measure the spatial distribution of electron density in the volume of interest. A method is described whereby this spatial distribution of electron density is programmed into the analog computer in order that the Hamiltonian equations describing ray paths may be solved. In addition to producing frequency vs. time plots for comparison with the experimental data, the simulator also gives results not easily measured in the field, such as take-off angle, angle of arrival, group time, phase time, off-path deviation, and height of reflection. . . .

THE FRESNEL SURFACE INTEGRAL
G. Millington, et al., Proc. Instn. Elect. Engrs., (Part C), vol. 109, no. 16, Sept. 1962, p. 430/437.

. . . the integral associated with the name of Fresnel was studied by him in connection with the problem of diffraction by a knife-edge. In extending the theory to propagation over two knife-edges in succession, the authors have found that the solution may be expressed in terms of an integral of Fresnel type taken over a surface. As they have been unable to find any Tables directly applicable, it is the purpose of this paper to define what will be termed the Fresnel surface integral and to provide expansions from which it may be computed in any specific case. . . .

DOUBLE KNIFE-EDGE DIFFRACTION IN FIELD-STRENGTH PREDICTIONS
G. Millington, et al., Proc. Instn. Elect. Engrs., (Part C), vol. 109, no. 16, Sept. 1962, p. 419/429.

. . . double application of Huyghens' principle expressed in terms of simple Fresnel theory. The solution is shown to depend on a Fresnel surface integral which will be discussed in a companion paper. Some typical curves of decibel loss . . .

EXPLORATORY PROGRAMMING STUDIES FOR IONOSPHERIC RAY TRACING
Electronic Associates, Inc., Princeton, N. J., Final rept., 8 Oct. 1962, 31 p., AD 412 487.

The development of preliminary analog computer programs for the solution of the two dimensional electromagnetic ray path equations is discussed. . . . Circuit diagrams, typical computer output plots, and the specialized forms of the equations used at low frequencies (5 kc.) and high frequencies (14 meg.) are included.

THE ANALYSIS OF IONOSPHERIC H (F) RECORDS USING THE METHOD OF LEAST SQUARES
D.J. Brown, et al., Ionosphere Research Lab., Penn. State U., University Park, 1 Jan. 1964, 48 p., Rept. no. SR202, AD 427 968.

Electron density-height profiles in the ionosphere can be obtained from vertical height-frequency records by solving an integral equation. A new method of solution is presented, using an iterative minimization scheme. . . . This is more general than most available techniques, since no particular model need be assumed for the underlying ionization. The uniqueness of the solutions which combined data from the ordinary and extraordinary rays for limited frequency ranges is discussed, . . .

WIDE-ANGLE RADIATION DUE TO ROUGH PHASE FRONTS
C. Dragone, et al., Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963 p. 2285/2296.

Nonuniformities in the phase fronts of electromagnetic and acoustical waves give rise to radiation in directions other than that desired. The magnitude of this effect is discussed here with special reference to quasi-random roughness . . .

A rough or nonuniform phase front, be it acoustical, radio, or optical, usually degrades

the desired performance of components which transmit, reflect, or receive the wave. . . . well known in the field of microwave antennas . . . and . . . of optical components. . . . In practice, it is difficult to describe the roughness properly . . .

RADIO PULSE PROPAGATION BY A REFLECTION PROCESS AT THE LOWER IONOSPHERE
J.R. Johler, J. Res. Nat. Bur. Stand., Section D - Radio Propagation, vol. 67D, Sept. - Oct. 1963, p. 481/499, 23 refs., A63-25322.

. . . using a method that employs direct analytic procedures for the evaluation of the Fourier transform-integral for the ground-wave pulse. A previous analysis of the reflection coefficient is employed to construct transfer functions for the ionospheric wave . . . the behavior of LF pulses propagated by a reflection process at the ionosphere is determined for three models for the lower ionosphere. The composite ground and ionospheric pulse is formed, and a method of tagging a point-in-time on the pulse is detailed.

PROPAGATION OF WAVES IN A MEDIUM WITH STRONG FLUCTUATION OF THE REFRACTIVE INDEX
V.I. Tatarskii, et al., (Zh. Eksper. Teor. Fiz., vol. 44, Feb. 1963, p. 676/685.), In Russian, Soviet Physics - JETP, vol. 17, Aug. 1963, p. 458/463, Translation, A63-21309.

Derivation of the formulas for the real and imaginary parts of the propagation constant of the transmitted wave, and for the scattered intensity of the field, for a wave propagating in a medium undergoing small strong-scale fluctuations of the refractive index. The propagation constant and the intensity are expressed in terms of the correlation functions of the fluctuations.

RADIO PROPAGATION ALONG MAGNETIC FIELD-ALIGNED SHEETS OF IONIZATION OBSERVED BY THE ALOUETTE TOPSIDE SOUNDER
D.B. Muldrew, J. Geophys. Res., vol. 68, Oct. 1, 1963, p. 5355/5370, 12 refs., A63-23363.

. . . theoretical model for the guidance of radio waves and hydromagnetic waves along an electron-density discontinuity in the magnetosphere which is suitable for heights less than 1,000 km above the Earth's surface, and is based on data obtained from the Alouette satellite . . . at frequencies as high as 5.6 Mc. It occurs most commonly near local midnight and local noon at low magnetic latitudes. Ray tracings along a model field-aligned sheet of ionization indicate that radio rays travel back and forth along the field, maintaining very nearly a constant track width . . . For radio energy propagated along a field-aligned sheet of ionization, the reflection level is found to be very nearly the same as the reflection level for vertical-incident propagation.

PERTURBATION METHODS APPLIED TO THE REFLECTION OF RADIO WAVES FROM THE IONOSPHERE
P.W. Norman, Ionosphere Research Lab., Penn. State U., University Park, 1 Feb. 1963, 28 p., incl. illus., 10 refs., (Scientific rept. no. 178), (AFCRL-63-215), AD 297 419.

. . . by treating the earth's field of magnetic induction as a perturbation, Maxwell's equations and the constitutive relationship are considerably simplified. First order approximations for the field reflected from a homogeneous sharply bounded ionosphere are found.

A THEORETICAL STUDY OF TROPOSPHERIC RADIOWAVE PROPAGATION
R.M. Ring, May 1963, 88 p., refs., (AFCRL-63-713) AD 426 306, N64-13664.

A time factor e^{iwt} is assumed, and results are expressed in terms of the modified Hankel functions of order one-third. A unified and reasonably short treatment is attempted of several problems which arise in investigating a homogeneous atmosphere, an inhomogeneous atmosphere, and superrefraction.

THE REFRACTION OF SATELLITE SIGNALS. I - THEORETICAL CALCULATIONS
J.E. Titheridge, J.Atmos. Terr. Phys., vol. 26, Feb. 1964, p. 159/175, 12 refs., A64-16128.

Presentation of simplified calculations of the refraction suffered by a radio wave passing through a spherically symmetrical ionosphere by considering the equivalent flat layer. An effective height for this layer is calculated for parabolic and Chapman layers for a number of different frequencies and angles of incidence . . . At small zenith angles the total electron content of the ionosphere can be determined by a method similar to that used in the analysis of Doppler frequency shift and Faraday fading records . . . restrictions to line-of-sight propagation with no path splitting are eliminated . . . errors caused by horizontal gradients of ionization are reduced. . . .

IONOSPHERIC SCATTERING EFFECTS IN LONG-DISTANCE PROPAGATION
H.A. Whale, J. Res. Nat. Bur. Stand, Section D - Radio Propagation, vol. 67D, May-June 1963, p. 287/296, A63-18082.

Presentation of a statistical theory of the behavior of rays scattered at successive ionospheric reflections. . . . The theory predicts the properties of the antipodal area, the deviation of bearing to be expected at places off the main transmitting beam. . . .

TRANSACTIONS OF THE ACADEMY OF SCIENCES OF THE USSR, INSTITUTE OF EARTH'S MAGENTISM, THE IONOSPHERE, AND RADIO WAVE PROPAGATION (SELECTED ARTICLES)
Foreign Technology Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 14 Feb. 1963, 107 p., (Trans. no. FTD-TT-62-1330 from Akademiya Nauk SSSR, Trudy Instituta Zemnogo Magnetizma, Ionosfery, i Rasprostraneniya Radiovoln 17:27, p. 216/239 and 240/280, Moskva, 1960, AD 298 207.

Related Publications:

STATISTICAL ANALYSIS OF FADING OF A SINGLE DOWN-COMING WAVE
P. Dasgupta, et al., J. Atmos. Terr. Phys., vol. 18, no. 4, Aug. 1960, p. 265/275.

A STUDY OF EXTREMELY-LOW-FREQUENCY WAVE MOTIONS
A. Cantor, et al., Sylvania Electric Products, Inc., Waltham, Mass., 30 Apr. 1963, 139 p., AFCRL 63 491, AD 408 099.

. . . concerned with a proper treatment of disturbances in the ionosphere. It develops the treatment of the excitation of extra-low-frequency (magnetohydrodynamic-like) wave-motions in an infinite, homogeneous plasma imbedded in a constant, unidirectional magnetic field, for which the electrical conductivity tensor is easily established and methods of analysis are highly developed.

FARADAY ROTATION NEAR THE TRANSVERSE REGION OF THE IONOSPHERE
G.A. Dulk, Ballistic Research Labs., Aberdeen Proving Ground, Md., April 1963, 32 p. Rept. no. 1200, AD 406 825.

It is shown that some of the equations usually used to describe Faraday rotation are incorrect for the case of propagation through an anisotropic magnetic field when the cosine of the angle between the magnet field and the wave normal changes sign along the ray path. . . . common when transmissions are from a high altitude satellite.

DISTORTION OF SIGNALS TRANSMITTED THROUGH THE IONOSPHERE
R.L. Greenspan, MITRE Corp., Bedford, Mass., Aug. 1963, 23 p., Rept. no. W5810, AD 415 013.

. . . The effect of the ionosphere on signal transmission is obtained by inversion of a Fourier integral, and the relevance of group velocity, signal velocity, and time delay concepts is examined. The dispersions decrease the output signal of a typical UHF correlation receiver by less than 3 db for normal ionospheric conditions.

1.632: Regular Characteristics of the Ionosphere

Included: Fading period at vertical and oblique incidence; Frequency scintillations; Influence of regular solar activity on the ionosphere; Spread-F effects; True height of the ionosphere; Group height of the ionosphere; Phase height of the ionosphere; Changes in the phase path; Critical frequencies; MUF (maximum usable frequency); E_s layer; Ionospheric wave guidance modes; Ionic structure of the ionosphere; Ionospheric forward scattering in general.

Not Included: Ionospheric theories in general; Geophysics of the ionosphere; Magneto-ionic theory of electro-magnetic waves.

Cross References: Irregular characteristics of the ionosphere (1.633); Analysis of multipath and fading channels (1.612); Ionospheric propagation for special frequency ranges (Sect. 1.4); Geographical specialties of ionospheric characteristics (1.637); Ionospheric scatter communications links (1.663); Equatorial spread-F effect (1.637).

Principal Publications:

REPORT ON URSI COMMISSION III - IONOSPHERIC RADIO PROPAGATION
L.A. Manning, Proc. IRE, vol. 46, July 1958, p. 1362/1366.

SOME QUESTIONS ON THE DISPERSION OF RADIOWAVES IN THE IONOSPHERE
V.D. Gusev, Radio Engng. Electronics, vol. 4, no. 1, 1959, p. 15/22.

The part played by non-uniform waves in the angle spectrum of a dispersed field is ascertained when the ionosphere is illuminated by plane and divergent waves. The full time-space correlation function is given.

AN ANALYSIS OF DRIFTS OF THE SIGNAL PATTERN ASSOCIATED WITH IONOSPHERIC REFLECTIONS
D.G. Yerg, J. Geophys. Res., vol. 64, Jan. 1959, p. 27/33.

DIRECT HF BACKSCATTER FROM THE F REGION
H.F. Bates, J. Geophys. Res. vol. 65, no. 7, July 1960, p. 1993/2002.

CONSTANT IONOSPHERE HEIGHT FOR AUDIO-FREQUENCY PROPAGATION (Correspondence)
F. Hepburn, Nature, vol. 185, no. 4713, Feb. 1960, p. 599.

SUNSPOT-CYCLE VARIATIONS IN THE DISCREPANCIES BETWEEN PREDICTED AND OBSERVED FREQUENCIES FOR USE IN RADIOCOMMUNICATION
R.J. Hitchcock, et al., Proc. Instn. Elect. Engrs., Part B, vol. 107, no. 35, Sept. 1960, p. 423/426.

MEASUREMENTS OF CHANGES IN THE PHASE PATH OF RADIO WAVES REFLECTED FROM THE IONOSPHERE AT NORMAL INCIDENCE
R.W. McNicol, et al., Austral. J. Phys., vol. 13, no. 2, June 1960, p. 120/131.

Fixed-frequency measurements were made at Brisbane, using pulse transmissions, of the changes in phase of radio waves received after reflection at normal incidence from the various ionospheric layers. . . .

EXPERIMENTAL RELATIONS BETWEEN IONOSPHERIC TRUE HEIGHT, GROUP HEIGHT, AND PHASE HEIGHT
J.A. Thomas, et al., Austral. J. Phys., vol. 13, no. 2, June 1960, p. 132/138.

Computations of ionospheric phase height at a particular frequency were made using true height analyses of h.f. curves. Temporal changes in these computed values agreed well with experimentally measured changes of phase path both in the case of regular diurnal variations and during an eclipse. The true height analyses were thus shown to be experimentally reliable, and at the same time one could allot an "absolute" value to the normal phase-path records. . . .

STUDY GROUP VI - IONOSPHERIC PROPAGATION
Telecommun. J., vol. 27, no. 1, Jan. 1960, p. 2.

. . . to study various methods . . . above 1.5 Mc/s. . . .

THE FADING OF RADIO WAVES REFLECTED FROM THE IONOSPHERE AT OBLIQUE INCIDENCE
O. Awe, J. Atmos. Terr. Phys., vol. 21, no. 2-3, June 1961, p. 120/141.

. . . studied by the use of pulse transmissions on frequencies near 2 Mc/s. It is found that echoes reflected from a height of about 90 km have a fading period of about 1 min. Echoes from a greater height of about 120 km, which usually appear only during or immediately after magnetic disturbances, have a shorter fading period of about 6 sec. . . .

THE FADING OF RADIO WAVES WEAKLY SCATTERED AT VERTICAL INCIDENCE FROM HEIGHTS NEAR 90 KM
O. Awe, J. Atmos. Terr. Phys., vol. 21, no. 2-3, June 1961, p. 142/156.

The fading of radio waves weakly scattered at vertical incidence from heights near 90 km was studied. Frequencies between 2 and 3 Mc/s were used. The fading rate was found to be of the order of 20 maxima/min. considerably faster than the fading rate for echoes from the normal E-region observed with the same frequency. . . . It is shown that the fading is mainly due to random movements of the scattering elements, rather than a steady drift, and the root-mean-square velocity of the scatterers is found to be about 13 m/sec. . . .

RECEPTION OF B.B.C. TELEVISION SOUND TRANSMISSIONS ON 41.4 MC/S AT HALLEY BAY, ANTARCTICA
L.W. Barclay, J. Brit. Instn. Radio Engrs., vol. 21, no. 1, Jan. 1961, p. 89/92.

The B. B. C. television sound transmissions from London were monitored at Halley Bay, Antarctica, on 130 days between April and October 1958. The observations show that a large part of the interceptions can be ascribed to normal F layer propagation. In some months propagation was better than exptected and this may have been due to the presence of abnormally long hops, though the possibility of some contribution from E_S modes cannot be eliminated. . . .

COUNTERING THE EFFECTS OF DECREASING SOLAR ACTIVITY
E.I. Finke, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 270/279, 28 refs.

. . . The current solar cycle, which reached its peak in 1958, is now rapidly approaching minimum. During periods of low solar activity, the severity of ionospheric disturbances is reduced, but the number of disturbed days is increased. . . . Spectrum usage can be increased by improving long-range propagation predictions, by increasing the validity and timeliness of warnings of ionospheric disturbances and by promulgating frequency assignments that take full advantage of available spectrum space. . . .

A COMPARATIVE STUDY OF THE RUSSIAN IONOSPHERE
M. Baron, Stanford Research Inst., Menlo Park, Calif., Dec. 1962, 76 p., (Technical rept. no. 3), AD 298 179.

IONOSPHERIC RADIO; XIIIth GENERAL ASSEMBLY OF URSI, LONDON, 1960
W.J. Beynon (editor), New York, American Elsevier Publishing Co., Inc., 1962, 262 p.

. . . papers and discussions on ionospheric radio. Included are short survey papers dealing with 1) the vertical distribution of electrons in the ionosphere: 2) F-region ionization; 3) sporadic-E region ionization; 4) rocket and satellite data for the ionosphere; 5) hydromagnetic waves and VLF emissions; 6) radio studies of the aurora; 7) ionospheric scattering of radio waves; and 8) ionospheric drifts. . . .

RAPID PROCESSES IN THE IONOSPHERE
N.D. Bulatov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 25/30.

. . . results of velocity observations made in a quiet and in a disturbed ionosphere. . . . The rate of phase change in radio waves reflected from the ionosphere, caused by fluctuations in the height of the reflecting layers, is determined. Quantitative data on the phase shifts are obtained. . . .

RADIO WAVE PROPAGATION AND THE IONOSPHERE
Y.A. Al'pert, New York, Consultants Bureau Enterprises Inc., 1963, 394 p.

. . . concerned with the basic phenomenology of radio waves of different wavelengths, ranging from millimeters to many kilometers. Although some sections are based on the author's own researches, he has tried to include most of the research results and factual data. The book's main concern is with the physics of the phenomena, but some theoretical calculations are reviewed and a resume of experimental data is included and several experimental techniques are described.

This book is translated from the Russian. . . .

AN IONOSPHERIC PHENOMENON DETECTED BY DOPPLER MEASUREMENTS (Correspondence)
P.R. Arendt, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 375/376.

. . . This fine structure . . . known as frequency scintillations. One specific Doppler curve of satellite 1959 IOTA . . . hump in the 20 Mc Doppler curve occurs about six minutes after the satellite's arrival, about the time when the satellite traveled from darkness into sunlight. The observed increase of frequency cannot be attributable to an abrupt change in the satellite's velocity component. We can rule out a change of the frequency in the satellite's transmitter. The discontinuity in the general trend of this Doppler curve can only be attributable to a change in the electron distribution. . . .

LIMITING FREQUENCIES AT OBLIQUE INCIDENCE FOR TWO TYPES OF E_S (Translation)
T.S. Kerblai, Geomagnetism and Aeronomy, vol. 2, no. 3, 1962, p. 406/410, A64-13102.

Estimation of the frequencies reflected upon oblique incidence for two E_S models (a thin layer and a layer with a high ionization gradient). It is noted that, in contrast to the muf of regular layers, the frequencies reflected from the E_S-layer depend on power radiated and on the sensitivity of the receiving equipment . . . It is concluded that, on communication circuits, high muf values that exceed the values may be explained if reflections from the types of E_S-layer considered are taken into account. . . .

SOME RESULTS FROM THE STATISTICS OF VARIOUS TYPES OF E_S-LAYER
T.S. Kerblai, Geomagnetism and Aeronomy, vol. 2, no. 3, 1962, p. 411/418, 10 refs., A64-13103 (Translation).

Presentation of a picture of the distribution of various types of the E_S -layers and their regularities for a number of stations located in various regions of the Earth. The diurnal variations of the probability of occurrence of f_0E_s and f_bE_s values exceeding 3 Mc were obtained for each type of E_s (according to international classification) from data of 25 ionospheric stations. . . .

IONIZATSIIA VERKHNEI ATMOSFERY KOROTKOVOLNOYYM IZLUCHENIEM SOLNTSA (Ionization of the Upper Atmosphere by Short-Wave Solar Radiation)
Ivanov-Kholodnyi, tr. by Zanis Stuberovskis, Emmanual Coll., Research Language Center, Boston, Mass., Feb. 1963, 33 p., AFCRL Trans. no. TR63 1, AD 415 483.

Taking into account new data about the energy and spectrum of short-wave solar radiation, the absorption of radiation and the rate of ion-formation in the atmosphere at heights of 100-800 km were calculated for different times of the day. . . . diurnal variation of h sub e in the E, F1, and F2 regions were explained. . . . possible to explain a number of ionospheric effects. Conclusions were drawn concerning the value of the effective coefficient of recombination.

HIGH FREQUENCY PHASE STUDIES
D.R. Macken, Griffiss AFB, N.Y., Space

Defense Systems Lab., Nov. 1963, 50 p. refs., (RADC-TDR-63-389; AD 287 785) N64-12307.

. . . From May 1962 through January 1963, recordings were made of relative signal intensity, fade rate, azimuthal direction of arrival, and changes in phase path length of an HF signal propagated over a great circle distance of 4400 km. . . correlated with solar flare activity and with possible traveling ionospheric disturbances.

OBSERVATIONS OF IONOSPHERIC MOVEMENTS BY INCOHERENT SCATTERING
G.H. Millman, et al., J. Geophys. Res., vol. 68, May 15, 1963, p. 3323/3327, 11 refs., A63-22978.

. . . detection of apparent ionospheric movements by the incoherent backscatter technique. The observations were made at Trinidad, West Indies, with a high-powered pulsed radar operating at a frequency of 425 Mc. . . .

PHENOMENA DURING THE GROWTH AND DECAY OF SPREAD-F
M.S. Rao, et al., J. Brit. Instn. Radio Engrs., vol. 25, no. 5, May 1963, p. 445/448.

Continuous observations of the ionospheric echoes at the time of the onset of spread-F and during the decay of the same, yielded useful information. Two different types of spread-F onset are described. . . .

PROJECT FLAYER III, A STUDY OF SPREAD-F ECHOES FROM THE IONOSPHERE
J. Renau, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Final rept., Aug. 1963, 48 p., CAL Rept. no. RA1684PI, AD 430 349.

Forty-four cases of Spread-F echoes at 2.4 Mcs were analyzed and the following conclusions were drawn: 1. The width of the video fading spectrum is commonly less than 1/2 cps although occasionally some of the spectra are as wide as 1 cps with much weaker components at 2 cps. 2. The amplitude distribution of Spread-F echoes at 2.4 Mcs obtained from one minute data runs are Rayleigh or Rice distributed only for the strongest and lower altitude echoes. The echoes from the largest slant ranges (and presumably higher altitudes) . . . show an unexpectedly large proportion of small or zero amplitude signals, a situation which suggests a sporadic nature of Spread-F echoes. 3. The amplitude correlation coefficient evaluated at 1700 foot (4 wavelength) spacing is typically much less than 0.4 implying that the cone angle of Spread-F echoes is commonly greater than 5 degrees. . . .

THE IONIC STRUCTURE OF THE IONOSPHERE
W. Swider, Ionosphere Research Lab., Pennsylvania State U., University Park, 15 Dec. 1963, 124 p., Scientific Rept. 201, AFCRL 63 913, AD 427 879.

. . . aeronomic study of the behavior of positive ions in the 100-300 km region of the ionosphere. The production of ions due to solar radiation and the recombination processes for ions are analyzed in terms of a basic atmospheric model . . . Sunrise (or sunset) production is studied in terms of functions which take the sphericity of the earth into account. . . The nighttime ionosphere is investigated by means of certain decay schemes. The rapid consequence of the effect of production. . .

SOME THEORETICAL ASPECTS OF VERTICAL INCIDENCE PHASE PATH STUDIES
L.H. Tveten, National Bureau of Standards, Boulder, Colo., 12 Aug. 1963, 32 p., AD 414 524.

Different ionospheric phenomena are discussed relative to their effects upon vertical incidence phase path length measurements. The variation in phase path lengths as a function of geomagnetic latitude for 2 and 4 Mc with the injection of ionization at different levels is explored in some detail.

DEVIATION OF CRITICAL FREQUENCIES ON QUIET AND DISTURBED DAYS FROM THE MONTHLY MEDIAN VALUE
E.M. Zhulina, Geomagnetizm i Aeronomiia, vol. 3, no. 4, 1963, p. 707 (In Russian), Geomegnetism and Aeronomy, vol. 3, no. 4, 1963, p. 569/571 (Translation), A64-17037.

Analysis of the data for 14 ionospheric stations situated at high and middle latitudes to compare the median values of the critical frequency of the F2 layer obtained on quiet and disturbed days, with media values for all days of the month. The analysis was made for periods of high (1957-1958), medium (1961) and low (1954-1955) solar activity . . .

INVESTIGATION OF HF/VHF IONOSPHERIC WAVEGUIDANCE MODES
Raytheon Co., Bedford, Mass., Final rept., 1 May 1963-15 March 1964, 15 March 1964, 154 p., Rept. no. BR2893, AD 436 761.

. . . experimental activity . . . investigation of the "whispering gallery" behavior of the earth's ionosphere below the F2 layer maximum, at HF and VHF. Endo-ionospheric waveguidance propagation has been investigated by using ground-based links in the band 20 to 50 mc/s. . . . endo-ionospheric waveguidance mechanism. . . . At 30 and 40 mc/s burst-type signals have been received at the Arcetri terminal, having the characteristics of meteor scattering. At 50 mc/s a link was operated

between Jicamarca, Peru and Littleton, Mass., but no firm evidence of reception was obtained.

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON THE IONOSPHERE, LONDON, JULY 1962
London: The Institute of Physics and the Physical Society, 1963, 528 p.

. . . held at Imperial College, . . . The proceedings contains 81 articles, divided into 4 sections . . . with an additional section giving preliminary results from the first Anglo-American satellite UK 1.

Related Publications:

A STUDY OF PHASE FADING OF IONOSPHERIC REFLECTIONS
P.E. Monro, Austral. J. Phys., vol. 15, no. 3, Sept. 1962, p. 387/404.

Pulsed 2.28 Mc/s radio waves were transmitted and measurements were made on the first-hop, vertically-incident reflections from the ionosphere. . . .

MICROWAVE RADIO RELAY. IONOSPHERIC TRANSMISSION MODELS. TASK 5. CORRELATION BETWEEN TRANSMISSION PARAMETERS OF DISPERSIVE CIRCUITS AND SYSTEM PERFORMANCE FOR APPLICATION TO ADAPTIVE COMMUNICATIONS SYSTEMS
M. Masonson, et al., RCA Defense Electronic Products, New York. Final rept., 28 March-30 Sept. 1963. 30 Sept. 1963, 256 p., Rept. no. CR63 419 12, AD 436 390.

. . . The principal objective is to develop suitable models, or concepts of transmission, via HF ionospheric links, on which to base predictions of performance given the expected channel conditions.

EXPERIMENTAL MF/HF PHASE PATH STUDIES
H.E. Petrie, et al., National Bureau of Standards, Boulder, Colo., 14 Aug. 1963, lv., AD 416 335.

. . . experimental measurements on phase path changes and group path time delays of MF and HF signals reflected from the ionosphere at vertical and oblique incidence are discussed and analyzed with a view to the value of these types of measurements in detection of deep space nuclear detonations.

ELECTROMAGNETIC NONLINEAR INTERACTION AND REFLECTION FROM A PLANE IONIZED MEDIUM
O.E. Rydbeck, Ionosphere Research Lab., Pennsylvania State U., University Park, 15 April 1963, 48 p. (Scientific rept. no. 183) (AFCRL 63-291), AD 299 981.

DISTORTION OF MULTITONE FM SIGNALS DUE TO PHASE NONLINEARITY
P.D. Shaft, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 25/35.

. . . to determine the distortion which results from propagation through the ionosphere. . . . the modulation will be an ensemble of sine waves which is similar to a band of white noise. . . .

1.633: Irregular Characteristics of the Ionosphere

Included: Ionospheric irregularities; Sporadic E events; F-scatter effects; Ionosphere dynamics; Ionospheric disturbances; Ionospheric storms; Short-wave fadeouts; Blackouts; Antipodal transmission effects; Solar bursts; Solar flares; Radio bursts.

Not Included: Nonlinear effects in the ionosphere; Luxemburg effect.

Cross References: Equatorial VHF ionospheric communications (1.637); Irregular polar propagation effects (1.637).

Principal Publications:

AN INVESTIGATION OF SIGNAL AMPLITUDE TO BEARING DEVIATION CORRELATION AS A FUNCTION OF TIME IN HIGH FREQUENCY RADIO DIRECTION FINDING
A. D. Bailey, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 1015/1028.

. . . based on the application of a method described by Licklider and Dzendolet and extended by Sugar. Statistical scatter diagrams of the signal amplitude vs. bearing deviation of high frequency radio direction finder signals may be displayed on a cathode ray oscilloscope. . . . A comparison is made between the actual data and that of plausible idealized Rayleigh-Gaussian distributions. . . .

SPORADIC E AT VHF IN THE USA
R. M. Davis, Jr., et al., Proc. IRE, vol. 47, May, 1959, p. 762/769.

SHORT-WAVE FADEOUTS WITHOUT REPORTED FLARES
H. DeMastus, et al., J. Geophys. Res., vol. 65, no. 2, Feb. 1960, p. 609/611.

PECULIARTIES OF THE IONOSPHERE IN THE FAR EAST: A REPORT ON IGY OBSERVATIONS OF SPORADIC E AND F-REGION SCATTER

E. K. Smith, Jr., et al., J. Geophys. Res., vol. 65, no. 3, March 1960, p. 885/892.

STUDIES OF IONOSPHERIC FORWARD SCATTERING USING MEASUREMENTS OF ENERGY DISTRIBUTION IN AZIMUTH
W. C. Bain, Proc. Instn. Elect. Engrs. Part B, vol. 108, no. 39, May 1961, p. 241/252.

A YEAR'S STUDY OF THE INDEX OF IONOSPHERIC STORMINESS
H. S. Marsh, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 364/391, 14 refs.

Hours-in per day and other attributes have been recorded and studied on selected WWV and CHU frequencies since June 1959. . . By comparison of disturbed days with monthly quiet day averages, indices of storminess-contraction of the useful path spectrum, of MUF and LUF deviations, and MUF/LUF index showing whether spectrum damage is mainly due to MUF or LUF deviation are found. . .

SOLAR ACTIVITY AND THE IONOSPHERE
N. I. Bugoslavskaia, New York, Pergamon Press, Inc., 1962, 56 p., Translation of SOLNECHNAIA AKTIVNOST'I EE VLIIANIE NA IONOSFERU, Moscow, Sviaz'izdat, 1962, Translated by G. O. Harding, A63-24418.

. . . intended for radio communications specialists, gives information on the composition of solar radiation, and about the connection between geomagnetic-ionospheric storms, which affect the regular operation of radio communications, and the radiation from active regions of the Sun.

R-F BLACKOUT PHENOMENA; AN ANNOTATED BIBLIOGRAPHY (1959-1962)
G. R. Evans (comp.), Lockheed Missiles and Space Co., Sunnyvale, Calif. April 1962, 86 p., 150 refs., AD 278 678, N63-16516.

. . . ionization of the air around the reentry body in the presence of applied magnetic fields creates an R-F blackout. . . . information on the theoretical and experimental studies of the causes of the R-F blackout phenomenon and possible solutions to the problem. The period covered is 1959 to February 1962.

PROPAGATION THROUGH A DISTURBED IONOSPHERE: EFFECT UPON RANGE ANGULAR RESOLUTION. PROJECT WIDE BAND.
W. A. Flood, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Radio Astronomy report, Jan. 1962, 31 p., Rept. no. UB-1363-P-4, RADC TDR 63-103, AD 297 933.

STUDY OF HF FREQUENCIES FOR EXO- AND ENDO-IONOSPHERIC COMMUNICATIONS
M. D. Grossi, et al., Raytheon Co., Bedford, Mass., Interim rept. no. 1, 28 March-28 June 1962, 12 July 1962, 66 p., incl. illus., tables, 23 refs., Rept. no. BR-1855, AD 278 296.

. . . various models of ionospheric irregularities and discontinuities. . . .

CHARACTERISTICS OF TYPE III RADIO BURSTS
J. M. Malville, Astrophys. J. 136:1, July 1962, p. 268/275, AD 407 688.

Observations of the drift rate, duration, and frequency range of type III bursts between 580 and 8 mc are discussed. The drift rate below 40 mc is systematically lower than expected from the interferometric measurements in the 60-45 mc range. . . . An observed mean duration of 5 seconds at 25 mc. . . The band width of the bursts should be determined primarily by the radial extent of the exciting agent and by thermal density fluctuations in the corona.

IONOSPHERIC IRREGULARITIES DETECTABLE IN V. H. F. IONOSPHERIC PROPAGATION
K. Tao, Rep. Ionosphere Space Res., vol. 16, no. 2, June 1962, p. 275/278.

It is suggested that it may be possible to investigate the irregularities in the ionosphere corresponding to D-scatter, sporadic-E, and F-scatter signals from observations of v.h.f. ionospheric propagation.

A STUDY OF IONOSPHERIC IRREGULARITIES
H. Boen, et al., Norwegian Defense Research Establishment, Technical summary rept., 10 March 1963, 92 p., AD 410 553.

. . . studying the correlation between radio waves reflected at closely spaced frequencies. Several different models are constructed of the ionosphere . . . of the equipment used in the observations.

SOLAR EFFECTS ON RADIO WAVE PROPAGATION
M. Bossolasco, et al., In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun. 1963, p. 177/183, refs., N64-15441.

. . . Some results regarding the reception of WWV signals (on 15 Mc/s) at Genova are presented.

SUDDEN FREQUENCY DEVIATIONS INDUCED BY SOLAR FLARES
K. L. Chan, et al., J. Geophys. Res., vol. 68, May 15, 1963, p. 3197/3224, 53 refs., A63-22968.

. . . (SFD) induced on HF radio waves by solar flares. . . . identifying and analyzing SFD's and related theories on absorption, recombination, and the shape of SFD's are described. More than 5,200 hr of continuous and simultaneous recordings of the instantaneous frequencies of four long-distance stable-frequency transmission paths were used. . . . The several peaks in a SFD are interpreted as due to successive energy outbursts

from the Sun during a solar flare. The period between successive burst varies from 1/2 to 4 min, the average interval being 2 min.

EQUATORIAL STUDY OF IRREGULARITIES IN THE IONOSPHERE
B. R. Clemesha, et al., Ghana U. (Africa), Final rept., Oct. 1960-Aug. 1963, Aug. 1963, 67 p., AFCRL 63 532, AD 430 914.

. . . covers 1960-63 results on oblique incidence, satellite scintillation, D region scatter, shape of irregularities in D and E regions, flutter fading, and direct back-scatter from the F region.

EQUATORIAL STUDY OF IRREGULARITIES IN THE IONOSPHERE
B. R. Clemesha, et al., Ghana U. (Africa), Summary rept. no. 2, Oct. 1961-Dec. 1962, 1 March 1963, 40 p., AFCRL 63 197, AD 410 983.

. . . experiments. . .designed to investigate F region irregularities by means of the back-scatter technique are described. . . The results show the seasonal and nocturnal variations in the occurence of irregularities which scatter 18 Mc/s signals . . . The results are discussed in the light of information obtained by other workers using different techniques. . .

THE INFLUENCE OF SOLAR DISTURBANCES ON VERY LOW FREQUENCY RADIO WAVE PROPAGATION OVER A LONG HIGH-LATITUDE PATH
A. Egeland, et al., In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 79/100, refs., N64-15433.

. . . effects of solar and terrestrial disturbances on the propagation conditions on 16 kc/s radio waves between Rugby, England . . . and Kiruna, Sweden. . .a distance of about 2,100 km. The principal findings. . . (1) Between September 1958 and March 1961 there were 14 periods during which the signal strength of VLF radio waves showed little or no diurnal variation. (2) SIDs do not influence the signal strength of 16 kc/s radio waves on the high-latitude path studied. (3) No direct correlation between sunspot numbers and the yearly VLF field strength has been found. . . (5) No "blackout" periods were noted. . .(6) An auroral D-layer may influence the propagation conditions for VLF radio waves considerably.

THE EFFECT OF DISTURBANCES OF SOLAR ORIGIN ON COMMUNICATIONS
G. J. Gassmann (editor), New York, Pergamon Press, 1963, 358 p., refs., Papers presented at 6th Ann. Symp. of Ionospheric Res. Comm., Agard Avionics Panel, Naples, 1961, (AGARDograph 59), N64-15426.

VERY LONG DISTANCE PROPAGATION
N. C. Gerson, J. of Atmos. Terr. Physics, vol. 25, Aug. 1963, p. 451/465, A63-23754.

Study of radio propagation over a nearly antipodal path made during July 1959. . . . frequencies between 12-30 Mc . . . path was efficient between 1700-2400-1000, local sidereal time (LST), receiver time. For these frequencies, absorption was almost complete between 1000-1700 LST, receiver time. A secondary absorption period occurred (for frequencies below 12 Mc) between 2000-0300 LST, receiver time. . . . the actual reception over a closely antipodal path proved superior to that expected from the usual MUF type of prediction.

RADIO COMMUNICATION CONDITIONS AT HIGH AND MIDDLE LATITUDES
E. E. Goncharova, et al., (Geomagnetizm i Aeronomiia, vol. 3, no. 1, 1963, p. 94), In Russian, Geomagnetizm and Aeronomy, vol. 3, no. 1, 1963, p. 75/82, 14 refs., Translation, A64-15810, N64-16421, AD 412 048.

. . . Prolonged interruptions in radio communication occurred during strong magnetic-ionospheric disturbances. Interruptions occurred on long range radio transmission even when the ionosphere was quiet. . . .

SOME RELATIONSHIPS BETWEEN 10.7-CENTIMETER SOLAR NOISE BURSTS, FLARES, AND SHORT-WAVE FADEOUTS
G. A. Harvey, Astrophysical Journal, vol. 139, Jan. 1, 1964, p. 16/44, 10 refs., A64-15536.

Investigation of the relationship between 1953 solar noise bursts. . . . 4527 flares, and 928 shortwave fadeouts that occured during concurrent observing periods from July, 1957, to December, 1960. Attention is focused on the importance and type of the fadeouts, and the intensity, energy, and type of the bursts. . . .

W.W.V. RECEPTION IN THE ARCTIC DURING IONOSPHERIC DISTURBANCES
G. E. Hill, et al., J. Res. Nat. Bur. Stand., vol. 67D, no. 2, March-April 1963, p. 179/182.

H. F. COMMUNICATION DURING IONOSPHERIC STORMS
G. E. Hill, J. Res. Nat. Bur. Stand., vol. 67D, no. 1, Jan.-Feb. 1963, p. 23/30.

A hypothetical communication network was set up to study systematically the problem of h. f. communications during disturbed ionospheric conditions. Vertical incidence radio data was used as the basis for determining the condition of the ionosphere. Frequencies and links available were computed for a period of severe ionospheric disturbance. Important spatial and temporal variations are clearly evident by this analysis. . . .

SPIRAL DISTRIBUTIONS OF BLACKOUTS AND MAGNETIC ACTIVITY IN THE SOUTHERN HEMISPHERE DURING THE IGY PERIOD

L. A. Iudovich, (Geomagnetizm i Aeronomiya, vol. 3, no. 3, 1963, p. 520), In Russian, Geomagnetism and Aeronomy, vol. 3, no. 3, 1963, p. 423/426, 10 refs., Translation, A64-15754.

Investigation of diurnal variations of the occurrence of blackouts at different seasons of the year during the International Geophysical Year (IGY) period. The data for fourteen vertical sounding ionospheric stations at high latitudes. . . The time of the maximum in the frequency of occurrence of blackouts is characterized by a spiral distribution. . . .

THE INFLUENCE OF POLAR BLACKOUTS ON VLF CIRCUITS

B. Landmark, In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun. 1963, p. 65/77, refs., N64-15432.

. . . There are at least two major types of polar radio blackouts. The most common type, which is normally referred to as the auroral type, is closely related to magnetic disturbances, and occurs most often near the zones of maximum auroral activity. . .have no great effect on the VLF circuits. The other type of polar blackout which is normally referred to as polar-cap-type events or proton events, is not closely related to magnetic activity, and occurs over most of the polar cap simultaneously. During these events, a significant reduction of the strength of the VLF signals has been observed.

MODEL STUDIES OF THE INFLUENCE OF IONOSPHERE PERTURBATIONS ON VLF PROPAGATION

S. W. Maley, et al., Colorado Univ., Boulder, Technical summary rept., 1 Jan. 1962-1 Jan. 1963, 1 Jan. 1963, lv., AD 420 379

. . . the use of models to study propagation in the earth ionosphere-waveguide for cases in which the effective height of the ionosphere changes along the path of propagation. The models in this investigation will be used to directly gain information as to the effect of perturbations in the ionosphere upon propagation . . .

IONOSPHERE DYNAMICS

G. H. Munro, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1475/1481.

. . . In recent years, the attention of research workers has turned more and more to the study of irregularities and movements in ionization. Irregularities examined range in size from the order of hundreds of kilometers to tens of meters and apparent speeds of movement also show a wide variation. . . . Recent observations with a high speed ionosonde, and recordings of signals from earth satellites are throwing new light on these phenomena, which at first may seem to increase the complexity, but on closer examination are tending to clarify results and point out methods of attack on the unresolved problems.

RADIO PROPAGATION QUALITY IN THE NORTH ATLANTIC AREA 1953-1960

M. E. Nason, In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 287/291, N64-15449.

. . . study. . .of HF radio propagation disturbances, to determine the frequency of occurrence and the duration of disturbances on a monthly, seasonal, and yearly basis. . . .

INFLUENCE OF SOLAR FLARES ON TRANS-ARCTIC HF PROPAGATION

J. Ortner, In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 101/107, N64-15434.

. . . conclusions. . . SIDs have only been observed in summer accompanying important 3 and 3+ solar flares. (2) Flares emitting solar protons with relativistic velocities were followed by absorption starting a few hours after the flares and lasting for several days (3) The correlation of absorption with geomagnetic activity as observed for Kiruna seems to be fairly good for the 18 Mc/s receptions.

MF/HF EXPERIMENTAL PHASE PATH STUDIES

H. E. Petrie, et al., NBS, Boulder, Colo., 7 Jan. 1964, 37 p., AD 428 330.

. . . experimental measurements on phase path length changes and group path time delays of MF and HF signals reflected from the ionosphere at vertical and oblique incidence. . . Examples of phase path anomalies induced by solar flares are discussed and phase path length changes observed during the eclipse of July 20, 1963 are discussed.

AN EXPERIMENTAL INVESTIGATION OF SIGNAL STRENGTH IN THE AREA AROUND A TRANSMITTER'S ANTIPODE

R. M. Pipp, et al., J. Res. Nat. Bur. Stand., Section D - Radio Science, vol. 68D, March 1964, p. 333/337, 7 refs., A64-15850.

Observations were made of signal strength as a function of distance from the antipode of an HF transmitter. A 15.9-Mc, 5-kw beacon transmitter was located at Perth, Western Australia, whose antipode is within 90 km of St. George, Bermuda. In December of 1961, an airborne receiving system was used to record signal strength to a range of 1600 km in each of the four cardinal compass directions from Bermuda. The airborne measurements were normalized with similar measurements recorded at a fixed receiving site at Bermuda. . . the area of antipodal

1.634: Characteristics of the Troposphere and of the Lower Atmosphere.

Included: Reflections from D-layer; Atmospheric ducts.

Cross References: Tropospheric scatter communications links (1.664).

Principal Publications:

ROLE OF TURBULENT SCATTERING IN LONG-DISTANCE RADIO PROPAGATION AT METRE WAVELENGTHS
F. A. Kitchen, et al., Nature, vol. 182, Aug. 1958, p. 302/304.

SUCCESSFUL VHF COMMUNICATIONS FOR 2540 MILES AT 144 MC AND 222 MC
J. T. Chambers, IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

TROPOSPHERIC SCATTER PROPAGATION CHARACTERISTICS
A. J. Svien, et al., IRE Nat. Conv. Rec., Pt. 1, vol. 7, 1959, p. 3/9.

THE TRADE-WIND INVERSION AS A TRANS-OCEANIC DUCT
M. Katzin, et al., J. Res. Nat.Bur. Stand., vol. 64D, no. 3, May-June 1960, p. 247/253.

VLF PROPAGATION EFFECTS OF A D-REGION LAYER PRODUCED BY COSMIC RAYS
W. F. Moler, J. Geophys. Res., vol. 65, May 1960, p. 1459/1468.

RADIO AND RADAR EXPERIMENTS
Brit. Commun. and Electrics, vol. 7, no. 4, April, 1960, p. 286.

Our American Correspondent discusses a newly-discovered radio propagating channel in the lower atmosphere which may provide a reliable means of intercontinental communications. Details are also given of Man's first radar contact with the Sun.

RADIO DUCTS CONFIRMED
Aviation Week, vol. 72, no. 8, Feb. 1960, p. 70.

PRECIPITATION SCATTER AS AN INTERFERENCE SOURCE IN COMMUNICATION SATELLITE SYSTEMS
A. S. Dennis, IRE Internat. Conv. Rec., vol. 10, no. 1, March 1962, p. 145/151, 24 refs.

. . . Communication satellite systems operating at frequencies as high as 3 Gc are now in the active planning stage. A number of recent papers have dealt with the interference produced at the ground receiving sites of such systems by tropospheric scatter from sources below the radio horizon. However, theoretical and experimental data from the field of radar meteorology show that scattering by precipitation particles at 3 Gc can easily exceed the tropospheric scatter component by several orders of magnitude.

RADIO-WAVE PROPAGATION IN THE TROPOSPHERE: PROCEEDINGS OF COMMISSION II OF THE XIIIth GENERAL ASSEMBLY OF URSI, London, 1960
J. A. Saxton (editor), New York American Elsevier Publishing Co. Inc., 1962, 199 p.

MEASUREMENT OF AN ELECTRON DENSITY AND COLLISION FREQUENCY PROFILE IN THE LOWER D REGION DURING POLAR RADIO BLACKOUT CONDITIONS
B. Bjelland, et al., Norwegian Defence Research Establishment, 18 Feb. 1963, 37 p., AD 408 288.

A rocket range has been established at Andya in North Norway. . . On 18 August 1962 the first Nike Cajun rocket was successfully fired. The purpose of the experiment was to measure electron density and collision frequency in the lower D region during polar radio blackout conditions. . .

PROPAGATION OF RADIO WAVES WITH FREQUENCY 99.9 MHZ AS A FUNCTION OF THE VERTICAL STRUCTURE OF THE ATMOSPHERE DERIVED FROM DAILY RADIOSONDE OBSERVATIONS
G. P. A. Braam, J. Res. Nat. Bur. Stand., Section D - Radio Science, vol. 68D, Feb. 1964, p. 257/260, 14 refs., A64-14891.

Investigation of the practicability of using routine radiosonde observations to forecast propagation of high frequency radio waves from a source below the horizon. Normal refraction and super-refraction and/or reflection are meteorological factors affecting UHF propagation. . . It is concluded that apart from a large refractive index gradient, a stable lower-level atmosphere is conducive to abnormal propagation.

REFLECTIONS FROM AN EXPONENTIAL ATMOSPHERE
K. Bullington, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2849/2867.

A quantitative explanation of tropospheric radio propagation is derived without the use of arbitrary numerical factors. It is based primarily on the average value and the standard deviation of the index of refraction at the earth's surface, both of which decrease exponentially with height.

This method seems to bridge the gap between the internal reflection and scatter hypotheses. . . .

AIR-MASS EFFECTS ON TROPOSPHERIC RADIO SCATTER
L. H. Doherty, Canad. J. Phys., vol. 42, April 1964, p. 608/615, A64-17457.

Significant differences in signal level and variability on a 2720-Mc 90-mile scatter propagation path are shown to be related to the air mass present over the path. Periods of super-refraction are almost always associated with maritime arctic air. Maritime tropical air results in a very stable, relatively high signal level. Continental arctic air, on the other hand, is associated with low signal levels which exhibit a reversed diurnal variation.

UBER TROPOSPHARISCHE SCHATTENZONEN IN DER UKW-AUSBREITUNG (On Tropospherical Skip-tones in UHF Propagation) (In German)
G. Eckart, Arch. Elekt. Uebertragung, vol. 17, Dec. 1963, p. 533/536.

The paper deals with the formation of shadow zones in VHF propagation because of horizontal stratification of the atmosphere, especially in the form of ducts with discontinuous and continuous transition between two values of the dielectric constant.

COMPARISON OF PRECIPITATION AND TROPOSPHERIC SCATTERING CROSS SECTIONS
F. G. Fernald, et al., Stanford Research Inst., Menlo Park, Calif., Jan. 1964, 31 p., Rept. no. TRI, AD 434 836.

. . . a means of identifying cases where precipitation scatter becomes predominant on scatter links. Two scattering cross sections, that of gaseous components of the atmosphere and that of precipitation particles, if present, are derived as functions of path length, beamwidth, frequency, and weather conditions. . . .

SURVEY OF PAPERS ON TROPOSPHERIC REFRACTION
R. O. Gilmer, et al., New Mexico U. Engineering Experiment Station, Albuquerque, Feb. 1963, 116 p., (Technical rept. no. EE-86), AD 400 155.

Five hundred eighteen papers concerning tropospheric refraction and some closely related topics are referenced in this report. Of these, 191 are abstracted. . . . Cross listings of authors and ASTIA numbers are given. . . .

DETERMINATION OF ISOTROPY PROPERTIES OF THE TROPOSPHERIC PERMITTIVITY AND WIND VELOCITY FIELDS BY RADIO-PROPAGATION METHODS
D. T. Gjessing, J. Geophys. Res., vol. 69, Feb. 15, 1964, p. 569/581, 13 refs., A64-15363.

Presentation of results from a simple radio beam swinging experiment. The purpose of the investigation was to consider scattered radio power and the Doppler spectrum due to air velocity as a function of the orientation in space of the plane in which the scattering takes place. . . The radio transmitting and receiving antennas are swung both in azimuth and elevation in such a way that the scattering angle remains constant. The permittivity field appears to be nonisotropic in most cases, and the fluctuating air velocity field is generally nearly isotropic.

AN EXPERIMENTAL DETERMINATION OF THE SPECTRUM OF PERMITTIVITY AND AIR VELOCITY FLUCTUATIONS ALONG A VERTICAL DIRECTION IN THE TROPOSPHERE USING RADIO PROPAGATION METHODS
D. T. Gjessing, J. Atmos. Terr. Phys., vol. 26, Feb. 1964, p. 273/296, 28 refs., A64-16137.

. . . The speed of fading increases linearly with the scattering angle which suggests that the fading is caused by multipath transmission via many moving scattering elements. . . The experiment was repeated 45 times using a 165 km path and 14 times using a 340 km path, with a frequency of 6000 Mc.

A METHOD FOR PREDICTING APPARENT ELEVATION ANGLE FOR A TROPOSPHERIC TARGET FROM SPECIFIED VALUES OF GEOMETRICAL ELEVATION ANGLE AND HEIGHT
P. Milnarich, Army Electronics Research & Development Activity, White Sands Missile Range, N. M., Oct. 1963, 12 p., AERDA 67, AD 422 333.

. . . Assumptions are made that the troposphere is horizontally homogeneous and that the index of refraction decreases monotonically with height above a spherical earth. . . . tool for tracking system error analysis, allows for a direct prediction of apparent elevation angle for a given target position and for a direct application of the ray-tracing formula for computing the corresponding radio range.

TROPOSPHERIC PHASE FLUCTUATIONS AT S-BAND
H. A. von Biel, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Oct. 1963, 21 p., Rept. no. UB1725 1, RADC TDR63 408, AD 423 223

A tropospheric propagation experiment to obtain the mean square phase fluctuations at 2250 mc over a 48-mile path is described. Experimental data pertain to a 10-minute time interval on a meteorogically quiet day. . . The experimental equipment used in this experiment consisted of four phase-locked interferometers having baselines of 100 m and 100 m north-south and east-west. The 2250-mc signal source was carried on board a B-57 aircraft at a mean altitude of 40,000 ft.

Related Publications:

THE ELONGATION OF IRREGULARITIES IN THE EQUATORIAL IONOSPHERE
B. R. Clemesha, J. Geophys. Res., vol. 68, May 1, 1963, p. 2363/2366, A63-16708.

Correlation analysis of spaced aerial fading measurements for medium-frequency radio waves scattered from the D and E regions at a location near the magnetic equator. . . . there is a slight . . . elongation of the diffraction pattern on the ground for echoes from 80 and 90 km, and considerable elongation for echoes from above 90 km. . . .

SPECTRAL CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS (Translation)
A. V. Men', Telecommun. Radio Engineering, Part 2 - Radio Engineering, July 1963, p. 24/32, 10 refs., A64-15463.

. . . for waves propagating in a turbulent medium. . .

reception was found to be approximately 500 km in radius with a minimum of signal strength at a radius of 1050 km. Some evidence was obtained which indicates that these results vary as a function of local time. . . .

SUDDEN IONOSPHERIC DISTURBANCES AND THE PROPAGATION OF VERY LOW FREQUENCY RADIO WAVES. PART II: WHISTLER TAPE ANALYSIS AND INSTRUMENT DEVELOPMENT

A. L. Whitson, et al., Stanford U., Calif., Final rept., April 1963, 60 p., AD 410 598.

The effects of a sudden ionospheric disturbance (SID) on atmospheric noise were investigated using data collected during the International Geophysical Year and the International Cooperation Year. During an SID, atmospheric noise is enhanced at frequencies above 12 and below 1 kc. At frequencies between 3 and 10 kc, it is decreased. A simple device that records the ratio of atmospheric noise at 27 kc over noise at 6 kc was developed as an SID detector. . .

1.635: Characteristics of Wave Propagation Near the Earth's Surface

Included: Ground backscatter propagation; Propagation influence of power lines; Railways and metallic structures and their propagation influences; Coast line effects on radio wave propagation; Plasma effects on propagation in the lower atmosphere; Terrain influence on propagation; Knife-edge diffraction propagation; Obstacle gain; Aircraft reflections; Echoes from overflying aircrafts.

Not Included: Re-entry communications links; Theory of plasma interaction with electromagnetic waves; Plasma effects for millimeter waves (3B).

Cross References: Ground wave propagation of medium frequencies (1.643); Trade wind inversion of UHF oceanic ducts (1.645); Fresnel surface integral (1.631); Echo distortions of all kinds (1.626).

Principal Publications:

THE INFLUENCE OF MOISTURE IN THE GROUND, TEMPERATURE AND TERRAIN OF GROUND WAVE PROPAGATION IN THE VHF-BAND

B. Josephson, et al., IRE Trans. Antennas Propagation, vol. AP-6, April 1958, p. 169/172.

THE USE OF VERTICAL POLARIZATION TO SOLVE UHF TELEVISION "GHOSTING" PROBLEMS IN A SHADOWED VALLEY

D. W. Peterson, RCA Rev., vol. 19, no. 2, June 1958, p. 208/215.

UHF Television broadcasting in hilly or mountainous terrain suffers from "ghosting" or multi-path reception in shadowed valleys. An experimental study of the ghosting problem has led to the conclusion that vertically polarized co-channel amplifier boosters and passive boosters will solve the problem of serving shadowed valleys. New service can be rendered without denying any existing service resulting from creation of a "mush" area. . . .

FOREGROUND TERRAIN EFFECTS ON OVER-LAND UHF TRANSMISSIONS

L. G. Trolese, et al., IRE Trans. Antennas Propagation, vol. AP-6, Oct. 1958, p. 330/337.

ON THE MEASUREMENT OF GROUND CONDUCTIVITY AT VLF

J. R. Wait, et al., IRE Trans. Antennas Propagation, vol. AP-6, July 1958, p. 273/277.

MICROWAVE PROPAGATION OVER ROUGH SURFACES

M. P. Bachynski, RCA Rev., vol. 20, no. 2, June 1959, p. 308/335, 104 refs.

The field of propagation of short radio waves over rough surfaces is surveyed. The results of available experimental measurements are summarized and theories which are readily amenable to calculation are discussed. . . . electromagnetic space above approximately 30 megacycles. . . .

ZUM TAGESGANG DER RUCKSTREU-FELDSTARKE VON TELEGRAPHIESIGNALEN (On the Diurnal Back-Scattering Field-Strength of Telegraphy Signals) (In German)

B. Beckmann, et al., Nachrichtentech. Z., vol. 12, Aug. 1959, p. 419/420.

DISTRIBUTION OF RECEIVED POWER IN OVERSEA PROPAGATION WITHIN LINE-OF-SIGHT

K. Morita, J. Inst. Elect. Commun. Engrs., vol. 42, no. 10, Oct. 1959, p. 929/934.

TESTS CONDUCTED OVER HIGHLY REFLECTIVE TERRAIN AT 4,000, 6,000 and 11,000 MEGACYCLES

A. Oxehufwud, Commun. Electronics, July 1959, p. 265/270.

American Telephone and Telegraph Company has conducted tests at 4,000 mc (megacycles) over most major microwave radio relay routes prior to the initial installations. It is planned to add 6,000 mc and, possibly 11,000 mc circuits to the existing routes.

A THEORY OF WAVELENGTH DEPENDENCE IN ULTRAHIGH FREQUENCY TRANSHORIZON PROPAGATION BASED ON METEOROLOGICAL CONSIDERATIONS
R. Bolgiano, Jr., J. Res. Nat. Bur. Stand., vol. 64D, no. 3, May, June 1960, p. 231/237.

ANALYSIS OF THE PERFORMANCE OF THE EDMONTON-YELLOWKNIFE JANET CIRCUIT
J. H. Crysdale, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 33/40.

CHARACTERISTICS OF BEYOND-HORIZON PROPAGATION OVER SEA. I.
T. Fukami, et al., Rev. Elect. Commun. Lab., vol. 8, no. 5-6, May, June 1960, p. 222/255.

. . . The results of diurnal, day-to-day and seasonal variations, and distributions of the median field intensity are given. Comparison is made between measured values and those predicted by conventional theory and empirical propagation curves. . . .

THE INFLUENCE OF TREES ON TELEVISION FIELD STRENGTHS AT ULTRA-HIGH FREQUENCIES
H. T. Head, Proc. IRE, vol. 48, June 1960, p. 1016/1020.

IONOSPHERIC BACKSCATTER OBSERVATION AT 440 MC/S
V. C. Pineo, et al., J. Geophys. Res., vol. 65, May 1960, p. 1620/1621.

AN EXAMINATION OF BACKSCATTER PROPAGATION BETWEEN BOZEMAN, MONTANA AND PALO ALTO, CALIFORNIA
R. T. Wolfram, Stanford Research Inst., Menlo Park, Calif., Jan. 1960, 18 p., (Scientific rept. no. 1), (AFCRC TN-60-120), AD 232 605.

Non-great-circle, ground backscatter, radio propagation paths . . . were studied by means of a radio scanning and direction-finding system operating at 33 Mc. The system utilized a 1.5-kw, FM transmitter at Bozeman and receiving and recording equipment at Palo Alto. . . . During the observing period great-circle propagation along the 1200 km path was negligible, but strong signals were received over two 5000-km, two-hop paths, one to the east and one to the northwest of the stations, almost every day, averaging seven to eight hours per day.

THE EFFECTS OF FLUCTUATIONS ON PROPAGATION THROUGH A PLASMA MEDIUM
G. S. Kino, et al., Union of German Physical Societies, International Conference, 5th, Proceeding, Munich, West Germany, Aug. 28-Sept. 1, 1961, IN: Ionization Phenomena in Gases, vol. I, Amsterdam, The Netherlands, North Holland Publishing Co., 1962, p. 602/611, A63-17127

. . . theory of phase modulation of an RF signal by the LF fluctuation of a plasma. . . . application of the results to the determination of sidebands that arise on an RF signal passed through a plasma medium to which a sinusoidal modulation in density is applied externally at a frequency that is low compared with that of the RF signal.

SOME FACTORS INFLUENCING 3 CM RADIOWAVE PROPAGATION OVERSEA WITHIN AND BEYOND THE RADIO HORIZON
F. A. Kitchen, et al., Proc. Instn. Electr. Engrs. Part B, vol. 108, no. 39, May 1961, p. 257/263.

. . . results of a number of short-term oversea measurements . . . from a 10 Gc/s transmitter . . . It is shown that the variation of signal level within the horizon was rarely that expected for propagation through an atmosphere having a uniform refractive-index gradient. Signal losses of from 5 to 30 dB frequently occurred well within the horizon, these losses being recovered when the range between transmitter and receiver was sufficiently reduced. A well-defined interference pattern usually occurred in the region of reduced signal level. . . . A direct relationship was found to exist between the signal level within the horizon and that propagated well beyond the horizon into the extra-diffraction region. . . .

RECEPTION OF SKYWAVE SIGNALS NEAR A COASTLINE
J. B. Andersen, Technical U., Copenhagen, Denmark, Sept. 1962, 15 p., TN3, 8 refs., AD 413 080 and also N63-19430.

. . . influence of ground inhomogeneities on the reception of skywave signals, especially the influence of the conductivity contrast near a coastline. This gives rise to a rapid decrease in field-strength near the coastline as is well known from groundwave mixed-path theory. . . .

PROLONGED SPACE-WAVE FADEOUTS IN TROPOSPHERIC PROPAGATION
A. P. Barsis, et al., J. Res. Nat. Bur. Stand., vol. 66D, no. 6, Nov., Dec. 1962, p. 681/694.

. . . The study also includes an evaluation of fadeouts observed over a path using a mountain peak as a diffracting knife edge obstacle between transmitter and receiver. . . .

AN INVESTIGATION OF ANOMALOUS TRANSHORIZON RADIOWAVE PROPAGATION OVER IRREGULAR TERRAIN
R. Cassam, Cornell U., Ithaca, N.Y., 15 Feb. 1962, 55 p., incl. tables, 12 refs., (Scientific rept. no. 4; Research rept. no. RS 35), (AFCRL 62-570), AD 286 152.

. . . anomalous nighttime propagation of radio waves was studied at frequencies of 9100, 2800, and 840 Mc/s observed on the 108-km path from Rochester to Ithaca, New York. Previously proposed theories that explain anomalous propagation by ducting, reflection, or diffraction fail to explain the irregular behavior studied. . . .

NOTE SUR DES ESSAIS DE PROPAGATION PAR DIFFRACTION AU CHILI (Propagation Observations on Diffraction Modes in Chili) (In French)
B. Dezerega, et al., Ann. Telecomm., vol. 17, no. 3-4, March, April 1962, p. 89/90.

PROPAGATION CHARACTERISTICS OF MAGNETO-IONIC PLASMA COLUMNS
D. Formato, et al., J. Res. Nat. Bur. Stand., vol. 66D, no. 5, Sept., Oct. 1962, p. 543/555.

The propagation characteristics of uniform, cylindrical plasma columns of circular cross-section in axial, constant magnetic fields are determined. The ratios (plasma wavelength)/(free-space wave-length) and (power flowing in the plasma)/(power flowing outside) are evaluated and discussed as functions of the diameter/wavelength ratio and of the plasma permittivity, for propagation of circularly symmetrical modes. . . .

ANALYSIS OF MATCHED-FILTER RADAR MULTIPATH RETURNS AT 435 MC
J. M. Goodman, Naval Research Lab., Washington, D. C., Interim rept., 17 April 1962, 21 p., incl. illus., tables, 5 refs., (NRL rept. no. 5767), AD 275 296.

An analysis . . . of the 3-pulse multipath aircraft echoes that are typical of a short-pulse airborne radar. . . . flown over water in a WV-2 aircraft. . . .

MICROWAVE MEASUREMENTS OF STEADY-STATE AND DECAYING PLASMAS
P. W. Kuhns, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 173/178, 12 refs.

. . . experimental study of the loss mechanism for electrons in plasmas. Steady-state and decaying plasmas were studied by means of microwave interferometers. Values of the electron-ion recombination coefficient for nitrogen and argon are given. . . . Data is also given on the transmission of microwave through an ionized layer about a body in a supersonic gas stream and the effect upon transmission of water vapor addition to the stream. . . .

ELECTROMAGNETIC PROPAGATION THROUGH SHOCK IONIZED AIR SURROUNDING GLIDE RE-ENTRY SPACECRAFT
W. M. McCabe, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 257/266.

. . . Exact analysis of the problem requires precise information regarding the flow field surrounding the vehicle of interest. Since these data are generally unavailable until late in the vehicle design phase, it is the purpose of this paper to examine means by which an approximation of the interference effects may be obtained when only the trajectory and body configuration are known. . . .

RADIOCOMMUNICATION BY BACKSCATTER
I. Ranzi, Centro Radioelettrico Sperimentale G. Marconi, (Italy), 31 Dec. 1962, 17 p., Final technical rept., AFCRL 63 101, AD 404 270.

Experiments on line-of-sight backscatter of h.f. radio waves . . . it was also shown that the power lines, the railways, and the metallic structures in general are very effective backscatters, to be considered when the h.f. backscatter occurs from a highly developed country.

NON-LINEAR PROPAGATION OF AN AMPLITUDE MODULATED ELECTROMAGNETIC WAVE IN A PLASMA
M. S. Sodha, et al., Proc. Phys. Soc., vol. 80, Pt. 5, Nov. 1962, p. 1155/1160.

The authors studied the change in modulation of an amplitude-modulated electro-magnetic wave in a Lorentzian plasma by using the geometrical-optics approximation as well as the wave equation. . . .

SCALE-MODEL INVESTIGATIONS OF ELECTROMAGNETIC WAVE PROPAGATION OVER NATURAL OBSTACLES
M. P. Bachynski, RCA Rev., vol. 24, no. 1, March 1963, p. 105/144.

. . . Scale-model techniques have been developed whereby the effect of natural obstacles on the propagation of electromagnetic waves over the surface of the earth can be investigated within the laboratory. . . .

The influence of obstacle shape (crest and profile) and the effect of the orientation of the radiated electromagnetic fields (angles of incidence and polarization) on the received power, as well as various cross-polarization phenomena have been experimentally determined. . . .

TRANSMISSION LOSS VARIABILITY AND FADING CHARACTERISTICS FOR LONG KNIFE-EDGE DIFFRACTION PATHS
A. P. Barsis, National Bureau of Standards, Boulder, Colo., 1 Feb. 1963, 16 p., 6 refs., NBS rept. no. 7652, AD 401 927.

. . . in the 750-900 mc/s range . . . in Colorado, Alaska, and Europe . . . analyzed in terms of power fading (long term variability) and short-term variability represented by prolonged space-wave fadeouts.

I. L.S. LOCALISER FEASIBILITY STUDY: THE MEASUREMENT OF THE BISTATIC ECHOING AREAS OF MODEL AIRCRAFT AS AN AID TO THE EVALUATION OF THE PROBLEM OF INTERFERENCE FROM OVERFLYING AIRCRAFT
P. Bowron, Royal Aircraft Establishment (Gt. Brit.), Aug. 1963, 1v. RAE TN Rad 846, AD 428 826.

. . . measurement of the echoeing areas of models of the Comet, Valiant, Victor and Vulcan aircraft for various bistatic angles and to estimate the volume of air-space within which an overflying aircraft may cause interference with a landing aircraft. It was found that in certain positions, overflying aircraft may present echoeing areas as great as 3,000 square meters.

MICROWAVE PROPAGATION OVER MOUNTAIN-DIFFRACTION PATHS Final Report
A. B. Carlson, Griffiss AFB, N.Y., RADC, March 1964, 135 p., refs., (RADC-TDR-64-13), AD 535 545, N64-18795.

. . . The field strength in the geometric shadow zone can be predicted from classical (Fresnel-Kirchoff) diffraction theory when the obstacle approximates the idealized knife edge. However, the modest amount of empirical knowledge available precludes an engineering evaluation of the obstacle-diffraction propagation mechanism from the viewpoint of microwave communications. Although the main concern was the total nature of the propagation, emphasis was given those factors that may affect the successful transmission of information.

THE PROPAGATION OF ULTRASHORT WAVES AND RADIO-RELAY LINKS (In Russian)
Yu. I. Davydenko, Moscow, Voyenizdat, 1963, 136 p.

. . . effect of the Earth's surface and meterological conditions on ultrashort wave propagation both for line-of-sight and the penumbra regions. Path profiles of radio-relay links are classified, and methods are described for calculating the effect of terrain irregularity for obstruction, nonobstructed and semiobstructed paths. . . . recommended to signals officers operating mobile radio-relay links. . . .

A THEORY OF INCOHERENT SCATTERING OF RADIO WAVES BY A PLASMA. III - SCATTERING IN A PARTLY IONIZED GAS
J. P. Dougherty, et al., J. of Geophys. Res. vol. 68, Oct. 1, 1963, p. 5473/5486, 18 refs. A63-23372.

Extension of the theory of incoherent scattering in a plasma to include the effect of ions and electrons colliding with neutral molecules, an effect that could be important in the ionosphere below perhaps 150 km for experiments at 50 Mc or less. . . .

APPLICATION OF DIFFRACTIONS BY CONVEX SURFACES TO IRREGULAR TERRAIN SITUATIONS
H. T. Dougherty, et al., J. Res. Nat. Bur. Stand., Section D - Radio Science, vol. 68D, Feb. 1964, p. 239/250, 25 refs., A64-14889.

Extension of the theory of the knife edge model as an approximation of mountain ridges to allow for the effect of broad crests, and to provide engineering formulas applicable to irregular terrain situations. . . .

ON THE THEORY OF RADIO WAVE PROPAGATION OVER INHOMOGENEOUS EARTH
K. Furutsu, J. Res. Nat. Bur. Stand., vol. 67D, no. 1, Jan., Feb. 1963, p. 39/62.

TRANSMISSION-LOSS MEASUREMENTS AND DIVERSITY TESTS MADE ON TWO KNIFE-EDGE DIFFRACTION PATHS IN EUROPE
R. E. Gray, Elect. Commun., vol. 38, no. 4, 1963, p. 457/464.

PERFORMANCE OF DIGITAL SIGNALS THROUGH REENTRY PLASMAS
H. Hodara, et al., IEEE Internat. Conv. Rec., pt. 5, vol. 11, March 1963, p. 32.

BIBLIOGRAPHY OF BACKSCATTER AND RELATED SUBJECTS
D. H. Lenhert, et al., New Mexico U., Albuquerque, Engineering Experiment Station, June 1963, 43 p., 549 refs., N63-20249.

. . . (1) backscatter and radar return, (2) lunar surface properties, (3) acoustic instrumentation and simulation of radar return from terrain and geometrical shapes, and (4) correlation of radar and photographic data. . . .

AUTOCORRELATION CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS
A. V. Menapas, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 2, Feb. 1963, p. 26/35.

. . . which occur in the propagation of waves in a turbulent medium are considered. Using a phenomenological description of the medium by means of a correlation function of Gaussian form, the autocorrelation coefficients for various paths are determined by taking into account the effect of transport both of "frozen" and "unfrozen" turbulence. . . .

THE INFLUENCE OF TERRAIN SHIELDING ON RADIO WAVE PROPAGATION AT 8000 MC (Correspondence)
W. E. Morrow, Jr., et al., Proc. IEEE, vol. 51, no. 6, June 1963, p. 955/956.

. . . made at the MIT Lincoln Laboratory, Millstone Hill, Mass. . . . during June 20-22, 1962. The transmitting terminal consisted of a 60-foot diameter X-band parabolic antenna mounted on an azimuth elevation mount. . . .

NESTATSIONARNYE IAVLENIIA PRI BEREGOVOI REFRAKTSII RADIOVOLN (Nonsteady Phenomena Observed in the Coastline Refraction of Radio Waves) (In Russian)
E.I. Nefedov, Radiotekhnika i Elektronika, vol. 8, Oct. 1963, p. 1659/1664, 12 refs., A64-10516.

. . . Using inverse Fourier transforms, the known solution of the steady problem is extended to the nonsteady problem of coastline radio-wave diffraction. The non-steady solution obtained is shown to apply to a wide class of pulsed signals.

AUXILIARY PROCEDURES USED IN THEORETICAL EVALUATION OF H-F BACKSCATTER OBSERVATIONS AND OTHER COMMUNICATIONS PROBLEMS
M. L. Phillips, Electro Physica Lab., ACF Electronics, Bladensburg, Md., 22 April 1963, 32 p., AD 407 187.

Contents:
Great-circle transmission paths at specific bearings
Estimation of ionospheric characteristics along the transmission path . . .
Revision of predicted ionospheric characteristics . . .

GEOMAGNETIC EFFECTS ON THE FREQUENCY SPECTRUM OF INCOHERENT BACKSCATTER OBSERVED AT 425 MEGACYCLES PER SECOND AT TRINIDAD
V.C. Pineo, et al., J. Geophys. Res., vol. 68, May 1, 1963, p. 2695/2706, 22 refs., A63-16743.

. . . The spectra measured at angles of incidence greater than about 1° were nearly flat topped with weak maximums about ±3.5 kc relative to the center frequency. Spectra measured at normal incidence to the field have a single peak at the center frequency and are narrower than the off- normal spectra. . . .

THE BEHAVIOR OF FIELDS NEAR MOUNTAINS
M.A. Plonus, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 33/38, 19 refs.

The electromagnetic fields near mountains and in the shadow of mountains are obtained by modeling such major natural obstacles with elemetary mathematical shapes for which an exact analysis exists. The shapes considered are the knife-edge, cylindrically-tipped and parabolically-tipped screens . . .

OBLIQUE PROPAGATION OF GROUNDWAVES ACROSS A COASTLINE. III.
J.R. Wait, J. Res. Nat. Bur. Stand., Section D-Radio Science, vol. 68D, March 1964, p. 291/296, 5 refs., A64-15844.

. . . numerical results for the field anomaly near a coastline when the surface impedance changes in a linear manner between land and sea. . . . the magnitude of the reflected field is greatly reduced as the width of the transition zone is increased beyond about one-quarter wavelength.

DISTORTION OF SIGNALS PROPAGATING THROUGH A PLASMA (Correspondence)
S.V. Yadavalli, Proc. IEEE, vol. 51, no. 6, June 1963, p. 956/957.

With the increasing importance of space communications, it appears that it will be of interest and importance to evaluate the distortion of signals propagating through an ionized medium. . . . we will indicate the method of calculation applicable under certain conditions. Some of the results obtained here can be generalized to include the effects of finite steady magnetic fields, presence of ions, etc. . . .

RADIO COMMUNICATION BY BACKSCATTER
Centro Radioelecttrico Sperimentale G. Marconi, Rome (Italy), Final Technical Report, (AFCRL-63-101), N63-16371.

. . . dependence . . . on the ground nature, and the influence of the vertical radiation diagram of the antenna . . .

1.636: Characteristics of Underwater and Underground Propagation Paths

Included: Rock strata propagation; Subsurface signal transmission; Underground communications; Lithospheric propagation; Seismic wave propagation; Pulse propagation under water; Deep strata radio communications.

Not Included: Equipment design for underground communications; Underground antennas; Submerged repeaters (2).

Cross References: Submarine cables (1.653).

Principal Publications:

BASIC EXPERIMENTAL STUDIES OF THE MAGNETIC FIELD FROM ELECTROMAGNETIC SOURCES IMMERSED IN A SEMI-INFINITE CONDUCTING MEDIUM
M.B. Kraichman, J. Res. Nat. Bur. Stand., vol. 64D, no. 1, Jan., Feb., 1960, p. 21/25.

STUDIES IN DEEP STRATA RADIO COMMUNICATIONS

J.T. de Bettencourt, et al., Raytheon Co., Norwood, Mass., Final Report, AFCRL-63-60, Oct. 1962, 518 p., 97 refs., N63-17589.

. . . certain effects observed on waves propagated through the rock between the antennas. Successful transmissions over a 1.1-mile path at Cape Cod have been obtained due largely to signal propagation through the rock near the overburden, rather than the up-over and down mode or any of the other modes of underground propagation. . . . Some data on noise in underground transmission are presented, but is incomplete, as are preliminary modulation tests. . . .

A SURVEY OF THE LITERATURE ON MIXED PATH PROPAGATION
T. Larsen, Technical U. Copenhagen (Denmark) Lab. of Electromagnetic Theory, Technical Note No. 1, March 1962, 25 p., 80 refs., (AFCRL-62-545), N63-21222.

. . .papers dealing with the propagation of radio waves over a ground consisting of areas of various electric constants . . . two parts, the first one describing the more or less semi-empirical solutions which have been proposed, the latter describing the more rigorous mathematical methods . . .

THEORETICAL AND MODEL STUDIES FROM THE PRODUCTION AND PROPAGATION OF EM SIGNALS FROM UNDERGROUND NUCLEAR EXPLOSIONS. VOLUME II: MODELING STUDIES
Space Electronics Corp., Glendale, Calif., Final Technical rept., Dec. 1962, 279 p. (Rept. no. SGC 68R-7), (RADC TDR 63-9, vol. 2), AD 299 789.

RADIO COMMUNICATIONS VIA ROCK STRATA
L.A. Ames, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 159/169.

. . . geological and geophysical considerations pertinent to communications system design. . . . performance factors of bare and insulated linear antennas, and transmission loss between antennas immersed in dissipative media. . . . Practical considerations in the design of communication circuits. . . .

ELECTROMAGNETIC MODELING STUDIES OF LITHOSPHERIC PROPAGATION
G. L. Brown, et al., IEEE Trans. Geoscience Electronics, vol. GE-1, Dec. 1963, p. 17/23, A64-13468.

Theoretical and experimental investigation of the propagation of electromagnetic waves in a low-conductivity lithospheric duct. The real-Earth situation is approximated by a low conductivity layer with uniform properties located between two regions of high conductivity (the upper crust of the Earth and the Earth's mantle). . . . Different models are constructed using scaling factors of the order of 10^5. . . . Good agreement is obtained between theoretical and experimental results for CW propagation. This agreement demonstrates the validity of the laboratory modeling techniques and lends confidence to the experimental results obtained for the effects of inhomogeneities in the duct.

RADIO COMMUNICATION WITHIN THE EARTH'S CRUST
C.R. Burrows, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 350/360, 10 refs.

. . . four methods of electrical communication within the earth's crust. . . .

COMMUNICATION VIA SEISMIC WAVES
K. Ikrath, et al., Army Electronics Research and Development Agency, Ft. Monmouth, N.J., May 1963, 155 p., AELRDL TR 2346, AD 429 786.

. . . design and performance of experimental seismic transducers are discussed. The significance of the results of experiments with these transducers for seismic communication . . . is emphasized.

SOME EXPERIMENTS AT AUDIO FREQUENCIES WITH A BURIED ELECTRODE SYSTEM
F.J. Dortez de Lobao, SHAPE Air Defense Technical Center, The Hague (Netherlands), March 1963, 31 p., SADTC TM57, AD 406146.

. . . for determining the feasibility of a communication system using buried electrodes and working the audio frequency range . . . The experiments showed that, because of the high noise levels encountered, the applicability of such systems appears to be even more limited than the theoretical calculations suggest . . . Even with a power of 10 kW, voice communication between two terminals 650 m apart would have been impossible. With dipoles 100 m long and eight electrodes at each end, and a power of 10 kW, a character error rate of 10 to the -3rd power can be achieved during the greater part of the year if the distance between transmitter and receiver is less than about 1.5 km. It is shown that in cases where the antennas can be placed within a few meters of the surface, it would be better to use much higher frequencies.

PULSE PROPAGATION INTO WATER
H.J. Schmitt, Cruft Lab., Harvard U., Cambridge, Mass., 18 March 1963, 16 p., TR405, AD408 445.

The transmission of short unidirectional plane-wave pulses into water and solutions of sodium chloride has been investigated experimentally . . . The dispersion of the pulse is mainly due to the ionic conductance of the solution . . .

ANTENNA AND RADIO WAVE PROPAGATION CHARACTERISTICS AT VHF NEAR AND IN THE GROUND
D.M. Schwartz, Texas U., Austin, Aug. 1963, 45 p., AD 416 468.

. . . The variations of the field strength of VHF signals, in and near the ground, have been measured and are reported. Good correlation was found between the measured and theoretical radiation patterns and field strength variation for above ground conditions. Theoretically, for the

same incident field strength, a larger signal is found for a few feet below the surface of the ground at VHF than at 1.0 mc/s . . .

INVESTIGATION OF THE DESIGN OF UNDERGROUND COMMUNICATION SYSTEMS
L. M. Vallese, et al., IEEE Intern. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 234/241.

. . . The design of underground communication systems has been studied with reference to a suitable stratified layer structure. Theoretical and experimental investigations of the propagation of low frequency electromagnetic waves in such media have been developed. Using an analog model of the underground system, the values of the attenuation have been studied as a function of frequency and distance. . . .

ATTENUATION IN SUBSURFACE SIGNAL TRANSMISSION
H. Scotti, et al., Innsbruck Univ. (Austria), 15 July 1963, 9 p. Rept. no. TN2, AFCRL 63 382, AD 420 599.

For the determination of ground conductivity from field strength measurements of VLF-transmitters, the respective attenuation factors of sky waves and surface waves must be taken into account. These factors were calculated for a wide range of frequencies and conductivities. . . . tables and diagrams . . .

UNDERGROUND COMMUNICATIONS. ANNOTATED BIBLIOGRAPHY OF SOVIET-BLOC LITERATURE FOR THE PERIOD 1960-1962
Aerospace Information Div., Library of Congress, Washington, D.C., 26 July 1963, 22 p., 54 refs., AID-B-63-99, N63-19311.

Related Publications:

STATE OF THE ART: GUIDANCE AND NAVIGATION (UNDERSEA WEAPON SYSTEMS)
B. Kovit, Space Aeronautics, vol. 33, no. 1, Jan. 1960, p. 64/67.

FBM subs to use inertial guidance . . .
Fairly low frequencies for radio systems . . .
Extensive signal processing is needed . . .

SEA-GOING LIGHTNING GENERATOR
M. M. Newman, et al., Electronics, vol. 33, no. 30, July 1960, p. 53/55.

Studies of low frequency propagation over long distances may have practical applications on long range communication, navigation. Artificial atmospherics are produced by sea-going generator. . . .

1.637: Propagation Characteristics of Special Geographic Areas

Included: Ionospheric characteristics in the Far East; Arctic communications; Extended transequatorial paths; Transequatorial F-layer propagation; Auroral zone propagation characteristics; Auroral disturbances; Polar radio blackouts; Northern latitude propagation; Polar communications; Equatorial spread-F effect; Radio aurora; Night time equatorial VHF propagation; Transequatorial VLF propagation; Arctic VLF propagation.

Cross References: Spread-F effect in general (1.632); VLF propagation in general (1.642).

Principal Publications:

RADIO ECHOES FROM AURORAL IONIZATION DETECTED AT RELATIVELY LOW GEOMAGNETIC LATITUDES
R. L. Leadabrand, et al., IRE Trans. Antennas Propagation, vol. AP-6, Jan. 1958, p. 65/79.

THE GEOMETRY OF AURORAL COMMUNICATIONS
R. L. Leadabrand, et al., IRE Trans. Antennas Propagation, vol. AP-6, Jan. 1958, p. 80/87.

V. H. F. OBSERVATIONS ON THE AURORA AUSTRALIS
T. J. Seed, J. Geophys. Res., vol. 63, Sept. 1958, p. 517/526.

THE FRINGE OF THE FIELD (ARTIFICIAL AURORA)
Elect. & Radio Engrg., vol. 35, May 1958, p. 168/170.

THE DIURNAL AND ANNUAL VARIATIONS OF FO F_2 OVER THE POLAR REGIONS
S. C. Coroniti, et al., J. Geophys. Res., vol. 64, Jan. 1959, p. 5/19.

TRANSEQUATORIAL PROPAGATION OF V. H. F. SIGNALS
R. G. Cracknell, Q.S.T., vol. 43, no. 12, Dec. 1959, p. 11/17.

PECULIARITIES AND SEASONAL VARIATIONS OF TE BACKSCATTER ECHOES OBSERVED AT MAYAGUEZ, PUERTO RICO
B. Dueno, IRE-URSI Joint Meeting, Oct. 19-21, 1959, San Diego, Calif.

TRANSIENT MODES OF HIGH-FREQUENCY RADIO WAVE PROPAGATION ACROSS THE AURORAL PATH
B. J. Fulton, et al., J. Atmos. Terr. Phys., vol. 16, Oct. 1959, p. 185/186.

EQUATORIAL SUNSET EFFECT
A. M. Humby, Wireless World, vol. 64, no. 7-8, July, Aug. 1959, p. 343/345.

PRELIMINARY RESULTS OF 400-MC RADAR INVESTIGATIONS OF AURORAL ECHOES AT COLLEGE, ALASKA
R. L. Leadabrand, et al., IRE Trans. Antennas Propagation, vol. AP-7, April 1959, p. 127/136.

A LOW POWER VHF RADAR FOR AURORAL RESEARCH
R. S. Leonard, Proc. IRE, vol. 47, Feb. 1959, p. 320/322.

AURORAL IONIZATION AND MAGNETIC DISTURBANCES
B. Nichols, Proc. IRE, vol. 47, Feb. 1959, p. 245/254.

AURORAL PHENOMENA
E. N. Parker, Proc. IRE, vol. 47, Feb. 1959, p. 239/244.

PROPAGATION OF HF AND VHF IN THE ARCTIC REGION
R. Penndorf, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 121/125.

VHF AND UHF RADAR OBSERVATIONS OF THE AURORA AT COLLEGE, ALASKA
R. I. Presnell, et al., J. Geophys. Res., vol. 64, Sept. 1959, p. 1179/1190.

HIGH-ALTITUDE 106.1 MCS RADIO ECHOES FROM AURORAL IONIZATION DETECTED AT A GEOMAGNETIC LATITUDE OF 43
J. C. Schlobohm, et al., J. Geophys. Res., vol. 64, Sept. 1959, p. 1191/1196.

PECULIARITIES OF THE IONOSPHERE IN THE FAR EAST - A REPORT ON IGY OBSERVATIONS OF SPORADIC E- AND F-REGION SCATTER
E. K. Smith, Jr., et al., IRE-URSI Joint Meeting, Oct. 19-21, 1959, Sand Diego, Calif.

NIGHT-TIME EQUATORIAL PROPAGATION AT 50 MC - FIRST RESULTS FROM AN IGY AMATEUR OBSERVING PROGRAM
M. P. Southworth, IRE-URSI Joint Meeting, Oct. 19-21, 1959, San Diego, Calif.

A STUDY OF TRANSEQUATORIAL SCATTER PROPAGATION
American Radio Relay League, W. Hartford, Conn., 1959, 25 p., Final Report, Report No. AFCRC TR-59-262, AD 227 864.

RADIO ECHOES FROM FIELD-ALIGNED IONIZATION ABOVE THE MAGNETIC EQUATOR AND THEIR RESEMBLANCE TO AURORAL ECHOES (Correspondence)
K. L. Bowles, et al., J. Geophys. Res., vol. 65, June 1960, p. 1853/1855.

A DAY-TIME MAXIMUM OF OBLIQUE AURORAL REFLEXIONS OBSERVED IN THE AURORAL ZONE (Correspondence) GEO-AND RADIO-PHYSICS
A. Egeland, et al., Nature, vol. 185, no. 4712, Feb. 1960, p. 519/521.

SIMULTANEOUS VHF AURORAL BACKSCATTER MEASUREMENTS
W. A. Flood, J. Geophys. Res., vol. 65, Aug. 1960, p. 2261/2268.

ANOMALOUS FO F_2 VARIATIONS IN THE ANTARCTIC
G. E. Hill, J. Geophys. Res., vol. 65, no. 7, July 1960, p. 2011/2023.

OBSERVED CHARACTERISTICS OF AN ULTRA-HIGH-FREQUENCY SIGNAL TRAVERSING AN AURORAL DISTURBANCE
J. C. James, et al., Nature, vol. 185, no. 4712, Feb. 1960, p. 510/512.

CONFERENCE ON ARCTIC COMMUNICATION
R. C. Kirby, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 1, Jan., Feb., 1960, p. 73/80.

A NEW METHOD FOR STUDYING THE AURORAL IONOSPHERE USING EARTH SATELLITES
R. Parthasarathy, et al., Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 164.

Sept. 1959 PROCEEDINGS - corrections being made

PECULIARITIES OF THE IONOSPHERE IN THE FAR EAST: A REPORT ON IGY OBSERVATIONS OF SPORADIC E AND F-REGION SCATTER
E. K. Smith, Jr., et al., J. Geophys. Res., vol. 65, no. 3, March 1960, p. 885/892.

NIGHT-TIME EQUATORIAL PROPAGATION AT 50 MC/S FIRST RESULTS FROM IGY AMATEUR OBSERVING PROGRAM
M. P. Southworth, J. Geophys. Res., vol. 65, no. 2, Feb. 1960, p. 601/607.

FADING CORRELATION BANDWIDTH AND SHORT-TERM FREQUENCY STABILITY MEASUREMENTS ON A HIGH-FREQUENCY TRANSAURORAL PATH
J. L. Auterman, National Bureau of Standards, Washington, D. C., Oct. 1962, 53 p., 15 refs., Technical note 165, AD 401 044.

. . . deviations of the instantaneous frequency from the average carrier frequency . . . 4500-km auroral path from Barrow, Alaska to Boulder, Colorado, at frequencies near 15 and 200 mc/s. The mean fading correlation bandwidth was found to be 4.3 kc/s . . . Generally, the bandwidth was smaller during periods of high magnetic activity or high fade rate. It also exhibited a minimum near midday. Cumulative distributions of instantaneous frequency deviations were obtained for a variety of conditions.

EQUATORIAL SPREAD F
W. Calvert, National Bureau of Standards, Boulder, Colo., 1 Aug. 1962, 107 p. incl. illus, refs., (Technical note no. 145), AD 297 341.

IONOSPHERIC D-REGION PHENOMENA ASSOCIATED WITH AURORAL DISTURBANCES AT SODANKYLA
W. Dieminger, et al., J. Atmos. Terr. Phys., vol. 24, Sept. 1962, p. 823/825.

The weak, low echoes which appear on ionograms under blackout conditions were observed at Sodankyla (Finland) to have a clear daily height variation with a minimum at noon, even under normal conditions. During a disturbance the height variation became more pronounced and the lowest echoes recorded were at approximately 60 km. At the same time the frequency range of the low echoes became larger, extending to 5 Mc/s and above. . . .

AURORAL ABSORPTION OF RADIO SIGNALS
C. W. Gartlein, et al., J. Geophys. Res., vol. 67, no. 9, Sept. 1962, p. 3393/3396.

Auroral data and radio data are studied in order to get a better picture of their interference and the location of the auroral zone. It appears that the aurora interferes with a radio signal that is reflected within 2^{o} of latitude of an aurora, and will stop a signal that attempts to pass through an aurora.

SOME COMMENTS ON COMMUNICATIONS IN THE ARCTIC
D. H. Jelly, Defence Research Telecommunications Establishment (Canada), Dec. 1962, 6 p., Rept. no. DRTE-1101, AD 297 730.

FREQUENCY SOUNDING TECHNIQUES FOR HF COMMUNICATIONS OVER AURORAL ZONE PATHS
G. W. Jull, et al., Proc. IRE, vol. 50, no. 7, July 1962, p. 1672/1682.

. . . valuable for improving the reliability of air-ground HF communications when propagation conditions are marginal. . . . results from air-ground radio communications trials supplemented by frequency sounding transmissions over flight paths of up to 1260 nautical miles into auroral zone latitudes from a ground station in Nova Scotia. . . .

AURORAL ZONE SATELLITE SCINTILLATION STUDIES
L. Liszka, Kiruna Geophysical Observatory (Sweden) 10 July 1962, 6 p., (Scientific rept. no. 4), (AFCRL-62-1054), AD 298 594.

SATELLITE SCINTILLATION OBSERVED IN THE AURORAL ZONE (In Swedish)
L. Liszka, Arkiv for Geofysik, 4:8, p. 211/225, 9 Jan. 1963, AD 403 614.

Satellite scintillation studies . . . at frequencies 20 and 54 mc during the last three years . . . The depth of the scintillation at 20 mc. There exists a difference between daytime and night-time scintillation, which is indicated by differences in correlation with auroral sporadic E and with magnetic activity.

THE PACIFIC NAVAL LABORATORY STANFORD UNIVERSITY CONJUGATE POINT EXPERIMENT
J. E. Lokken, et al., Pacific Naval Lab. (Canada), March 1962, 14 p. illus., 12 refs., (Rept. no. 62-4), AD 299 696.

Micropulsations between 0.003 and 3 cps and ELF signals between 3 and 30 cps were measured simultaneously at two stations in the boreal and one in the austral auroral zones . . . Some applications of high gain narrow band receivers, together with selected samples of remarkably coherent signals, are included.

ASPECT-SENSITIVE SPREAD AND MULTIPATH DELAY ON OFF-AXIMUTH HF ARCTIC SIGNALS LARGELY ABOVE THE MUF
H. S. Marsh, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 184/192.

APSECT-SENSITIVE SPREAD AND MULTIPATH DELAY ON OFF-ASIMUTH HF ARCTIC SIGNALS LARGELY ABOVE THE MUF
H. S. March, et al., Air Force Cambridge Research Labs., Bedford, Mass., Oct. 1962, 5 p., (AFCRL-62-777), AD 298 629.

RADIO PROPERTIES OF THE AURORAL IONOSPHERE, PART I
L. Owren, et al., Geophysical Inst., U. of Alaska, College, March 1962, 88 p., incl. illus., tables, 34 refs., (RADC TR 61-217, pt. 1), AD 297 288.

SIGNAL AMPLITUDE ANALYSIS OF HIGH-FREQUENCY CIRCUITS CROSSING THE AURORAL ZONE
G. F. Rourke, et al., Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., Final scientific rept., Item 2 on Research Concerning Forecasting Anomalous Propagation at High Latitudes, 7 May 1962, 88 p. incl. illus., tables, 8 refs., (Technical rept. no. RAD-TR-62-4), (AFCRL-62-106), AD 275 328.

Pulsed transmissions at 12 and 18 mc from College, Alaska and Thule, Greenland were continuously monitored at Boston, Massachusetts for

a period of nine months. . . . Comparisons are drawn between the observed and predicted values of signal intensity and maximum usable frequency (MUF). The predicted values of signal intensity were 10 to 20 db higher than the observed signal intensity. . . .

RADIO PROPERTIES OF THE AURORAL IONOSPHERE (PART 3)
Geophysical Inst., U. of Alaska, College, Final report, March 1962, 76 p., incl. illus., tables, refs., (RADC TR 61-217, pt. 3), AD 297 289.

DIURNAL CHANGES OF TRANSMISSION TIME IN THE ARCTIC PROPAGATION OF VLF WAVES
W. T. Blackband, J.Res. Nat. Bur. Stand., Section D - Radio Sciences, vol. 68D, Feb. 1964, p. 205/210, 5 refs., A64-14884.

. . . An explanation is given of the mechanism of these variations. Owing to the 24-hour daylight or darkness periods in the Arctic in summer or winter, the normal trapezium shape of the change curve does not appear during these periods, and the phase patterns become more complex. . . .

TRANSEQUATORIAL RECEPTION OF A VERY-LOW FREQUENCY TRANSMISSION
C. J. Chilton, et al., Journal of Geophysical Research, vol. 69, April 1, 1964, p. 1319/1328, 20 refs., A64-16788.

Comparison between the phase and amplitude of the 18-kc signal NBA (Balboa, Panama) recorded at Boulder, Colo., in the northern hemisphere and Tucuman, Argentina, in the southern hemisphere. . . .

THE PROBLEM OF ARCTIC COMMUNICATIONS FOLLOWING SOLAR DISTURBANCES
S. C. Coroniti, et al., In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 207/228, refs., N64-15444.

Analysis of polar ionosonde data for 5 solar-induced ionospheric storms shows that the reflecting and the absorbing ionospheric layers vary in a fixed, predictable, and complex pattern . . . used to design hypothetical HF polar communication links that are reliable during quiet and disturbed periods of the ionosphere . . .

RESEARCH CONCERNING FORECASTING ANOMALOUS PROPAGATION AT HIGH LATITUDES
S. C. Coroniti, et al., Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., Final rept., 28 Feb. 1963, 100 p., TR 63 15, AFCRL 63 54, AD 403 140.

Research concerning variations in the Arctic ionosphere and polar radio-propagation conditions . . . improving radio communications in the high-frequency band at high latitudes. . . . Eighteen scientific reports and twenty-one related journal articles have been published . . . extensive bibliography . . . polar cap absorption (PCA) events . . . during the first six months of IGY . . .

A NOTE ON HF COMMUNICATIONS DURING POLAR RADIO BLACKOUTS
K. Folkestad, et al., In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 59/64, N64-15431.

. . . study of HF transpolar propagation conditions. Transmissions from College, Alaska, on 12 and 18 Mc/s, received at Kjeller have been analyzed . . .

NATURAL COMMUNICATIONS STUDY PHASE I, FEASIBILITY STUDY ON A RELIABLE POLAR HF COMMUNICATIONS SYSTEM
G. E. Hill, Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., 22 April 1963, 128 p., RAD TR63 13; Technical note no. 1., RADC TDR63 112, AD402 625.

. . . some experimental data on a test propagation path is analyzed. . . . Data on HF equipment and systems is presented. . . . A traffic load is assigned to a hypothetical network during the height of a polar cap absorption event. The results show that communication can be maintained during the event, but at a reduced level.

NATURAL COMMUNICATIONS STUDY. PHASE I. FEASIBILITY STUDY ON A RELIABLE POLAR HF COMMUNICATIONS SYSTEM
G. E. Hill, Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., 25 June 1963, 18 p., TN2, RAD TR63 24, RADC TDR 63 248, AD 408 711.

The feasibility of securing reliable HF communications in polar regions, especially during disturbed conditions, is analyzed. The behavioral patterns of the ionospheric layers are reviewed . . . A computer program was developed to find available frequencies and paths during both quiet and disturbed conditions . . . Predictions of propagation losses are made for frequencies at intervals of 3 mc within the frequency range of each mode . . .

NATURAL COMMUNICATIONS STUDY. PHASE IXX: FEASIBILITY STUDY ON A RELIABLE POLAR HIGH-FREQUENCY COMMUNICATIONS SYSTEM
G. E. Hill, Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., Final rept., 31 July 1963, 170 p., Technical rept., RAD TR63 37, RADC TDR63 381, AD 418 368.

. . . The feasibility of obtaining reliable high frequency (HF) communications within and outside polar regions, especially during disturbed conditions, is investigated . . .

POLAR AURORAE
S. I. Isaev, et al., Joint Publications Research Service, Washington, D. C., 22 April 1963, 115 p. (figs. omitted), AD 408 240.

NORTHERN LATITUDE PROPAGATION
L. Liszka, Kiruna Geophysical Observatory, Sweden, Final rept., 23 March 1963, 14 p., refs., AFCRL 63-462, AD 402 303.

Satellite recordings . . . at frequencies 20 and 54 mc/s during the last three years . . . statistical analysis of the diffraction pattern produced by radio waves from Transit IV A at 54 mc/s . . . evidence that auroral zone scintillation may be produced at altitudes below F-maximum.

AURORA POLARIS. PART II. THE RADIO AURORA
J. M. MacDonald, Royal Canadian Air Force, 8 May 1963, 22 p., AD 411 307.

It has been shown that radar reflections from the aurora (the so-called "radar aurora") can be received provided frequencies to which the normal ionosphere is transparent can be used . . . Visible aurora is usually accompanied by radar aurora in the same part of the sky, but no proof for the converse for this exists . . . Several theories to describe the aurora's radar reflecting properties have been put forward, but none are entirely satisfactory . . .

ARCTIC PROPAGATION STUDIES AT IONOSPHERIC MODES OF PROPAGATION
L. Owren, et al., Geophysical Inst., Univ. of Alaska, College, Final rept., May 1963, 93 p., Rept. no. UAGR141, AFCRL 63146, AD 421 863.

. . . during 1959-1962 . . . transpolar pulse transmissions on 12, 18, 24 and 30 Mc/s between Alaska, Norway, Sweden and Greenland. In addition, ionospheric absorption and synchronized step-frequency measurements were utilized in the analysis.

VHF COMMUNICATIONS OVER EXTENDED TRANSEQUATORIAL PATHS
C. L. Washburn, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 310/318.

New and revealing evidence has been obtained indicating the potential of new, extended range, VHF communication circuits for paths transversing the equator. Excellent signal-to-noise ratios have been consistently obtained using low power, simple antennas, and conventional receivers. An experimental study demonstrated TEF signals are observed regularly between 30 50 mc and sometimes as high as 75 mc for a 4800 km path. Signal strengths were at times close to the calculated free space signal strength, strongly suggesting ray focusing . . . Transequatorial F-Layer Propagation mode (TEF) . . . Six fixed-frequency transmitters in Balboa, Canal Zone, transmitted simultaneous CW signals on a 24-hour-per-day schedule, while the received signal outputs from six receivers located 4800 km away in Santiago, Chile, were continuously recorded. . . .

TRANSEQUATORIAL F-LAYER PROPAGATION STUDY
C. L. Washburn, et al., ITT Federal Labs., Nutley, N. J., Final rept., July - Oct. 1962, 14 June 1963, 1v., RADC TDR63 178, AD411 242.

. . . transequatorial F-layer propagation (TEF) in the 30 mc to 100 mc frequency range . . . characteristics of one-way transmission in the Western Hemisphere during July to October 1962. Six fixed-frequency transmitters in Balboa, Canal Zone, transmitted simultaneous CW signals on a 24-hour-per-day schedule, while the received signal outputs from six receivers located 4800 km away in Santiago, Chile, were continuously recorded. This study demonstrates TEF signals are observed regularly beween 30 and 50 mc and sometimes as high as 75 mc. Signal strengths were high and at times were close to the calculated free space signal strength, strongly suggesting ray focusing. Rapid fading of the signal was observed. The depth of fading varied from at least 35 db to shallow fading of a few db.

1.638: Characteristics of Other Natural Propagation Media

Included: Exospheric propagation; Exospheric ducts; Extra-terrestrial propagation media.

Principal Publications:

A POSSIBILITY OF THE LONG DISTANCE H. F. PROPAGATION ALONG THE EXOSPHERIC FIELD-ALIGNED IONIZATIONS
T. Obayashi, Rep. Ionosphere Space Res., vol. 13, no. 3, Sept. 1959, p. 117/186.

Transequatorial very long range echoes of the order to 7000 km detected by the h.f. backscatter sounder at Hiraiso are interpreted as the ground back-scatter propagation launched on the path along the exospheric field aligned ionizations. Ray path calculation on this longitudinal mode of propagation between the geomagnetically conjugate points along its field line is made for various geomagnetic latitudes. . . . A possible use of this propagation mode of backscatter as a tool of exospheric sounding is suggested.

ELECTROMAGNETIC WAVE PROPAGATION IN THE SUPER HIGH ATMOSPHERE (EXOSPHERE)
American Meteorological Society, Boston, Mass., Nov. 1962, 22 p., AD 410 900.

. . . problem of radio propagation in a gyrotropic plasma. It is shown that the earth's exosphere is divided into four domains by three characteristic frequencies which specify the condition of local plasma . . . There are discussed various mechanisms generating radio emissions due to the interaction of energetic-charged particles with the plasma bearing the magnetic field . . . observed radio emissions originating in the ionosphere and the exosphere.

PROGRAMMING STUDY FOR HIGH FREQUENCY EXOSPHERIC DUCTING
R. Beadle, et al., Electronic Associates, Inc., Princeton, N.J., Research and Computation Div., Nov. 2, 1962, 54 p., 2 refs., Technical Rept. no. 1, N63-19517 and also AD 410 285.

This report presents specific analog-computer programs effective in the solution of a two-dimensional simplified description of the ray paths of radio waves propagating into the earth's exosphere. The main phenomenon examined concerns the conditions necessary for a high-frequency (~14 meg) radio wave to be trapped in a channel of enhanced ionization that is parallel to one of the earth's magnetic-field lines. Complete circuit diagrams, a typical computer output plot, and detailed descriptions of special purpose circuits required to simulate the plasma channel are included.

1.639: Experimental Evaluation of Propagation Media

Included: Sweep frequency pulse sounding; Oblique incidence sounding techniques; Lunar Reflection experiments to study ionospheric electron density; Satellite experiments for ionospheric studies; Digital ray tracking procedure; Incoherent scatter techniques for ionospheric exploration; Step frequency backscatter sounding; FM technique of VLF whistler observations; Light modulated scattering technique for diffraction field measurements.

Not Included: Ionospheric sounding techniques for adaptive communications (2); Ionospheric research satellites (4B); Geophysical research with sounding rockets.

Cross References: Measurement, recording and simulation of time variant channels (1.619); Computer programs to analyze communications channels (1.619); Mathematical models of propagation media (1.639); VLF results of satellite experiments (1.642).

Principal Publications:

FREQUENCY VARIATIONS IN SHORT-WAVE PROPAGATION
T. Ogawa, Proc. IRE, vol. 46, Dec. 1958, p. 1934/1939.

. . . utilizing the standard frequency transmission of station JJY in Tokyo. The distance from the station to the receiving point was about 360 km. The propagation of signals (at 5 mc at night and 10 mc throughout 24 hours) which are widely used for communication service was accompanied by considerably large frequency variations, up to 3×10^{-7}.

AN AMPLITUDE DISTRIBUTION FUNCTION ANALYZER
E. E. Austein, Cornell U. School of Electrical Engrg., Ithaca, N.Y., Aug. 1959, 91 p., Scientific rept. no. 3 on Radio Scattering in the Troposphere, (Research rept. no. EE 434; AFCRC TN-59-950), AD 230 372.

FURTHER RESULTS OF SWEEP-FREQUENCY OBLIQUE-INCIDENCE PULSE TRANSMISSIONS
W. Dieminger, et al., J. Atmos. Terr. Phys., vol. 14, April 1959, p. 179/180.

THE STRUCTURE OF HF SIGNALS REVEALED BY AN OBLIQUE INCIDENCE SWEEP FREQUENCY SOUNDER
D. J. Doyle, et al., IRE Trans. Antennas Propagation, vol. AP-8, no. 4, June 1960, p. 449/451.

OBSERVATIONAL RESULTS OF VHF, UHF AND SHF PROPAGATION BEYOND THE RADIO HORIZON
A. Takahira, et al., J. Radio Res. Lab., vol. 7, May 1960, p. 197/211.

The results are reported of a series of trans-horizon propagation experiments over a 125 km path. Frequencies used were 150, 600, 3000 and 10,000 M/cs. The authors conclude that in daytime, the mode of propagation at v.h.f. consists of the superposition of reflected and diffracted waves; at u.h.f. the reflected wave, and at s.h.f. the scattered wave predominates. At nighttime, the reflected wave predominates in all frequency bands.

RAPID FREQUENCY ANALYSIS OF FADING RADIO SIGNALS
J. M. Watts, et al., J. Geophys. Res., vol. 65, Aug. 1960, p. 2295/2301.

STUDIES IN IONOSPHERIC PROPAGATION
H. Hoogasian, Raytheon Co., Waltham, Mass., Final rept. 1 Feb. 1960-31 May 1961, 30 June 1961, 116 p., AD 268 270.

. . . The primary objective was to design and perform conventional pulse propagation experiments to study transmission characteristics. Specific areas . . . a spectrum analysis of backscatter . . . special attention to the phase stability of the signals under normal and disturbed conditions, investigation of properties of signals circulating around the world, and an investigation

of sporadic E backscatter . . . the problem of instrumenting this technique was taken up in detail.

LOCATION OF HF RADIO STATIONS FROM THEIR FADING CHARACTERISTICS
A. E. Laemmel, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., 19 Oct. 1961, 57 p., incl. illus., 11 refs. (Rept. no. PIBMRI-962-61, Scientific rept. no. 1), (AFCRL 62-79), AD 278 705.

. . . Observations are made at one receiving station of the fluctuations of carrier level of AM signals. The main emphasis has been on ionospherically propagated signals in the range 3-30 mc. The approach used is statistical, and is formally similar to other current projects which come under the heading of 'pattern recognition'.

RADC TRINIDAD TEST SITE. VOLUME V, A STUDY OF THE IONOSPHERE UTILIZING THE INCOHERENT SCATTER TECHNIQUE
General Electric Co., Syracuse, N.Y., 30 June 1961, 86 p., incl. illus., Final rept., phase 1, RADC TDR 61-194, vol. 5, AD 401 912.

. . . analysis of ionospheric incoherent backscattered echoes displaying Faraday rotational effects . . .

ROCKET AND SATELLITE IONOSPHERE STUDIES USING A DIGITAL RAY TRACING PROCEDURE. SUMMARY REPORT
G. A. Dulk, et al., Ballistic Research Labs., Aberdeen Proving Ground, Md., Dec. 1962, 158 p., (BRL Report no. 1163), AD 299 270.

SYSTEM CONCEPTS FOR A COMMON-USER RADIO TRANSMISSION SOUNDING SYSTEM (CURTS)
R. G. Gould, et al., Stanford Research Inst., Menlo Park, Calif., Final rept., Oct. 1962, 241 p., incl. illus., tables, 12 refs., AD 288 102.

A Common-User Radio Transmission Sounding System (CURTS) is studied. It is demonstrated that oblique ionospheric sounders can find usable frequencies during periods of a disturbed ionosphere and that usable frequencies can be predicted with high accuracy for periods of a quarter of an hour or more during times of average magnetic activity. . . . A systems operational concept for use of sounders is described and analyzed. . . . Problems that have arisen during field tests are discussed . . .

SOME PRELIMINARY RESULTS FROM AN OBLIQUE INCIDENCE STEP SOUNDER LINK
W. R. Vincent, et al., Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 280.

Since July 1961 . . . duplex Philips oblique sounder system between Palo Alto, California and Fort Monmouth, New Jersey. The path is being used to study HF propagation as it applies to communication systems. . . .

FIELD-STRENGTH MEASUREMENTS IN A MULTIPATH FIELD
C. C. Watterson, National Bureau of Standards, Boulder, Colo., 28 June 1962, 21 p., incl. illus., (Technical note no. 1, NBS rept. no. 7600), (RADC TDR 62-339), AD 284 571.

. . . often are ambiguous because of the prevalence of multipath propagation. A method of making field-strength measurements in a multipath field from which it is possible to calculate the amplitude, polarization, relative time phase, and direction of arrival of each of the multipath components is given. It is an aperture-synthesis technique which requires that the amplitude and phase of the signal from a moving antenna be measured as the antenna is moved successively along three orthogonal straight-line paths. . . .

IONOSPHERIC RESEARCH AND PROPAGATION STUDIES
H. D. Webb, et al., Electrical Engineering Research Lab., U. of Illinois, Urbana, Quarterly progress rept. no. 8, 1 April-30 June 1962, 30 June 1962, 14 p., incl. table, AD 282 100.

A calibration program was started for measuring the beamwidths and gains of the antenna at approximately 50 mc intervals from 300 to 1200 mc, using the sun as a radio source . . . Signals received by reflection from meteor bursts should be at the same frequency as the transmitted frequency except for a small Doppler frequency component due to ionospheric winds. Moon reflected signals were received on 47 days during the period for a total of approximately 470 hours. . . .

STUDY OF THE ARCTIC IONOSPHERE BY MEANS OF STEP-FREQUENCY BACKSCATTER SOUNDING
H. F. Bates, Geophysical Inst., U. of Alaska, College, Final Report. June 1963, 11 p., AFCRL 63 184, AD 412 950.

. . A Granger step-sounder was installed and operated in the backscatter mode at College, Alaska. Preliminary results indicate that direct backscatter echoes from the E and F regions predominate when sounding north. . . .

SPACE DIVERSITY RECEPTION IN TROPOSPERIC SCATTER FIELD MEASUREMENTS
V. Biggi, Compagnie Generale de Telegraphie sans fil, Paris (France) Final rept., 15 June 1963, 17 p., AFCRL 63 356, AD 419 971.

. . . measurements . . . over a period of one year (March 1962 to March 1963) on a swept frequency tropospheric scatter link operated at S band. The frequency transmitted is swept over a range of 200 Mc/s at a rate of 10 c/s. The receiver covers the same band in synchronization with the transmitter. Reception is effected in space diversity by means of two antennas whose spacing is variable. Successive sweeps are received alternately on the two antennas. . . .

ETUDE EXPERIMENTALE DE LA STRUCTURE FREQUENTIELLE INSTANTANEE DE LA PROPAGATION EN MILIEU HETEROGENE (Experimental Study of the Instantaneous Frequency Structure of Propagation in a Heterogeneous Medium)
J. Biggi, et al., IN: RADIO WAVES AND CIRCUITS, Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960. Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 269/273, In French, with summary in English, A64-10838.

A transmitter-receiver system equipped with carcinotrons made by C.S.F. allows scanning in /120 sec of a frequency band of 200 Mc in the frequency range of 3,000 Mc. When used over a link of 300 km, this equipment permits a rapid analysis of the frequency structure of tropospheric propagation beyond the horizon. . . . results on the instantaneous frequency band which can be propagated through the irregular medium of the troposphere. . . .

THE USE OF AN HF LUNAR REFLECTION CIRCUIT IN THE STUDY OF IONOSPHERIC ELECTRON DENSITY
J.R. Davis, et al., Naval Research Lab., Washington, D.C., 19 July 1963, 15 p. refs., (NRL-5968, AD 414 850), N64-15130.

A high-power HF transmitter has been used to illuminate the moon at moonrise. The returned signals that have been observed display both the smooth-sphere scattering components and the rough-scatter components reported previously by observers utilizing the VHF and UHF bands . . . analyzed . . . possible extent of polarization-rotation undergone by radio waves traversing the ionosphere. The rotation of the plane of polarization has been found, on each occasion, to have a distinct echo-fading frequency as the ray path rises through the ionosphere. In the present investigation, the fading period varied from 90 to 113 seconds.

AN IMPROVED SYSTEM FOR RECORDING THE PHASE AND AMPLITUDE OF VLF AND LF STANDARD FREQUENCY TRANSMISSIONS
A.H. Diede, NBS, Boulder, Colo., 28 Jan. 1964, 79 p., AD 433 249.

. . . The versatility and ease of maintenance of the system has been greatly improved by the use of modular construction and plug-in printed circuit boards. . . . for coherent measurements in the LF and VLF region. . . .

RESEARCH IN CONNECTION WITH PROPAGATION OF HIGH FREQUENCY (HF) WAVES
J. Eitzenberger, et al., Battelle Inst., Frankfurt Am Main (W. Germany), Special Technical Report, July 1, 1962-June 30, 1963, N63-21673.

. . . short wave radio propagation . . . (1) the development of a special narrow-band gain stable receiver for the purpose of measuring ionosphere fluctuations over long distances; (2) measurements of the ionosphere Doppler effect and the MSF frequencies 2.5 and 5.0 mc. . .

RADIO WAVE PROPAGATION FROM SPUTNIK III
N. C. Gerson, J. Atoms. Terr. Phys., vol. 25, Dec. 1963, p. 699/706, 15 refs., A64-13974.

. . . results of observations of the 20-Mc emissions from Sputnik III satellite recorded during the period of May 16 to June 6, 1958. Propagation modes, effects of ionospheric disturbances, and antipodal propagation are discussed. . . .

A STUDY OF INTERFERENCE IN THE ALOUETTE TOPSIDE SOUNDER RECORDS
T. R. Hartz, Defense Research Telecommunications Establishment (Canada) Oct. 1963, 14 p., AD 430 222.

The Alouette ionograms . . . are found to be of poor quality because of unidentified man-made interference. . . . mainly prevalent over densely populated regions of the world and seriously degrades the night-time ionograms obtained at stations like Ottawa and Winkfield . . . not apparent in recordings from the South Atlantic station. The most probable cause of the interference is ground transmissions that propagate above the F-region critical frequency and intermodulate in the satellite receiver. No evidence has been found for a contribution to the interference by way of the whistler mode of propagation.

AN ANALYSIS OF THE INTERFERENCE POTENTIAL OF AN OBLIQUE IONOSPHERIC SOUNDER
H. Kimball, IIT Research Inst., Chicago, Ill., Aug. 1963, 28 p., AD 417 357.

. . . effects of potential HF interference which might be produced by an ionospheric sounder operated between Navy communication stations near Washington, D.C., and Honolulu, Hawaii. The sounder uses a transmitter and receiver at each station and emits pulses of differing widths, at varying repetition rates, and with center frequencies distributed at selected points the 2-32 mc band. The analysis considered interference to telephony, telegraphy, and facsimile, those being the three types of service predominant in that band. . . .

A STUDY OF IONOSPHERIC IRREGULARITIES USING SATELLITE TRANSMISSIONS AT 54 MC/S (In Swedish)
L. Liszka, Arkiv. for Geofysik, 4:9, 9 Jan. 1963, p. 227/246, AD 403 613.

A statistical analysis of the diffraction pattern produced by radio waves from artificial satellites is presented.

SIMULTANEOUS FARADAY FADING RECORDS OF SATELLITE SIGNALS

J. Mass, (Israel Annual Conference on Aviation and Astronautics, 6th Tel Aviv and Haifa, Israel, Feb. 24, 25, 1964, Proceedings), Israel Journal of Technology, vol. 2, no. 1, 1964, p. 21/26, 13 refs., A64-16195.

. . . Faraday fading rate of a satellite's radio signal should be independent of the observer's position. A comparison of simultaneous Faraday records of the Explorer 7 satellite, as recorded at four European stations, tends to confirm this. . . . may solve the problem of determining the total electron content as well as its horizontal gradient.

RADIO PROPAGATION ALONG MAGNETIC FIELD-ALIGNED SHEETS OF IONIZATION OBSERVED BY THE ALOUETTE TOPSIDE SOUNDER

D. B. Muldrew, Defence Research Telecommunications Establishment, Ottawa (Ontario), 7 June 1963, 16 p., AD 437 408.

Some of the traces obtained from the topside sounder ionograms recorded at low latitudes are identified as being caused by propagation along magnetic field-aligned sheets of ionization. . . . compared with the vertical electron-density distribution obtained from the regular topside F-layer traces. Close agreement . . . indicating . . . that radio waves propagated along the field lines are reflected very near the vertical-incidence reflection level.

INVESTIGATING IONOSPHERIC DUCTING WITH THE ORBIS BEACON

J. P. Mullen, Air Force Cambridge Research Labs., Bedford, Mass., Jan. 1964, 19 p., AFCRL 64 29, AD 430 420.

An experiment is described which uses a satellite-borne, two-frequency HF beacon to perform a synoptic investigation of ionospheric ducting. The expected ducting modes are described qualitatively and quantitatively using the AFCRL ray tracing computers.

REDUCTION AND ANALYSIS OF EXPLORER VI AND PIONEER V DATA, VOLUME I

A. Rosen, et al., Space Technology Labs., Inc., Redondo Beach, Calif., Final Report, 60 Nov. 1962, 199 p., refs., Rept. 8626-6006-RU000, N64-17677.

. . . discussed: (1) the structure composition and dynamics of the Radiation Belt during August and September 1959; (2) Explorer VI Satellite observations of the geomagnetic field during magnetic storms; (3) Pioneer V data reduction and analyses; (4) an investigation of signal fading on Explorer VI and Pioneer V transmission; and (5) satellite signal fluctuation caused by ionospheric irregularity.

HF COMMUNICATION EFFECTS SIMULATION: INSTRUMENTATION AND OPERATION OF THE FIELD EXPERIMENT

R. A. Shepherd, Stanford Research Inst., Menlo Park, Calif., Interim rept. 3, Dec. 1963, 103 p., AD 434 554.

. . . examination of six propagation paths, some of which pass through the auroral zone and some of which are south of the zone. . . . examined with oblique-incidence ionosphere sounders which collect propagation data between 4 and 64 Mc. Two of the paths are also studied using a phase-stable CW system for the measurement of phase and amplitude of propagated signals. The primary equipment used in the experiment, consisting of Granger Associates ionosphere sounders and of a phase-stable CW system developed by SRI, is described . . .

IONOSPHERIC ELECTRON CONTENT AND ITS VARIATIONS FROM FARADAY FADING OF SATELLITE RADIO TRANSMISSIONS

Y. V. Somayajulu, et al., National Physical Lab., New Delhi (India), May 30, 1963, 27 p., 18 refs., A paper based on this report was presented at the 4th Intern. Space Sci. Symp. on COSPAR, June 3-12, 1963, Warsaw, N63-22300.

. . . some preliminary results obtained of the total electron content of the ionosphere up to 1200 km, using Faraday-fading of the 20.008 Mc Transmissions from the satellite 1962 Upsilon-1 (Cosmos V). The results reveal that the ratio of the maximum daytime electron content up to 1200 km to the minimum reached in the early morning hours is about 7 . . . The scale-height of the F-region is 100 km during midday, and 50 km during early morning hours. The results are compared with earlier work and discussed.

THE REFRACTION OF SATELLITE SIGNALS. II- EXPERIMENTAL RESULTS

J. E. Titheridge, J. Atmos. Terr. Phys., vol. 26, Feb. 1964, p. 177/191, 24 refs., A64-16129.

Calculation of the scale height at the peak of the F-layer and the total electron content of the ionosphere over a period of 16 months, using the records of the elevation of the 20 Mc signal from the satellite Explorer 7. . . . The seasonal variation is only half as large as that shown by similar measurements in the northern hemisphere, suggesting that the world-wide decrease in the critical frequency of the ionosphere in June results from an increase in the temperature of the ionosphere. . . .

A LIGHT-MODULATED SCATTERING TECHNIQUE FOR DIFFRACTION FIELD MEASUREMENTS

A. M. Vural, et al., Journal of Research, Section D—Radio Science, vol. 68D, April 1964, p. 355/362, 12 refs., A64-17492.

Description of a scattering technique, employing light modulation, for measuring microwave diffraction fields. A small photoelectric cell is suspended in the field as a scatter, and light, pulsed at an audio rate, is shone upon it. Only the signal scattered back by the photoelectric cell is modulated. A coherent detector is used which has an output voltage proportional to the square of the tangential component of the field being measured . . . Extensive data and three-dimensional graphs of amplitude ratios for the near-zone diffraction fields of finite cones are presented.

IONOSPHERIC RESEARCH AND PROPAGATION STUDIES

H. D. Webb, Electrical Engineering Research Lab. U. of Illinois, Urbana, Quarterly progress rept. no. 12, 1 April-30 June 1963, 30 June 1963, 20 p., AD 437 568.

Observations of moon reflected signals were made on 20 days for a total of 191 hours . . . The relative polarization angle was read out from all of the records. The relative electron content has been calculated for all of this data . . .

INVESTIGATION OF PHASE INTERACTION AS A MEANS FOR THE STUDY OF THE LOWER IONOSPHERE

S. Weisbrod, Ionosphere Research Lab., Penn. State U., University Park, 1 March 1964, AFCRL 64 32, AD 435 736.

. . . a new technique . . . based on the simultaneous observations of phase and amplitude wave interaction. . . . To measure, or even to detect . . . minute changes in the phase of ionospherically reflected echoes, which are subject to rapid amplitude fading and phase tumbling, required the development of special techniques and instrumentation. The scheme is based on the extension of the Fejer pulse technique which has been used in the past by a number of investigators in the study of the amplitude interaction. The theory of interaction is extended and generalized by the introduction of the complex coefficient of interaction, which embodies both amplitude and phase effects. . . . On the average, below 75 or 80 km., the phase perturbations, measured in radians, are stronger than the amplitude perturbations.

IONOSPHERIC REFRACTION ERRORS MEASURED IN THE DOPPLER SHIFT OF RADIO TRANSMISSIONS FROM ARTIFICIAL EARTH SATELLITES

J. F. Willman, et al., Defense Research Lab., U. of Texas, Austin, 11 Feb. 1963, 1v., Rept. no. DRL 491, AD 415 771.

Data from eighty-five passes of Satellite 61151 occurring from September 1961 to June 1962, are chosen to illustrate variations of electron density resulting from time of day, direction of the pass, and seasonal changes . . . variations in magnitude of the higher order refraction error terms . . . evidence of horizontal and vertical gradients in the electron density . . . error analysis of the refraction error digital computation program . . . Synthesized Doppler data with varying amounts of error are processed by the IBM 1620 and the results are shown.

(No title)

Defense Research Telecommunications Establishment (Canada), Annual rept. for 1963, March 1964, 1v., DRTE 1135 U, AD 436 278.

Contents: In Flight Performance of Alouette I; Scientific Results from Alouette I; Properties of The Topside of the Ionosphere . . .

Related Publications:

MEASUREMENTS ON TIME-VARIANT COMMUNICATION CHANNELS

T. Kailath, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 229/236.

. . . problems of measuring the characteristics of time-variant communication channels. . . . the use of such media as tropo-scatter links, meteor trials, auroral belt, and orbital-chaff channels makes the assumption of slow changes unsatisfactory. . . . The . . . signals . . . pass through a (linear or nonlinear) filter, A, for example the ionosphere or an underwater link. There is also an additive noise, n, usually due to front end receiver noise or to co-channel interference. The measurement problem is to determine the parameters of the filter, A, by input-output operations on the channel. That is, we put in suitable probing signals . . . and make appropriate computations on the output . . . in order to calculate the filter parameters. There is also, of course, the problem of determining the characteristics of the additive noise . . .

DATA TRANSMISSION INVESTIGATION

R. F. Salava, Motorola, Inc., Chicago, Ill., Quaterly progress rept. no. 5, 11 Sept. - 10 Dec. 1963, 10 Dec. 1963, 1v. Rept. no. 9, AD 430 726.

Field test results obtained while transmitting digital data over the AN/VRC-12 radio set are . . . at 41.5 mc using FSK and Di-Phase modems. . . . impulse noise from passing vehicles and thunderstorms to multipath conditions from airplanes. . . . When no severe disturbances were present, many tests were conducted within a ten mile radius without encountering any errors. Near the range limit of the radio set (15 to 20 miles) error rates were found to vary from 10 to the minus 4 power to 10 to the minus 2 power. The digital Encoder and digital Decoder constructed for the program are discussed . . . The system is capable of providing error detection, random error correction, burst error correction and detection. Unique implementation in the decoder gives the system the capability of providing a large number of cyclic codes.

AN IMPROVED LOW FREQUENCY SWEEP POLARIMETER
S. Weisbrod, et al., Ionosphere Research Lab., Penn State U., University Park, 1 April 1963, 30 p., incl. illus., 3 refs., Scientific rept. no. 182, AFCRL 63-290, AD 401 674.

. . . describes an improved version of a low-frequency polarimeter which is used in conjunction with the low-frequency sweep studies at the Ionosphere Research Laboratory.

RESEARCH IN CONNECTION WITH PROPAGATION OF HIGH FREQUENCY (HF) WAVES
Battelle Institut, Frankfurt Main (Germany) Special technical rept., 1 July 1962-30 June 1963, 31 July 1963, 1v., AD 418 494.

. . . (1) The development of a special narrow band gain stable receiver for the purpose of measuring ionosphere fluctuations over long distances, and (2) Measurements of the ionosphere Doppler effect and the MSF frequencies 2.5 and 5.0 Mc carried out at the Battelle Institute . . .

Section 1.64
Practical Propagation Characteristics of Special Wave Bands

Space communications links require engineering data for practically all wave ranges, from VLF to microwaves. This section attempts to compile references to such data without overloading the material with publications on physical fundamentals of propagation theory or with design information on specific equipment.

References to millimeter wave technology and to optical communications appear in volume 3B under advanced techniques for space communications.

Information on special classes of communications channels will follow in the next sections. The material of this section has been selected exclusively on the basis of wavebands.

1.641: Comparison of Propagation Effects in Several Wavebands

Included: Effects of nuclear explosions on propagation; High altitude explosions.

Not Included: Detection of nuclear explosions.

Principal Publications:

AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF RADIATION ON THE PROPAGATION OF ELECTROMAGNETIC SIGNALS IN AIR
M. N. Hirsh, et al., G. C. Dewey and Co., Inc., New York, Quarterly progress rept. no. 4, 1 April - 30 June 1962, 30 June 1962, 22 p., Rept. no. R146 4, AD 418 646.

THE EFFECT OF HIGH-ALTITUDE NUCLEAR EXPLOSIONS ON RADIO COMMUNICATION
H. P. Williams, IRE Trans. Mil. Electronics, vol. MIL-6, no. 4, Oct. 1962, p. 326/338.

. . . considerable interference with long distance radio communication resulted from the explosion of the two 4-MT bombs at high altitude over Johnston Island in August, 1958. A study was made of the effects reported in unclassified literature with the object of finding which type of transmissions, if any, could still be relied upon under such conditions.

The conclusion reached is that VHF links using meteorscatter or ionoscatter propagation would have escaped the severe blackouts experienced with LF, MF and HF transmissions. The positive disruption of such VHF links requires some 100 times more ionization than was produced by these bombs. To a lesser extent VLF transmissions would also have escaped a blackout—in this case it is estimated that some 10 times the ionization is required for a blackout. . . .

THE EFFECTS OF HIGH ALTITUDE NUCLEAR EXPLOSIONS ON THE PROPAGATION OF V. L. F. WAVES
B. Burgess, et al., Royal Aircraft Establishment, Farnborough (England), Aug. 1963, 41 p., RAE TN RAD842, AD 423 109.

A number of VLF transmissions were being monitored at various locations throughout the world during the latter half of 1962, when a number of American and Russian high altitude nuclear explosions occured . . . showed that the lower ionosphere (less than 90 km altitude) could be affected by geomagnetically trapped radiation particles from the explosion over the major part of the world within minutes of the explosion.

. . . The major effects observed can be semi-quantitatively explained on current knowledge of VLF propagation and nuclear and particle physics. Further the effects of the nuclear explosion have confirmed certain hypotheses concerning anomalous VLF propagation phenomena.

VLF ANOMALIES OBSERVED AT STATE COLLEGE, PA., DURING THE U.S. 1962 HIGH-ALTITUDE NUCLEAR TESTS
C. F. Sechrist, Jr., (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Col., Aug. 12-14, 1963, Paper 68D1-326.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 125/133, 17 refs., A64-14699.

VLF DISTURBANCES CAUSED BY THE NUCLEAR DETONATION OF OCTOBER 26, 1962
A. J. Zmuda, et al., J. Geophys. Res., vol. 68, July 1, 1963, p. 4105/4114, 33 refs., A63-20136.

Study of sudden and delayed VLF perturbations that followed the nuclear detonation of Oct. 26, 1962, in the vicinity of Johnston Island . . .

1.642: Very Low Frequency Propagation

Included: VLF interplanetary communications; VLF satellite experiments; LF polar propagation; Whistler mode of propagation for man-made signals; ELF-electromagnetic radiation; Mode theory of VLF propagation; Nonreciprocal east-west VLF propagation; Musical atmospheres; Magneto-ionic duct propagation.

Not Included: VLF standard frequency transmissions.

Cross References: ELF and VLF atmospheric noise (1.722); FM technique for observation of VLF whistler mode propagation (1.639); SID and VLF propagation (1.633); Transequatorial VLF propagation (1.637); Arctic VLF propagation.

Principal Publications:

PHASE VARIATIONS OF 16 KC/S TRANSMISSIONS FROM RUGBY AS RECEIVED IN NEW ZEALAND
D. C. Crombie, et al., Proc. Instn. Elect. Engrs., pt. B, vol. 105, May 1958, p. 301/304.

DIFFERENCES BETWEEN THE EAST-WEST AND WEST-EAST PROPAGATION OF VLF SIGNALS OVER LONG DISTANCES
D.D. Crombie, J. Atmos. Terr. Phys., vol. 12, 1958, p. 110/117.

ON COMMUNICATION IN THE SEA BY VLF ELECTROMAGNETIC WAVES
K. Furutsu, J. Radio Res. Labs., vol. 5, Jan. 1958, p. 19/33.

OBSERVATIONS OF MAGNETO-IONIC DUCT PROPAGATION USING MAN-MADE SIGNALS OF VERY LOW FREQUENCY
R.A. Helliwell, et al., Proc. IRE, vol. 46, April 1958, p. 785/787.

TRANSMISSION LOSS CURVES FOR PROPAGATION AT VERY LOW RADIO FREQUENCIES
J.R. Wait, IRE Trans. Commun. Syst., vol. CS-6, Dec. 1958, p. 58/61.

ON PROPAGATION VELOCITY OF ELECTROMAGNETIC WAVES AT AUDIO FREQUENCY
Y. L. Al'pert, et al., Radiotekh. Elektron., vol. 4, Feb. 1959, p. 195/201.

VLF REFLECTIONS FROM THE IONOSPHERE IN THE PRESENCE OF TRANSVERSE MAGNETIC FIELD
N. F. Barber, et al., J. Atmos. Terr. Phys., vol. 16, Oct. 1959, p. 37/45.

ATMOSPHERIC WHISTLERS
R.A. Helliwell, et al., Proc. IRE, vol. 47, Feb. 1959, p. 200/208.

VERY-LOW FREQUENCY SPECTRA OF ATMOSPHERICS PROPAGATED THROUGH THE IONOSPHERE
T. Obayashi, Nature, vol. 184, July 1959, p. 34/36.

A report of experimental results which support the mode theory suggested by Budden.

OBSERVATIONS ON NSS PROPAGATED BY DOUBLE-HOP WHISTLER MODE
H.O. Peterson, et al., IRE-URSI Joint Meeting, Oct. 19-21, 1959, San Diego, Calif.

ATMOSPHERICS AND THE PROPAGATION OF RADIO WAVES OF FREQUENCIES LESS THAN 1 KC
E. T. Pierce, IRE-URSI Joint Metting, Oct. 19-21, 1959, San Diego, Calif.

DIURNAL CHANGE OF IONOSPHERIC HEIGHTS DEDUCED FROM PHASE VELOCITY MEASURMENTS AT VLF
J.R. Wait, Proc. IRE, vol. 47, May 1959, p. 998.

CHANGES IN THE FADING SPEED OF LOW-FREQUENCY RADIO WAVES
W.A. Cilliers, J. Atmos. Terr. Phys., vol. 18, no. 4, Aug. 1960, p. 339/341.

A FOUR-YEAR SUMMARY OF WHISTLER ACTIVITY AT WASHINGTON, D. C.
H.E. Dinger, J. Geophys. Res., vol. 65, no. 2, Feb. 1960, p. 571/575.

GEOMAGNETIC DISTURBANCES AND 5 KILOCYCLES PER SECOND ELECTROMAGNETIC RADIATION
G.R. Ellis, J. Geophys. Research, vol. 65, June 1960, p. 1705/1710.

ON THE THEORY OF REFLECTION OF LOW AND VERY-LOW-RADIOFREQUENCY WAVES FROM THE IONOSPHERE
J.R. Johler, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 3, May - June 1960, p. 269/285.

POSSIBLE APPLICATION OF THE SYSTEM LOSS CONCEPT AT ELF
K.A. Norton, J. Res. Nat. Bur. Stand., vol. 64D, no. 4, July - Aug. 1960, p. 413/414.

THE PROPAGATION OF RADIO WAVES OF FREQUENCY LESS THAN 1 KC
E. T. Pierce, Proc. IRE, vol. 48, no. 3, March 1960, p. 329/331.

A BRIEF SURVEY OF VARIOUS PARAMETERS RELATING TO THE PROPAGATION OF VLF SIGNALS
F. Secretan, et al., Collins Radio Co., Western Division, April 1960, p. 1/20.

DAYTIME ATTENUATION RATES IN THE VERY LOW FREQUENCY BAND USING ATMOSPHERICS
W.L. Taylor, J. Res. Nat. Bur. Stand., vol. 64D, no. 4, July - Aug. 1960, p. 349/355.

VLF ATTENUATION FOR EAST-WEST AND WEST-EAST DAYTIME PROPAGATION USING ATMOSPHERICS
W.L. Taylor, J. Geophys. Res., vol. 65, no. 7, July 1960, p. 1933/1938.

ON THE PROPAGATION OF ELF RADIO WAVES AND THE INFLUENCE OF A NONHOMOGENEOUS IONOSPHERE
J.R. Wait, J. Geophys. Res., vol. 65, no. 2, Feb. 1960, p. 597/600.

TERRESTRIAL PROPAGATION OF VERY-LOW-FREQUENCY RADIO WAVES: A THEORETICAL INVESTIGATION
J.R. Wait, J. Res. Nat. Bur. Stand., vol. 64D, no. 2, March - April 1960, p. 153/204.

A self-contained treatment of the waveguide mode theory of the propagation of very-low-frequency radio waves is presented. . . . influence of earth curvature is also considered. . . . Other factors considered are the influence of the earth's magnetic field, antipodal effects, resonator type oscillations, and the influence of stratification at the lower edge of the ionosphere.

INFLUENCE OF SOURCE DISTANCE ON THE IMPEDANCE CHARACTERISTICS OF ELF RADIO WAVES (Correspondence)
J.R. Wait, Proc. IRE, vol. 48, July 1960, p. 1338/1339.

LF LINKS UNDER ARCTIC CONDITIONS
(In Norwegian)
J. Dalland, Telektronikk, no. 3-4, July - Dec. 1961, p. 121/132.

The results of observations of the field strength of some l.f. radio links in artic areas are given, with special emphasis on the behaviour during polar radio blackout conditions. The observations were carried out at Isfjord (Spitsbergen). Three transmitting stations were recorded at 57°7, 80°3 and 121°6 kc/s, the distance being in the range from 1600 to 3000 km. Noise recordings were also made on a frequency of 70 kc/s. . . .

THE PHASE VARIATION OF VERY-LOW-FREQUENCY WAVES PROPAGATED OVER LONG DISTANCES
B. G. Pressey, et al., Proc. Instn. Elect. Engrs. Paper 3456 E., vol. 108B, March 1961, p. 214/226.

The proposed use of very-low-frequency waves (10-20kc/s) for navigational aids of the phase-comparison type has led to the study of the phase variations of these waves when propagated over distances up to 6000 km. . . . Measurements have been made. . . between the signals received from a single transmitter at two spaced receiving stations. The two principal transmitters used were Varberg, Sweden, on a frequency of 17.2 kc/s and at a range of 1000 km, and Annapolis, United States, on 15.5 kc/s at a range of 6000 km. Receiver baselines, up to 280 km in length, were situated in England and oriented both transverse to, and along, the direction of propagation. . . .

RESULTS OF MEASUREMENT OF FIELD INTENSITY OF V.L.F. WAVES OVER GREAT DISTANCES
A. Sakurazawa, et al., J. Radio Res. Lab., vol. 8, no. 40, Nov. 1961, p. 425/439.

Field intensities of 18°6 kc/s transmissions from Oso, Washington, were continuously recorded over a period of 1 1/2 years at the Inubo Radio-Wave Laboratory, and 19°8 kc/s transmissions from Maui, Hawaiian Is., were also recorded during the latter half year. . . .

A NEW APPROACH TO THE MODE THEORY OF VLF PROPAGATION
J.R. Wait, J. Res. Nat. Bur. Stand., vol. 65D, no. 1, Jan. - Feb. 1961, p. 37/46.

Presents a concise derivation of the mode theory of v.l.f. propagation. Taking note of the fact that the important modes for long-distance propagation are near grazing, suitable approximate forms of the wave functions are introduced at the outset, rather than at the end, of the analysis. It is thus possible to account for the influence of earth curvature in a relatively concise manner. The influence of the earth's magnetic field is also discussed. Finally, numerical results for the attenuation and the phase velocity of the dominant mode are presented. . . .

IONOSPHERIC RADIO: XIIIth GENERAL ASSEMBLY OF URSI, LONDON, 1960
W.J. Beynon (editor), New York, American Elsevier Publishing Co., Inc., 1962, 262 p.

. . . 5) hydromagnetic waves and VLF emissions . . .

PROPAGATION OF RADIO WAVES AT FREQUENCIES BELOW 300 KC/S
W.T. Blackband (editor), Proc. of the 7th Meeting of the AGARD Ionospheric Res. Comm., Munich 1962, (AGARDograph 74) Pergamon Press and Mac Millan Co., 1964, 490 p., N64-19676, 30 papers.

ELF ELECTROMAGNETIC RADIATION FROM SMALL EXPLOSIVE CHARGES IN AIR AND WATER
G.D. Curtis, Proc. IRE, vol. 50, no. 11, Nov. 1962, p. 2298/2301.

Two short series of tests involving measuring low-frequency electromagnetic radiation from ten-gram explosive charges in air and water have revealed signals lower than 1 cps, of duration occasionally greater than fifteen seconds. Care was used to insure that the signals were not of microphonic or other spurious origin. . . .

SOME REMARKS ON "PENETRATION OF THE IONOSPHERE BY VERY-LOW-FREQUENCY RADIO SIGNALS" (Correspondence)
H. Hodara, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 2000.

In a recent article, Leiphart, Zeek, Bearce, and Toth have published some interesting data furnished by the Navy satellite "LOFTI I" . . . Their conclusions . . . seem to confirm early theoretical investigations done by the writer. . . .

PROPAGATION OF TERRESTRIAL RADIO WAVES OF LONG WAVELENGTH - THEORY OF ZONAL HARMONICS WITH IMPROVED SUMMATION TECHNIQUES
J.R. Johler, et al., J. Res. Nat. Bur. Stand., vol. 66D, no. 6, Nov. - Dec. 1962, p. 737/773.

Demonstrates that the field of the propagated long wavelength radio wave (frequencies less than approximately 50 kc/s) can be evaluated by a summation of a series of zonal harmonics. . . .

PROPAGATION OF THE LOW-FREQUENCY RADIO SIGNALS
J.R. Johler, Proc. IRE, vol. 50, no. 4, April 1962, p. 404/427, AD 414 293.

. . . propagation in the time domain is reviewed for linear amplitude systems. . . . propagation of a ground wave pulse is considered in detail. A stretching in the form or shape of the pulse is noted as a result of the filtering action of the propagation medium. Theoretical transfer characteristics for the media of propagation of LF signals are introduced and methods of computation are considered. . . .

PROPAGATION PHASE VARIATION MEASUREMENTS AT VERY LOW FREQUENCIES
J.L. Knox, Antenna Lab., Ohio State U., Research Foundation, Columbus, Scientific rept. no. 17, (Rept. no. 1116-26), 31 Oct. 1962, 114 p. (AFCRL-63-44), AD 298 763.

DIFFERENT TYPES OF MUSICAL ATMOSPHERES AND THEIR RELATIONS TO LIGHTNING DISCHARGES
E. Knudsen, et al., Uppsala U., Sweden, 1962, 19 p., AD 404 953.

The recording method at a whistler observation station allowed of a correlation between lightning discharges and musical atmospheres produced by them. About 700 musical whistlers collected in 1958-1961 have been analysed. It was found that about 70% of the records were correlated to lightning discharges and about 30% were not.

A SUMMARY OF LITERATURE PERTAINING TO VLF AND ELF PROPAGATION VOLUME ONE: A-K
F.H. Smith, Stanford Research Inst., Menlo Park, Calif., July 1962, 418 p., AD 406 160.

A SUMMARY OF LITERATURE PERTAINING TO VLF AND ELF PROPAGATION VOLUME TWO: L - Z
F.H. Smith, et al., Stanford Research Inst., Menlo Park, Calif., July 1962, lv., AD 406 161.

SURVEY AND BIBLIOGRAPHY OF RECENT RESEARCH IN THE PROPAGATION OF VLF RADIO WAVES
J.R. Wait, IN: RADIO NOISE OF TERRESTRIAL ORIGIN. International Scientific Radio Union, General Assembly, 13th, Commission 4 on Radio Noise of Terrestrial Origin, Proceedings, London, England, Sept 1960. New York, Elsevier Publishing Co., 1962, p. 176/202, A63-22898.

. . . current knowledge of the application of LF radio waves to long-range navigational systems, communications, and world-wide frequency standards. Recent research on ground-wave transmission is described, and ray and mode concepts of ionospheric propagation are considered. . . .

COMMENTS ON "PENETRATION OF THE IONOSPHERE BY VERY-LOW-FREQUENCY RADIO SIGNALS - INTERIM RESULTS OF THE LOFTI I EXPERIMENT" (Correspondence)
C. Altman, et al., Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 250.

NAVIGATION BY MEANS OF VLF RADIO TRANSMISSIONS
O.J. Baltzer, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, p. 13-26/13-31.

Use of carrier-stabilized VLF transmissions for frequency calibration and precision timing applications is becoming widespread. It is also possible to utilize these same transmissions for radio navigation purposes in areas where LORAN C and OMEGA is not available . . . problems and . . . accuracy limitations, both for "dead reckoning" and for an absolute navigation system. . . .

PRELIMINARY RESULTS FROM THE VERY-LOW FREQUENCY RECEIVER ABOARD CANADA'S ALOUETTE SATELLITE
R.E. Barrington, et al., Nature, vol. 198, May 18, 1963, p. 651/656, A63-19276.

Presentation and analysis of VLF observations of whistlers and ionospheric noise recorded by the Canadian Alouette satellite (1962 Beta Alpha 1). . . .

THE OBLIQUE REFLECTION OF CW LOW-FREQUENCY RADIO WAVES FROM THE IONOSPHERE
J.S. Belrose, In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, p. 149/165, ref. Pergamon Press and Mac Millan Co., N64-19687.

. . . some measurements made on waves of low and very low frequency reflected from the ionosphere at oblique incidence are discussed, specifically, the amplitude and phase variations of waves propagated over distances up to 2,500 km over middle-to high-latitude paths . . .

THE NORMAL PHASE VARIATIONS OF THE 18 KC/S SIGNALS FROM NBA OBSERVED AT FRANKFURT, GERMANY
A.H. Brady, et al., National Bureau of Standards, Boulder, Colo., 8 Dec. 1963, 34 p., refs., (NBS-TN-20601), N64-13941 and AD 431 287.

. . . given in the form of monthly averages and standard deviations at 5-minute intervals . . . Short term normal phase differences are also briefly discussed.

THE NORMAL PHASE VARIATIONS OF THE 18 KC/S SIGNALS FROM NBA OBSERVED AT MAUI, HAWAII
A.H. Brady, et al., Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., Rept, no. 2, 19 March 1964, 23 p., NBS TN206 2, AD 433 252.

. . . radiated from the Canal Zone and received in Maui, Hawaii . . . monthly averages and standard deviations at five minute intervals. The relations between the diurnal variation in the length of sunlit path are shown. The calculated mean diurnal change in effective height of reflection is 13.7 km. . . .

THE NORMAL PHASE VARIATIONS OF THE 18 KC/S SIGNALS FROM NBA OBSERVED AT BOULDER, COLORADO, U.S.A.
A.H. Brady, et al., Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., 10 April 1964, 27 p., AD 435 848.

. . . given in the form of monthly averages and standard deviations at five minute intervals. The relations between the diurnal phase variations and the diurnal variation in the length of sunlit path are shown. . . . Values of the short term phase differences are also given.

ON THE LONG TERM PHASE STABILITY OF THE 19.8 KC/S SIGNAL TRANSMITTED FROM HAWAII, AND RECEIVED AT BOULDER, COLORADO

A.H. Brady, Journal of Research, Section D - Radio Science, vol. 68D, March 1964, p. 283/289, 7 refs., A64-15843 and AD 435 897.

The use of VLF signals for intercontinental frequency comparision has become very popular in recent years, and it has been shown by other workers that a precision of about 2 parts in 10^{11} can be achieved with measurements over a 24-hr period. . . . transmission . . . studied for several periods of nearly two weeks duration in 1962. . . . show an attainable precision of 2.5 parts in 10^{11} in a 24-hr observation, extending to 3.1 parts in 10^{12} in a 192-hr observation . . . there is no evidence that the propagation conditions over the path are limiting this precision. . . .

SOME EXPERIMENTAL RESULTS CONCERNING NONRECIPROCAL EAST-WEST VLF WAVE PROPAGATION

B. Burgess, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14 1963, Paper 68D1-310.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 17/18, 5 refs., A64-14684

. . . experimental results substantiating nonreciprocal propagation of VLF waves in east-west and west-east directions. . . . observations of phase of the VLF transmitter NPM (19.8kc) in Hawaii, monitored at Singapore, 11,000 km distant by short path, and 29,000 km distant by long path. . . .

NATURAL ELECTROMAGNETIC FIELD FLUCTUATIONS IN THE 3.0- to 0.02-CPS RANGE

W.H. Campbell, Proc. IEEE, vol. 51, no. 10, Oct. 1963, p. 1337/1342.

Using large loop antennas the ultra-low frequency research group at the National Bureau of Standards has studied the upper atmosphere phenomena of geomagnetic micropulsations. Data taken at a number of world stations on both direct reading chart and magnetic tape indicate a division into three contributing phenomena for the frequency range of 3.0 to 0.02 cps. . . .

ON A REMARKABLE CORRELATION BETWEEN WHISTLER-MODE PROPAGATION AND HF NORTHSCATTER

G.B. Carpenter, Stanford U., Calif., Stanford Electronics Labs., June 1963, 30 p., 6 refs., Scientific Report No. 4 and Technical Report No. 2, (SEL-63-082; AFCRL-63-692), N63-22678.

. . . The geometry of F-region northscatter is such that the scattering irregularities are in the general latitude region in which the whistler-mode signals are believed to be propagating. . .

PHASE VARIATIONS IN V.L.F. PROPAGATION

C.J. Chilton, et al., In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, p. 257/290, refs., Pergamon Press and Mac Millan Co., N64-19695.

The experimental work describing the variation in phase of VLF signals received after ionospheric reflections at small and large distances is reviewed . . . At all distances, regular systematic variations in phase occur when the path changes from day to night . . .

VARIATIONS IN PHASE PATH OF MAN-MADE ONE-HOP WHISTLER MODE SIGNALS AT 18.6 KILOCYCLES PER SECOND

D.D. Crombie, et al., J. Geophys. Res., vol. 68, Dec. 1, 1963, p. 6229/6235, A64-11578.

. . . from the VLF transmitter NPG near Seattle, Washington, observed in New Zealand. . . . characterized by a change in frequency, presumably introduced by variations in the phase path length. The observations indicate that the phase path length can alter at a rate of about 1 km/sec, and total phase path changes of the order of 200 km can occur in a period of 3 min. . . .

PERIODIC FACING OF VLF SIGNALS RECEIVED OVER LONG PATHS DURING SUNRISE AND SUNSET

D.D. Crombie, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-313.) Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 27/34, 9 refs., A64-14687.

Account of fading phenomena over two selected long paths, with an outlined explanation. Observations of diurnal phase and amplitude variations between NPM and NBA received at Frankfurt are plotted, and comments made on features of interest. Similar plots and comments are made for seasonal variations and mean rate of change of phase. . . .

OBLIQUE INCIDENCE PULSE MEASUREMENTS AT 100 KC/S

R.H. Doherty, In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, 1v., p. 133/148, refs., Pergamon Press and Mac Millan Co., N64-19686.

Fast rising pulses propagated over long ranges have provided a means for separating the ground-wave and various order sky-wave time modes at 100 kc. Amplitude and phase measurements of the once reflected sky wave show that besides the normal phase variations other phenomena occur. For example, large amplitude variations are not accompanied by phase variation; phase delays may differ for opposite directions of propagation along the same path; the attenuation rate of the signals increases with latitude . . . The observed phenomena are interpreted as further evidence of the existence of a low-altitude low-electron density region in the ionosphere.

EXPERIMENTAL RESEARCH INVESTIGATION OF EXTREMELY LOW FREQUENCY PROPAGATION

G.R. Dunn, et al., Space General Corp., El Monte, Calif., Final rept., 28 Feb. 1964, 75 p., Rept. no. 212R8, AFCRL 64164, AD 437 777.

. . . measuring the characteristics of CW signals transmitted over a 400 cps link, over a distance of 3000 km. A 67-mile section of power transmission line was used to radiate the 400 cps energy. Data which could be reduced to yield signal strength, attenuation rate, transmission path phase variations, and atmospheric noise amplitude probability distributions (APD) were recorded at the receiver site. The measured attenuation rate was 3.5 db/1000 KM for nighttime path and 9db/1000 KM for a daytime path. . . . Atmospheric noise data were recorded for all transmission periods. Samples of these data are presented in the form of amplitude probability distributions and impulses per unit time distributions. Performance measurements and calculations for the power line transmitting antenna are presented.

AUDIO- AND SUBAUDIO-FREQUENCY ELECTROMAGNETIC RADIATION AT HIGH LATITUDE

A. Egeland, et al., Kiruna Geophysical Observatory (Sweden), 25 March 1963, 24 p., AFCRL 63 475, AD 404 656

. . . special emphasis on the 700 cps emission band . . . All the emissions at 700 cps are probably caused by the same physical process or processes. The hypothesis that the 700 cps signals are generated outside the E-layer, by the arrival of protons is discussed.

VERY LOW FREQUENCY RADIO WAVE PROPAGATION AT HIGH-LATITUDES

A. Egeland, et al., Kiruna Geophysical Observatory (Sweden), 25 June 1963, 22 p., Scientific rept. no. 1, 14 refs., AFCRL Rept. no. 63 856, 14 refs., AD 415 186.

Diurnal, seasonal and yearly variations of the normal 16 kc signal strength from the Rugby (GBR) transmitter . . . five years of continuous recording (Sept. 1958 to May 1963) at Kiruna Geophysical Observatory. . . .

AN INVESTIGATION OF THE NATURAL ELECTROMAGNETIC RADIATIONS BETWEEN 10C/S AND 10KC/S

A. Egeland, et al., Kiruna Geophysical Observatory (Sweden) 20 Feb. 1964, 42 p., AFCRL 64 304, AD 437 820.

Naturally occurring electromagnetic radiation in the audio-frequency range . . . Several emission bands, which are quite distinct from the normal background-signals and are obtained as strong enhancements in portions of the spectrum, have been recorded.

LONG TERM VARIATION OF IONOSPHERIC REFLECTION HEIGHTS FOR V.L.F. RADIO WAVES

A. Egeland, et al., J. Atmos. Terr. Phys., vol. 26, March 1964, p. 351/365, 16 refs., A64-16809.

RESEARCH IN CONNECTION WITH PROPAGATION OF VERY LOW FREQUENCY (VLF)

J. Eitzenberger, et al., Batelle Institut, Frankfurt Main (Germany) Interim annual technical rept., 1 July 1962 - 30 June 1963, 31 July 1963, lv., AD 419 257.

VLF receiving station Frankfurt/Main-Receiving site . . . improvement and construction of equipment . . . slow amplitude recording device . . . Antenna problems and construction; Noise suppression systems. . . .

APPLICATION OF VLF TO INTERPLANETARY COMMUNICATIONS

J. Farber, et al., Rec. Nat. Space Elec. Symp., 1963, p. 7.5.

. . . The presence of galactic and extra-terrestrial noise in the plane of the ecliptic has been a predominant factor in favoring the microwave band for both deep space communications and interplanetary communications. . . . adoption of S-band as the most favorable telemetry band for NASA's deep space probes. . . . lies within the radio window of the earth's atmosphere (100MC - 10,000 MC) and represents a satisfactory compromise between antenna aperture size, antenna gain, power and receiver sensitivity at ranges out to VENUS and MARS and MERCURY. . . . As a result of recent measurements. . . there is mounting evidence to support the fact that attenuation bands centered in the VLF part of the spectrum exist around the planets and the sun by virtue of their ionized atmosphere. . . . resulting in extremely low noise levels at VLF in interplanetary space. . . .

EXTRA-LOW-FREQUENCY PROPAGATION
J. Galejs, Sylvania Electric Products, Inc., Waltham, Mass., July 1963, 119 p., AD 417 239.

The principal amount of ELF wave energy remains within the spherical shell between the earth and the ionosphere. The propagation of the waves depends on the ground characteristics and on the ionosphere properties. . . . The excitation of ELF waves by thunderstorms is reviewed. Experimental data on propagation characteristics and noise . . .

AN INTERPRETATION OF RAPID CHANGES IN THE PHASE OF HORIZONTALLY POLARIZED VLF WAVES RECORDED AT NIGHT OVER A SHORT PATH IN THE SOUTHWESTERN UNITED STATES
E.E. Gossard, et al., (VLF Symposium, Boulder, Colo., Aug. 12-14, 1963.), Journal of Research, Section D - Radio Science, vol. 68D, March 1964, p. 265/274, 14 refs., A64-15841.

. . . The observations show certain striking features. The records of receivers placed to the east of the transmitter are different in character from records of receivers placed in a correponding position to the west of the transmitter. Characteristic records of components polarized in the plane of incidence are often very different from those of components polarized normal to the plane of incidence. Rapidly moving features often pass over the triangle of receiving stations causing 180^{o} to 360^{o} phase changes. . . .

AN EXPERIMENTAL STUDY OF THE PHASE STABILITY OF VLF SIGNALS
D.E. Hampton, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-311.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 19/20, A64-14685.

Examination of diurnal phase variation records. Phase and amplitude of VLF signals have been shown to be stable from day to day. For distances exceeding 4000 km, phase difference is linearly dependent on distance. In cases of paths part in light and part in dark, a "step" is assumed in the ionosphere height at the dawn and dusk points, and phase velocity is discontinuous across these points. . . .

RADIO PULSE PROPAGATION BY A REFLECTION PROCESS AT THE LOWER IONOSPHERE
J.R. Johler, Journal of Research, Section D - Radio Propagation, vol. 67D, Sept. - Oct. 1963, p. 481/499, 23 refs., A63-25322.

. . . using a method that employs direct analytic procedures for the evaluation of the Fourier transform-integral for the gournd-wave pulse. A previous analysis of the reflection coefficient is employed to construct transfer functions for the ionospheric wave . . . the behavior of LF pulses propagated by a reflection process at the ionosphere is determined for three models for the lower ionosphere. The composite ground and ionospheric pulse is formed, a method of tagging a point-in-time on the pulse is detailed.

SOME RESULTS OF FIVE YEARS OF WHISTLER OBSERVATIONS FROM LABRADOR TO ANTARCTICA
T. Laaspere, et al., Proc. IEEE, vol 51, no. 4 April, 1963, p. 554/568.

. . . whistler data are averaged over a long period of time to smooth out random short-term variations . . . Local season is such a strong factor in determining the shape of the diurnal curves of observed whistler activity that even in the case of the north-south "Whistlers-East" chain of audio-frequency receiving stations, diurnal curves of the northern-and southern-hemisphere stations tend to be similar not during the same period of the year but during the same local season at the point of observation. . . . The curves presented should . . . be useful in predicting the behaviour of man-made signals propagating in the "whistler mode" through the ionosphere and the magnetosphere of the earth. . . .

(No Title)
H.R. Machin (editor), Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., Quarterly progress rept. no. 7, Jan. - March 1963, March 1963, 116 p., NBS Rept. no. 7694, AD 419 303.

. . . study of ionospheric transmission of LF/VLF radio pulses . . .

PHASE VELOCITY OF ELECTROMAGNETIC WAVES IN THE RANGE 1—25 KCPS
G.A. Mikhaylova, et al., Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 20 Sept. 1963, 7 p., AD 422 578.

. . . obtained through harmonic analysis of radio disturbances recorded simultaneously in Moscow and Leningrad in the daytime for distances $r > 1,000$ km. . . .

PROPAGATION DELAY FROM WWV
D.W. Proctor, Sperry Gyroscope Co., Great Neck, N.Y., In its Minimum Variance Orbit Determination Program, 8 Nov. 1963, p. 56/60, N64-18229.

The raw data from the range-and-range rate system are related to the time of the measurement at the ground station. These times are synchronized to WWV and include the time delay from WWV to the ground site . . . propagation-delay corrections from WWV to the site must be included . . . Since only three stations are involved, these corrections can be precomputed and stored as program constants for each station location. An equation is derived for computing timing-signal delay from WWV to a range-and-range-rate tracking station . . .

RECENT V.L.F. WORK AT THE U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY

F.H. Reder, et al., In AGARD Propagation of Radio Waves at Frequencies Below 300 kc/s, 1964, p. 335/338, refs., Pergamon Press and Mac Millan Co., N64-19698.

. . . propagation studies and long-distance clock synchronization experiments that have been conducted . . . since 1959. Atomic Cs beam frequency standard, type NC 1001, was used for driving transmitters and clocks, and for providing local references for VLF and LF receivers. Measured values of the depth of the phase trapezoid patterns for various VLF transmission paths are included.

PRECISE PHASE AND AMPLITUDE MEASUREMENTS ON VLF SIGNALS PROPAGATED THROUGH THE ARCTIC ZONE

F.H. Reder, et al., (VLF Symposium, Boulder, Colo., Aug. 12-14, 1963.), Journal of Research, Section D - Radio Science, vol. 68D, March 1964, p. 275/281, 6 refs., A64-15842.

. . . results for the period from February to June 1963. Typical diurnal phase and amplitude patterns of NPM and NPG transmissions received at Stockholm are given for each month. The diurnal NPG amplitude change at Stockholm reached a maximum of 38 db during March. . . . Arctic paths were found to be worse by only a factor of about 2. Preliminary analysis of geomagnetic disturbance data and observed VLF phase anomalies indicates reasonable correlation for the NPG-Stockholm path. . . .

EXPERIMENTAL RESEARCH INVESTIGATION OF EXTREMELY LOW FREQUENCY PROPAGATION

R.D. Smith, et al., Space Electronics Corp., Glendale, Calif., 15 Feb. 1963, 45 p., AFCRL 63 46, AD 404 564.

. . . measuring the characteristics of cw signals transmitted over a 400 link. Signal strength, received and transmitted signal phase, and atmospheric noise were recorded. . . . received values of signal strength were 2 db less during night-time and 4 db less during daytime than the values predicted by analytical studies . . .

SOME OBSERVATIONS ON VLF STANDARD FREQUENCY TRANSMISSIONS AS RECEIVED AT SYDNEY, N.S.W.

A.M. Thompson, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1487/1493.

The phase and amplitude of standard frequency transmissions from G.R.R. (16 kc) and N.B.A. (18 kc) are recorded continuously by comparison with a local standard. . . . Over a 24-hour interval frequency comparisons to better than 1 in 10^{10} are possible . . . Some variations due to ionospheric disturbances are noted including the high altitude bomb test on July 9, 1962 . . . Multimode transmission gives rise to interference effects and in the case of N.B.A. the 1-second modulation has been used to differentiate between the long and short path transmissions. Interference between these two transmission paths can lead to an apparent gain or loss of a cycle per day and would present difficulties to an automatic clock synchronizing system based on these transmissions.

EXTRA LONG WAVES PROPAGATION WITH ROCKETS

E.J. Vassy, Paris U. (France), Final rept., 30 Dec. 1963, 49 p., AD 434 771.

Measurements were made of the field of a 16.8 Kc transmitter at long distance (2200 Km) versus the height. The field disappears at the height of 110 km by day as well as by night. There is no modulation when the loop rotates with the rocket. . . .

HEIGHT-GAIN FOR V.L.F. RADIO WAVES

J.R. Wait, et al., J. Res. Nat. Bur. Stand., vol. 67D, no. 2, March - April 1963, p. 183/187.

The height dependence of the field strength of v.l.f. radio waves is considered. Using a previously developed theory, the height-gain function of the first two modes is calculated in terms of Airy functions of complex argument. It is indicated, for frequencies of the order of 25 kc/s that the height-gain function reaches a maximum value at a height of the order of 40 km when the reflecting layer is about 70 km. . . .

TWO-DIMENSIONAL TREATMENT OF MODE THEORY OF THE PROPAGATION OF VLF RADIO WAVES.

J.R. Wait, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-320.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1964, p. 81/93, 11 refs., A64-14694.

Development of final formulas for terrestrial VLF radio propagation from a two-dimensional formulation . . . The theory is extended to waveguides of nonuniform widths, and then to waveguides with localized obstruction. . . .

ON PHASE CHANGES IN VERY-LOW-FREQUENCY PROPAGATION INDUCTED BY AN IONOSPHERIC DEPRESSION OF FINITE EXTENT
J.R. Wait, J. Geophys. Res., vol. 69, Feb. 1, 1964, p. 441/445, 7 refs., A64-14165.

. . . The height changes are not restricted to points along the great circle path connecting the transmitter and receiver. By choosing a simple example, it is shown that ionospheric perturbations lying within the first Fresnel zone are most effective in modifying the phase of the received signal.

REFLECTION OF VLF RADIO WAVES FROM AN INHOMOGENEOUS IONOSPHERE. II - PERTURBED EXPONENTIAL MODEL
J.R. Wait, et al., Journal of Research, Section D - Radio Propagation, vol. 67D, Sept. - Oct. 1963, p. 519/523, A63-25324.

. . . oblique reflection of radio waves from a continuously stratified, ionized, isotropic medium. . . .

INFLUENCE OF THE LOWER IONOSPHERE ON PROPAGATION OF VLF WAVES TO GREAT DISTANCES
J.R. Wait, Journal of Research, Section D - Radio Propagation, vol. 67D, July - Aug. 1963, p. 375/381, A63-20995.

Theoretical calculation of the attenuation and phase velocity of the dominant modes in the frequency range from 8 to 30 kc. . . . Initially the ionosphere is regarded as a sharply bounded isotropic medium. The influence of the terestrial magnetic field is not considered . . . The results for the phase velocities and attenuation modes are presented in graphical form.

VLF PROPAGATION UNDER THE IONOSPHERE IN THE LOWEST MODE OF HORIZONTAL POLARIZATION
H.A. Wheeler, (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-323), Journal of Reasearch, Section D - Radio Science, vol. 68D, Jan. 1964, p. 105/113, 19 refs., A64-14696.

. . . Examination of the various modes shows that the TE-01 mode has low attenuation and no opportunity for fading. With horizontal polarization attenuation due to imperfect ground conductivity is lessened, particularly at higher frequencies. . . .

VLF ENVELOPE TIMING EXPERIMENT
ITT Federal Labs., Nutley, N.J., Quarterly progress rept. no. 2, 8 Sept. - 7 Dec. 1963, 7 Dec. 1963, 23 p., AD 435 781.

. . . design of precision VLF envelope timing equipment to be used to demonstrate the feasibility of time synchronization at separate geographical locations. . . .

STUDY OF NATURAL AND MAN-MADE VLF PHENOMENA
Stanford Electronics Labs., Stanford U., Calif., 31 July 1963, 7 p., AD 428 348.

. . . (1) Whistler-mode propagation; (2) magnetosphere electron density studies using whistlers; and (3) wave-particle interactions. . . . reports and publications listed in an attached bibliography. . . .

LOW FREQUENCY PROPAGATION TEST POWER BOX III
Boeing Co., Seattle, Wash. May 1963, 406 p., ASD TDR63 94, AD 411 241.

Previous tests of low-frequency radio wave propagation established the feasibility of radiating signals of 151 kc from a trailing-wire antenna to distances of 1000 nautical miles. The current program . . . to include operational tests at 46 kc as well as measurements of certain antenna parameters from 30 to 60 kc . . . Three promising MODEM techniques were tested in a side-by-side comparision. Error rates as a function of signal-to-noise ratios are presented.

RESEARCH IN CONNECTION WITH PROPAGATION OF VERY LOW FREQUENCY (VLF)
Battelle Institut , Frankfurt Main, (Germany), Interim annual technical rept., 1 July 1962 - 30 June 1963, 31 July 1963, 52 p., AD 414 203.

The VLF receiving station in Frankfurt/Main is continuously monitoring the transmissions of GBR (16 kc/s) with regard to fast phase and amplitude and those of NBA (18 kc/s) with regard to slow phase and amplitude. . . .

Related Publications:

VLF PROPAGATION MEASUREMENTS FOR THE RADUX-OMEGA NAVIGATION SYSTEM
C.J. Casselman, et al., Proc. IRE, vol. 47, May 1959, p. 829/839.

NEW VLF TO REACH ALL POLARIS SUBS
Electronics, vol. 33, July 1960, p. 34/35.

WORK ON VERY LOW FREQUENCY AND PROPAGATION MEASUREMENTS USING SHORT WAVES
J. Hillmann, et al., Battelle Institut, Frankfurt Main, (Germany), Quarterly technical status rept. no. 1, 1 July - 30 Sept. 1961, 31 Oct 1961, 6 p., AD 416 256.

Principal Publications:

THE NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS GOVERNING THE REFLEXION OF LONG RADIO WAVES FROM THE IONOSPHERE: PART 3
D.W. Barron, et al., Proc. Roy. Soc. London, A., vol. 249, Jan. 1959, p. 387/401.

PROPAGATION OF A GROUND WAVE PULSE AROUND A FINITELY CONDUCTING SPHERICAL EARTH FROM A DAMPED SINUSOIDAL SOURCE CURRENT
J.R. Johler, et al., IRE Trans. Antennas Propagation, vol. AP-7, Jan. 1959, p. 1/11.

SOME INVESTIGATIONS ON LONG-WAVE PROPAGATION
S.N. Mitra, J. Inst. Telecommun. Engrs., India, vol. 5, June 1959, p. 121/135.

An analysis of observations made on a frequency of 164 kc. . . . Aug. 9th. to Dec. 16th., 1958 shows that solar flares of all classes of importance give rise to sudden increases in amplitude of the received signal.

FURTHER STUDIES OF THE DEVIATION OF LOW-AND-MEDIUM-FREQUENCY GROUND WAVES AT A COAST-LINE
B.G. Pressey, et al., Proc. Instn. Elect. Engrs., pt. B, vol. 106, Nov. 1959, p. 548/554.

CHARACTERISTICS OF MEDIUM-WAVE FADING (In Japanese)
E. Sawamura, J. Inst. Elect. Commun. Engrs., Japan, vol. 42, no. 10, Oct. 1959, p. 934/937.

SOME MEDIUM FREQUENCY SKY WAVE MEASUREMENTS
J.M. Dixon, Proc. Instn. Radio Engrs., Australia, vol. 21, June 1960, p. 407/409.

RAPID PERIODIC FADING OF MEDIUM WAVE SIGNALS (Correspondence)
H. Misra, Proc. IRE, vol. 48, June 1960, p. 1167/1168.

IONOSPHERIC PROPAGATION ON LONG AND MEDIUM WAVES. RESULTS OF AN INVESTIGATION ORGANIZED BY THE EUROPEAN BROADCASTING UNION. III
W. Ebert, EBU Rev. A., no. 73, June 1962, p. 109/121.

. . . Ionospheric propagation curves are given for frequencies of 150, 200, 300, 500, 700, 1000 and 1500 kc/s, and represent the annual median of the hourly field-strength medians as a function of the propagation distance under specified conditions. . . .

LOW FREQUENCY SWEEP GROUP HEIGHT AND POLARIZATION RECORDS
J.D. Hardy, Ionosphere Research Lab., Penn. State U., University Park, 15 Feb. 1963, 220 p., incl. illus., 3 refs., Scientific rept. no. 179, Rept. for 5 March - 22 Aug. 1962 on Ionospheric Research, AFCRL 63-256, AD 401 184.

. . . covering the . . . range of 100-1000 kc . . . Its purposes is determination of the structure of the lower ionosphere. Included in these data are the preliminary results of a stepped frequency experiment. These appear to be the only such records being obtained in the world at this time.

Related Publications:

THE ENGINEERING OF COMMUNICATION SYSTEMS FOR LOW RADIO FREQUENCIES
J.S. Belrose, et al., Proc. IRE, vol. 47, May 1959, p. 661/680.

A POINT-TO-POINT DATA TRANSMISSION SYSTEM USING MF RADIO
P.J. Ferrell, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 325/330.

DIRECTIONAL AERIALS FOR MF BROADCASTING
N.J. Medlin, Proc. Instn. Radio Engrs., Australia, vol. 24, no. 10, Oct. 1963, p. 734/748.

. . . problems associated with the efficient use of the 108 channels in the medium frequency broadcasting band (525 kc/s-1604 Kc/s). . . .

H. F. PROPAGATION—ITS PRESENT AND FUTURE USE FOR COMMUNICATION PURPOSES
A. F. Wilkins, J. Brit. Instn. Radio Engrs., vol. 20, no. 12, Dec. 1960, p. 939/951, 28 refs.

In the present congested conditions of the h.f. band the planning of frequency allocation demands improved accuracy of prediction of both maximum and minimum frequencies usable on any radio circuit. Such improvement involves greater accuracy in the prediction of ionospheric critical frequencies and m. u. f. factors. . . . Current work on these problems, especially that at the Radio Research Station, is reviewed. The effects of ionospheric irregularities, such as storms, in degrading the accuracy of prediction is noted, and new results on irregularities in trans-equatorial propagation are described. Recent work on the study of lateral deviation of h. f. signals and on the application of the backscatter technique to the determination of optimum signalling frequencies and to the study of the distribution of sporadic-E ionization is summarized. . . .

LAUNCHING OVER THE SEA OF VERTICALLY POLARISED WAVES FOR LONG DISTANCE IONOSPHERIC PROPAGATION
E. O. Willoughby, Proc. Instn. Radio Engrs., Australia, vol. 21, no. 9, Sept. 1960, p. 591/597.

Simple vertically polarized aerials of mast heights of 150' or less, launching over the sea are shown to be capable of gains exceeding 14 db over a frequency band of the order of 5-15 Mc/s with good matching and efficient radiation between 1^{o} and 10^{o} elevation. This is much superior to what can be achieved with any land-based aerial vertically polarized or horizontally polarized, of similar height. . . .

IMPROVED COMMUNICATIONS USING GROUND-SCATTER PROPAGATION
R. T. Wolfram, Electronics, vol. 33, no. 44, Oct. 1960, p. 74/78.

When communication is difficult or impossible over the great - circle paths between two stations, it may be feasible over non-great-circle paths. The instrumentation for research into propagation phenomenon which creates these paths is described and results of investigations given.

THE PREDICTION OF HF COMMUNICATION SERVICES
L. W. Barclay, Marconi Rev., vol. 24, 1961, p. 39/50.

. . . The techniques employed for calculating the maximum usable frequencies and the signal-to-noise ratios for a particular circuit are. . .outlined.

IONOSPHERIC ABSORPTION OF H. F. WAVES IN HIGH LATITUDES
N. Wakai, et al., J. Radio Res. Lab., vol. 8, no. 40, Nov. 1961, p. 413/423.

Measurements of the field intensitites of h.f. waves were made at the Syowa base, Antarctica, from February, 1959, to January, 1960. The transmissions received were from stations at distances from 4820 to 15060 km, the frequencies ranging from 2.5 to 20 Mc/s. Analysis of the results is presented from the view-point of seasonal variations on quiet days. . . .

SIMPLIFIED CALCULATION OF UNABSORBED FIELD INTENSITY ON OVERSEAS TRANSMISSION CIRCUITS (Correspondence)
H. J. Albrecht, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2495/2496.

Unabsorbed field intensity is defined as the strength of a signal received at a distant point in the absence of ionospheric absorption. It depends . . . on path attenuation. Adding an eventual ionospheric absorption attenuation, the over-all signal attenuation is obtained. . . .

STUDY OF RADIO WAVE PROPAGATION IN SWEEP FREQUENCY PULSE TRANSMISSION TESTS IN JAPAN
Y. Aono, J. Radio Res. Lab., vol 9, March 1962, p. 127/200.

The tests described were carried out over a long period on paths of length about 1000 km and 2000 km, the equipment used permitting continuous tuning of the transmitter and receiver in the frequency ranges 2-32 Mc/s and 7-37 Mc/s. The total duration of the sweeping time was 3.5 minutes and the peak transmitted power was 10 kW. Simultaneously with the sweep-frequency pulse transmission tests, vertical-incidence sounding of the ionosphere was carried out at a place near the apex of the propagation path in order to compare the results of the transmission tests with theoretical results based on the data obtained in the sounding of the ionosphere. This comparison indicates that the propagation characteristics of the radio wave can be fairly well estimated from the ionospheric conditions at the apex of the transmission path. Analysis relating to the m. u. f. of the F layer indicates that the determination of the m. u. f. can be much improved on the basis of the curved earth and curved ionosphere. . . .

THE EFFECTS OF FLUCTUATIONS ON PROPAGATION THROUGH A PLASMA MEDIUM

G.S. Kino, et al., Union of German Physical Societies, International Conference, 5th Proceeding, Munich, West Germany, Aug. 28 - Sept. 1, 1961, IN: Ionization Phenomena in Gases, vol. 1, Amsterdam, The Netherlands, North Holland Publishing Co., 1962, p. 602/611, A63-17127.

. . . theory of phase modulation of an RF signal by the LF fluctuation of a plasma. . . . application of the results to the determination of sidebands that arise on an RF signal passed through a plasma medium to which a sinusoidal modulation in density is applied externally at a frequency that is low compared with that of the RF signal.

THE EFFECT OF HIGH-ALTITUDE NUCLEAR EXPLOSIONS ON RADIO COMMUNICATION

H.P. Williams, IRE Trans. Mil. Electronics, vol. MIL-6, no. 4, Oct. 1962, p. 326/338.

. . . The conclusion reached is that VHF links using meteorscatter or ionoscatter propagation would have escaped the severe blackouts experienced with LF, MF and HF transmissions. The positive disruption of such VHF links requires some 100 times more ionization than was produced by these bombs. To a lesser extent VLF transmissions would also have escaped a blackout—in this case it is estimated that some 10 times the ionization is required for a blackout. . . .

ARRAY TECHNIQUES FOR SENSITIVITY IMPROVEMENT OF INFRA-AUDIO RECEIVING SYSTEMS

R.M. Ady, Electronic Defense Lab., Mountain View, Calif., 1 Feb. 1963, 49 p., AD 418 408.

. . . Comparisons are made of three array types—broadside, end-fire and circular . . .

THE USE OF LOW FREQUENCY RADIO AIDS IN SUPERSONIC AIRCRAFT

V.H. King, et al., J. Inst. Navig., vol. 17, Jan. 1964, p. 57/65, 9 refs., A64-14777.

. . . A Ground-based system and low-frequency radio aids for navigation are recommended.

VLF UTILIZATION AT NASA SATELLITE TRACKING STATIONS

C.H. Looney, Jr., (Symposium on the Ionospheric Propagation of VLF Radio Waves, Boulder, Colo., Aug. 12-14, 1963, Paper 68D1-315.), Journal of Research, Section D - Radio Science, vol. 68D, Jan. 1963, p. 43/45, A64-14689.

Description of tracking stations in the NASA network, and discussion of the applicability of VLF transmissions to time and frequency requirements of the network. It is shown that good signal reception is possible at low power, and that accurate frequency measurements can be made. It is necessary to keep the transmitted frequency as invariant as possible, and to ensure that the receiver maintain the signal-to-noise ratio available at the antenna . . . The utility of VLF propagation for time transmissions is discussed, and it is concluded that this is practicable.

ACCURACY OF THE OMEGA NAVIGATION SYSTEM

M.L. Tibbals, et al., Navy Electronics Lab., San Diego, Calif., 2 Oct. 1963, 13 p., (NEL-1185 AD 422 435), N64-11173.

. . . with the present experimental system, operating at 10. 2 kc, long-term root-mean-square timing errors are about 4.5 and 11.5 percent of a carrier period, at day and night, respectively. Root-mean-square fix errors are expected to be about 0.5 and 1.2 miles, at day and night . . .

1.643: Medium Frequency Propagation

Included: Ground wave pulse propagation; Long wave propagation; Medium wave fading; Skip zones.

Not Included: Radio broadcasting systems.

Cross References: Analysis of multipath and fading channels (1.612).

1.644: Short Wave Propagation

Included: HF propagations; High frequency propagation; Long distance HF communications; Long distance pulse propagation; MUF = maximum usable frequencies; RTW = round the world signals; Lunar semi-diurnal tides in transequatroial HF propagation; HF point-to-point links.

Not Included: HF prediction services and techniques; Overseas communications services.

Cross References: Analysis of multipath and fading channels (1.612); Regular characteristics of the ionosphere (1.632); Irregular characteristics of the ionosphere (1.633); Equatorial VHF ionospheric propagation (1.637); Antipodal transmission effects (1.633); MRF = multipath reduction factor (1.612); Scatter communications channels (Sect. 1.66).

Principal Publications:

BEOBACHTUNG DER MEHRWEGEAUSBREITUNG AUF DER KURZWELLENUBERTRAGUNG-SSTRECKE OSAKA - FRANKFURT A. MAIN (Observations of Multipath Propagation on the Shortwave Link OSAKA - Frankfurt A. Main) (In German)
B. Beckmann, et al., Nachrichtentech. Z., vol. 11, Oct. 1958, p. 519/523.

KORRELATIONSMESSUNGEN IM KURZWELLEN-BEREICH (Correlation Evaluation in the Short Wave Range) (In German)
V. J. Grosskopf, et al., Nachrichtentech. Z., vol. 11, Feb. 1958, p. 91/95.

PROPAGATION OF ELECTROMAGNETIC PULSES AROUND THE EARTH
B. R. Levy, et al., IRE Trans. Antennas Propagation, vol. AP-6, Jan. 1958, p. 56/61.

ON THE "MINIMUM LOSS OPERATION TIME" FOR SHORT-WAVE COMMUNICATION: PART 2
H. Shibata, J. Radio Res. Labs. Japan, vol. 5, Oct. 1958, p. 335/340.

This concept is not only a useful one for prediction purposes, but it also allows the integration of all possible modes of propagation. The importance of the E_s layer is stressed. . . .

A LONG DISTANCE PULSE PROPAGATION EXPERIMENT ON 20.1 MEGACYCLES
R. Silberstein, J. Geophys. Res., vol. 63, Sept. 1958, p. 445/466.

POLARIZATION OF ATMOSPHERIC PULSES DUE TO SUCCESSIVE REFLECTIONS FROM THE IONOSPHERE
A. P. Tantry, et al., J. Geophys. Res., vol. 63, Sept. 1958, p. 527/538.

SHORT WAVE PROPAGATION
S. Leinwoll, New York, John Rider Inc., 1959, 147 p.

. . . of particular interest to the radio amateur and any person who has to communicate long distances with short waves. . . .

PULSE-PHASE-CHANGE SIGNALING IN THE PRESENCE OF IONOSPHERIC MULTI-PATH DISTORTION
S. F. Lutz, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 102/110.

RESEARCH ON PULSE TRANSMISSION AT OBLIQUE IONOSPHERIC INCIDENCE
K. M. Rawer, Ionospharen-Institut, Breisach (Germany), July 1959, 6p., Annual summary report for 1958/1959, AFCRC TN 59-770, AD 228 772.

RESULTS FOR THE APPROXIMATE CALCULATION OF RADIO WAVE FIELD STRENGTH AT THE LIMITS OF THE TRANSMISSION FREQUENCY RANGE
B. Beckman, Nachrichtentech. Z. (NTZ), vol. 13, no. 10, Oct. 1960, p. 470/472.

. . . semi-empirical formulae for the approximate calculations of field strength at the limits of the m. u. f. and l. u. f. transmission frequency ranges, calculated results being compared with observed values of the 15 Mc/s transmissions from station WWV received at Darmstadt. . . .

THE PROPAGATION OF HIGH-FREQUENCY RADIO WAVES TO LONG DISTANCES
F. Kift, Proc. Instn. Elec. Engrs. Part B, vol. 107, no. 32, March 1960, p. 127/140.

STATISTICAL STUDY TO ASCERTAIN THE VALIDITY OF THE AMR RADIO CIRCUIT PERFORMANCE SUMMARIES FOR HF RADIO OUTAGE
J. L. Bagg, Aerospace Corp., Patrick AFB, Fla., 29 Feb. 1964, 32 p., AD 430 925, N64-16877.

Upon examining the RCA Radio Circuit Performance Summaries for the first 8 months of 1963; it was concluded that these summaries make it appear that outage due to frequency fade or propagation difficulties was not randomly distributed for an extended time period. It is contended that outage is more likely to be recorded during a period near launch time when circuit monitoring and traffic are heavy . . . consequently, studies based upon the RCA Radio Circuit Performance Summaries undoubtedly are biased.

THE TRANSMISSION OF DIGITAL DATA OVER 500 KM H. F. RADIO LINKS
R. W. Brown, (British Institute of Radio Engineers, Meeting, London, England, Nov. 14, 1962, Radio Electronic Eng., vol. 26, July 1963, p. 35/43, A63-20959.

. . . an experiment conducted to demonstrate the feasibility of using HF radio for the transmission of low-grade digital data . . . determination of the error rates for the transmission as a function of transmitter power and frequency, transmission rate, time of day, and location of the receiving site. . . . bit error rates of the order of 1 in 10^4. . . . should lower rates be required, either the performance of the HF radio link must be improved, by adding error-correcting redundancy, or an inherently more reliable system must be used.

SOLAR ACTIVITY AND THE IONOSPHERE FOR RADIO COMMUNICATIONS SPECIALISTS (Translation)
N. Ya. Bugoslavskaya, Oxford, England, Pergamon Press Limited, 1962, 39 p.

. . . largely a generalization of experimental work carried out under the direction of the Ministry of Communications of the U.S.S.R. during research into the earth's magnetism, the ionosphere and propagation of radio waves . . . composition of solar radiation . . . connection between geomagnetic-ionospheric storms which affect the regular operation of radio communications . . . radiation from active regions of the sun . . .

THE OPTIMUM BIT LENGTH FOR HF DATA TRANSMISSION
H. Fiege-Kollmann, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 108/115, 13 refs.

HIGH FREQUENCY RADIO DATA TRANSMISSION THROUGH MULTIPATH DISTURBANCE
J. C. Hansen, Mitre Corp., Bedford, Mass., 13 Sept. 1962, 18 p., incl. illus., 14 refs., (Technical memo. no. TM-3359), (ESD TDR 62-327), AD 290 538.

. . . A degradation of performance can occur during periods of high signal strength due to multipath disturbance. This phenomenon, along with a number of proposed methods of solution, are described.

IONISATIONSSCHWANKUNGEN IN DER IONOSPHARE MITTLERER BREITEN UND VARIATION DER BRAUCHBAREN FREQUENZEN IM KURZWELLENWEITVERKEHR ALS WIRKUNG LUNARER GEZEITEN (Variations of the Ionosphere at Medium Latitudes and the Influences of Lunar Tides on Short Wave Propagation) (In German)
G. Lange-Hesse, et al., Arch. Elekt. Uebertragung, vol. 16, April 1962, p. 205/212, 36 refs.

. . . observational data . . . are analyzed in order to find . . . the lunar tidal influence on the ionosphere . . . The practical significance of these results for short-wave long-range communications is discussed. . . .

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM
National Cash Register Co., Dayton, Ohio, Quarterly progress engineering rept. no. 5, 1 June-31 Aug. 1962, 15 Oct. 1962, 101 p., incl. illus., (NCR rept. no. 3-5Q), AD 287 485.

. . . system that provided highly reliable operation in the presence of multipath propagation and doppler shift. . . . operation of the circuits used in the control and coding equipment. . . .

RECHERCHE EXPERIMENTALE SUR LE GUIDAGE GEOMAGNETIQUE DES ONDES DECAMETRIQUES (Experimental Investigation of Guided RF Propagation Along Geomagnetic Field Lines) (In French)
F. Du Castel, Ann. Telecomm., vol. 18, no. 9-10, Sept., Oct. 1963, p. 177/189, 23 refs.

THE EFFECT OF MAGNETIC STORMS ON AROUND-THE-WORLD HIGH-FREQUENCY PROPAGATION
R. B. Fenwick, et al., J. Geophys. Res., vol. 68, Aug. 15, 1963, p. 4683/4688, A63-21404.

Experimental study of around-the-world (RTW) HF propagation at Stanford, California, in order to obtain data on the correlation of RTW signal maximum usable frequency (MUF), lowest useful frequency (LUF), and the presence (or absence) with the magnetic index (K_p) . . . Detailed study of the effect of magnetic storms on RTW propagation suggests a destruction of normal mode structure rather than an increase of absorption and a decrease of ionospheric critical frequencies.

A TEST OF THE IMPORTANCE OF IONOSPHERE-IONOSPHERE REFLECTIONS IN LONG DISTANCE AND AROUND-THE-WORLD HIGH-FREQUENCY PROPAGATION
R. B. Fenwick, et al., J. Geophys. Res., vol. 68, Oct. 15, 1963, p. 5659/5666, A63-24918.

RADIO TRANSMISSION OF DIPHASE SIGNALS
J. J. Kolarcik, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 289/296.

The feasibility and reliability of the transmission of modified diphase signals at RF, using available receiving and transmitting equipment, was determined by means of a series of brief experiments. . . . Amplitude Modulation with modified diphase signals was studied. . . .

COMPUTING MAXIMUM USABLE FREQUENCIES OF RADIO COMMUNICATION LINKS
V. N. Navysh-Bylinskaya, Joint Publications

Research Service, Washington, D.C., 30 April 1963, 25 p., refs., Transl. into English from Tr. Inst. Zemnogo Magnetizma, Ionosferii i Rasprostraneniya Radiovoln Akad. Nauk SSSR (Moscow), no. 19(29), 1961, p. 71/84, N64-10812 and AD 408 899.

. . . to compare the accuracy of two different methods of computation of the maximum usable frequency for shortwave radio communication links . . . These are the method of "reference points" and the method of "Equal jumps." . . . comparing the calculated values of maximum usable frequency with the actual values observed on several radio communication links . . .

CIRCUIT RELIABILITY, FREQUENCY UTILIZATION, AND FORECASTING IN THE HIGH FREQUENCY COMMUNICATION BAND
J.H. Nelson, RCA Communications, Inc., New York, N.Y., In Agard, Paris, The Effect of Disturbances of Solar Origin on Commun., 1963, p. 293/301, N64-15450.

LUNAR SEMI-DIURNAL TIDES IN HF AND THEIR INFLUENCE ON TRANSEQUATORIAL RADIO PROPAGATION
J.A. Thomas, Journal of Research, Section D-Radio Science, vol. 68D, April 1964, p. 419/427, 18 refs., A64-17496.

. . . A propagation analysis shows that appreciable mode pattern changes resulting from changes in the phase of the Moon are not to be expected for 16 Mc transequatorial propagation from Brisbane.

BACKSCATTER- UND IMPULSFERNUBERTRAGUNGSVERSUCHE AUF DER FUNKSTRECKE LINDAU/HARZ-TSUMEB/SUDWESTAFRIKA (Backscatter and Pulse Transmissions on a Link from LINDAU (Germany) to Tsumeb (Southwest Africa) (In German)
H. Werle, Arch. Elekt. Uebertrangung, vol. 17, March 1963, p. 121/130, 19 refs.

Pulse transmissions at oblique incidence at seven fixed frequencies were carried out between Lindau/Harz and Tsumeb/Southwest Africa. Simultaneously backscatter echoes were recorded at the transmitting end. The transit time of the different paths was determined by retransmission from Tsumeb. The identification of the different paths or propagation was facilitated by these additional measurements. . . . Fur die Versuche wurden die Sendefrequenzen 10,425; 13,86; 18,21; 24,25; 27,12; 34,00 und 40,00 MHz benutzt. In Lindau stand ein quarzgesteuerter 100-kW-Sender zur Verfugung. Er wurde mit einer Tastfolgefrequenz von 1 Hz getastet bei einer Impulsdauer von 250 μs. . . .

ANALYSIS OF NBS PREDICTIONS OF PERFORMANCE AMR HF RADIO CIRCUITS
ITT Communication Systems Inc., Paramus, N.J., 22 April 1963, 1v., Rept. no. ICS63 TR156, ESD TDR 63 628, AD 420 272.

An analysis is presented of extensive electronic computer calculations of expected reliabilities and signal-to-noise ratios. The circuits extend from Cape Canaveral into the Indian Ocean and from various land locations to instrumentation ships in the Atlantic and Indian Oceans. . . . purpose . . . to determine the grades of service that the circuits can be expected to give . . . optional routings . . . to establish the amount of improvement that it would be desirable and practical to obtain to get an acceptable grade of service. The analysis of error rates has been based solely on signal-to-noise ratios.

Related Publications:

DISTRIBUTION OF THE DURATION OF FADES IN FADES IN RADIO TRANSMISSION: Gaussian Noise Model
S. O. Rice, Bell Syst. Tech. J., vol. 37, no. 3, May 1958, p. 581/635.

THE DAILY COURSE OF THE BACK-SCATTER FIELD. STRENGTH OF TELEGRAPHY SIGNALS.
B. Beckmann, et al., Nachrichtentech. Z., vol. 12, no. 8, Aug. 1959, p. 419/420.

CONSIDERATIONS IN SSB AND ISB SYSTEMS FOR LONG-DISTANCE RADIOTELEGRAPH COMMUNICATIONS
W. Lyons, Commun. and Electronics, no. 46, Jan. 1960, p. 921/924.

STATISTICAL ANALYSIS OF MULTIPATH JITTER
J.J. Brandinger, et al., RCA Rev., vol. 22, no. 3, Sept. 1961, p. 487/507.

. . . the relation of multipath jitter to the performance of communications system is briefly discussed.

ON THE DESIGN OF A HIGHLY RELIABLE HF DIGITAL COMMUNICATION SYSTEM. PROBLEMS, DESIGN PROCEDURES AND THE DESCRIPTION OF A PROPOSED DESIGN
K. Otten, National Cash Register Co., Dayton, Ohio, Oct. 1961, 38 p., AD-269 891.

. . . it was concluded that statistical information on the correlation between disturbances must be known . . . it was also concluded that it is entirely feasible to design and build a 3 kc bandwidth system which will offer substantial performances advantages over an FSK (frequency shift keying) system.

TROPOSPHERIC SCATTER AS AN ALTERNATIVE TO CERTAIN HF RADIO SYSTEMS
T. H. Moriarity, Page Communications Engineers, Inc., Washington, D.C., 1961, 16 p., AD419 282.

The present report is a part of the background material being prepared by PEAC (Panel of Experts Advisory Committee) for the United States member of the International Panel of Experts

which will meet in Geneva during September of 1961. . . . to prepare recommendations to the International Telecommunications Union on means of reducing congestion in the hf radio band. . . . relates to the use of tropospheric scatter in place of certain hf radio systems. . . . which have a path length of 500 miles or less.

LINK EVALUATION AND TAPE MERGING COMPUTER PROGRAMS
B. M. Sifford, Stanford Research Inst., Menlo Park, Calif. Final rept., Dec. 1962, 60 p., Rept. no. TR 7, AD 434 833.

. . . computer program designed to predict the performance of communication networks using HF, ionospheric scatter, and tropospheric scatter propagation modes. . . .

TAKING INTO ACCOUNT THE INFLUENCE OF THE COHERENTLY REFLECTED PORTION OF A SIGNAL UPON ITS CORRELATION CHARACTERISTICS
V. A. Chena, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 4 Sept. 1962, 11 p., incl. illus., 8 refs., (Trans. no. FTD-TT-62-1029 from Izvestiya Vysshikh Uchebykh Zavedeniy, Fizika 4: p. 17/22, 1961), AD 286 571.

ORIENTATION OF LINEARLY POLARIZED HF ANTENNAS FOR SHORT-PATH COMMUNICATION VIA THE IONOSPHERE NEAR THE GEOMAGNETIC EQUATOR
G. H. Hagn, Stanford Research Inst., Menlo Park, Calif., Aug. 1963, 26 p., Research Memo, no. 5, AD 418 497.

A COMPUTER METHOD OF HF IONOSPHERIC PROPAGATION PREDICTION AND ANALYSIS
F. T. Koide, IEEE Trans. Antennas Propagation, vol. AP-11, Sept. 1963, p. 540/558, A63-25312.

. . . a method of HF ionospheric forecasting and analysis suitable for digital computers. . . .

HIGH-FREQUENCY PROPAGATION PREDICTIONS USING AN IBM 650 COMPUTER
L. E. Petrie, Defense Research Telecommunications Establishment (Canada), April 1963, 21 p., DRTE 1117, AD 420 217.

. . . predictions of usable frequencies must be calculated for a large number of radio propagation paths and must be altered frequently for reliability. . . . a digital computer program to calculate the maximum usable frequency and the minimum frequency due to E layer cut-off of the F layer has been set up and is described herein.

COMPARISON OF TECHNICAL SPECIFICATIONS FOR THREE TWIN/TRIPLE CHANNEL HF RECEIVERS
W. M. Sherill, et al., Southwest Research Inst., San Antonio, Tex., Task summary rept. no, 18, 1 Dec. 63-29 Feb. 1964, 29 Feb. 1964, 98 p., AD 434 335.

A PHASE-LOCKED RECEIVING ARRAY FOR HIGH-FREQUENCY COMMUNICATIONS USE
D. E. Svoboda, IEEE Transactions on Antennas and Propagation, vol. AP-12, March 1964, p. 207/215, 6 refs., A64-16611.

. . . The array corrects essentially all phase errors between the distant transmitter and the point where the received signals are combined. The phase errors include those due to the propagation path, array element motion, near-field obstructions, and the instabilities in electronic equipment and RF cables. The array also corrects phase shifts due to changes in angle of arrival, thus giving it the ability to automatically track a desired signal. . . .

1.645: VHF-UHF Propagation

Included: Trade wind inversion of oceanic ducts; Ultra short wave propagation; Off path propagation at VHF; Refraction of VHF signals at ionospheric heights.

Cross References: Characteristics of propagation on the Earth's surface (1.635); Mobile communications channels (1.673); Terrain effects on VHF/UHF propagation (1.635).

Principal Publications:

SOME REMARKS ON THE ANALYSIS OF FADING IN M AND DM-RANGE (In German)
J. Grosskopf, Nachrichtentech. Z., vol. 11, Nov. 1958, p. 577/586.

SHORT BURSTS OF AMPLITUDE OF A 50 MC/S WAVE RECEIVED OVER A DISTANCE OF 480 KM
G. S. Kent, Symp. Long Dist. Prop. Above 30 mc, Jan. 1958, Paper No. 2530.

ATMOSPHERIC EFFECTS ON VHF AND UHF PROPAGATION
G. H. Millman, Proc. IRE, vol. 46, Aug. 1958, p. 1492/1501.

RESULTS OF EXPERIMENT OF LONG-DISTANCE OVERLAND PROPAGATION OF ULTRA SHORT WAVES
N. Onoe, et al., J. Radio Res. Labs., vol. 5, April 1958, p. 79/94.

OFF-PATH PROPAGATION AT VHF
V. C. Pineo, Proc. IRE, vol. 46, May 1958, p. 922.

ATMOSPHERICALLY-PERTURBED MODES AND X-BAND PROPAGATION OVER OPTICAL PATHS
T. J. Carroll, Paper from IRE-URSI Joint Meeting - Oct. 19 - 21, 1959, San Diego, Calif.

SIMULTANEOUS ANGULAR DIVERSITY-FREQUENCY SWEEP MEASUREMENTS AT 2290 MC OVER A 188-MILE PATH BETWEEN ROUND HILL AND CRAWFORDS HILL, N. J.
J. H. Chisholm, et al., Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

INVESTIGATIONS OF PROPAGATION OVER RADIO-LINK PATHS WITHIN AND BEYOND OPTICAL RANGE AT 1.1 to 1.3 GC/S (In German)
U. Kühn, Tech. Mitt BRF, vol. 3, Oct. 1959, p. 32/41.

EXTRAORDINARY PROPAGATION CONDITIONS FOR ULTRASHORT WAVES (In German)
J. Ortner, et al., Arch. Elekt. Ubertragung, vol. 13, no. 10, Oct. 1959, p. 420/428.

FORECASTING MAXIMUM TRANSMISSION RANGE AT VHF
L. B. Gardner, IRE Winter Conv. Military Electronics, Feb. 1960.

OBSERVED CHARACTERISTICS OF AN ULTRA-HIGH-FREQUENCY SIGNAL TRAVERSING AN AURORAL DISTURBANCE
J. C. James, et al., Nature, vol. 185, no. 4712, Feb. 1960, p. 510/512.

THE TRADE-WIND INVERSION AS A TRANS-OCEANIC DUCT
M. Katzin, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 3, May-June 1960, p. 247/253.

REFRACTION OF VHF SIGNALS AT IONOSPHERIC HEIGHTS
S. Weisbrod, et al., IRE Trans. Antennas Propagation, vol. AP-8, no. 1, Jan. 1960, 1. 107/109.

PROBABILITIES OF INTERFERENCE WITH MOBILE FIELD RADIO DERIVED FROM A FIELD-STRENGTH SURVEY AT 59 MC/S
D. R. Thomas, Proc. Instn. Electr. Engrs. Part B, vol. 108, no. 39, May 1961, p. 264/272, 25 refs.

. . . experimental investigation of common- and immediately-adjacent-channel interference areas for mobile radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. . . . Particular attention has been paid to investigating the distribution of field strength at each distance, which is shown to approximate closely to log-normal. It is also established that the variance of these log-normal distributions may be considered to have a single value for each type of country, irrespective of range. Protection ratios acceptable for satisfactory operation are determined from experimental observation of common- and adjacent-channel interference. . . .

GROUNDWAVE PROPAGATION EFFECTS ON MICROSECOND PULSES AT 141 MCS
R. W. Heffner, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 182/196.

. . . A test program was performed to investigate the propagation effects around 141 mcs using microsecond pulses of different carrier frequencies. These investigations used omnidirectional antennas at the transmitter and receiver locations. Antenna height at both locations was twelve feet. The results to be discussed are: a) propagation attentuation contour; b) pulse stretching; c) selective fading and enhancement of pulses within the time-frequency matrix frame; d) backscatter pulse stretching, and; e) polarization dependence. . . . only limited information was applicable to the special wide band multiple pulse system requirements of RACEP. . . .

Related Publications:

EXPERIENCE WITH LONG-DISTANCE TELEVISION FIELDS USED FOR RE-TRANSMISSION
W. L. Braun, Commun. Electronics, no. 45, Nov. 1959, p. 594/595.

. . . long-distance (100-150 miles) very-high frequency propagation . . . of wideband performances. . . . ultimate use as signal sources for a community antenna system. . . .

RADIO TRANSMISSION LOSS DETERMINATION BY RADAR TECHNIQUES
S. R. Bradshaw, et al., Motorola, Inc., Riverside, Calif., Feb. 1959, Quarterly Rept. no. 5, Nov. 1958-Jan. 1959, (Rept. no. RLQ-3835-5), AD 213 454.

RADIO TRANSMISSION LOSS DETERMINATION BY RADAR TECHNIQUES
S. R. Bradshaw, et al., Motorola, Inc., Riverside, Calif., Aug. 1959, 208 p., Quarterly rept. no. 7, May-July 1959, (Rept. no. RLQ-3835-7), AD 225 396.

Experimental results for test areas K and L are described. Predictions of path losses, using several different methods, are compared with measured values . . . Backscatter histograms at both L- and X-band are shown . . .

1.646: Microwave Propagation

Included: Echo signals on microwave paths; Fluctuations of microwave signals.

Cross References: Knife edge diffraction propagation (1.635); Terrain influence on microwave propagation (1.635); Channel characteristics of radio relay links (1.662); Passive repeaters in microwave radio relay links (1.662).

Principal Publications:

ANALYSIS OF MILLIMICROSECOND RF PULSE TRANSMISSION
M. P. Forrer, Proc. IRE, vol. 46, Nov. 1958, p. 1830/1835.

. . . through uniform systems. Quadratic approximations for the complex propagation constant are used, and a Gaussian pulse envelope is assumed. Employing Fourier transformation, the received waveforms are obtained for the general case of lossy, dispersive systems. The results are discussed and illustrated separately in terms of pulse distortions due to dispersion, due to losses and due to bandwidth limitations.

MICROWAVE LINE-OF-SIGHT PROPAGATION
M. W. Gouch, Elect. Engr., vol. 30, May 1958, p. 237/247.

AN INVESTIGATION OF THE ATMOSPHERIC PHYSICAL CONDITIONS ASSOCIATED WITH MICROWAVE PROPAGATION
L. P. Riggs, Texas A. and M. Coll., College Station, March 1958, 65 p., AD 159 404.

RADIO ATTENUATION AT 11 KMC AND SOME IMPLICATIONS AFFECTING RELAY SYSTEM ENGINEERING
S. D. Hathaway, et al., Bell Syst. Tech. J., vol. 38, Jan. 1959, p. 73/98.

PROLONGED SIGNAL FADE-OUT ON A SHORT MICROWAVE PATH
D. R. Hay, et al., Canad. J. Phys., vol. 37, March 1959, p. 313/321.

ON THE MEASUREMENT OF ATTENUATION BY RAIN AT 8.6 MM WAVE LENGTH
S. Okamura, et al., J. Radio Res. Labs., vol. 6, April 1959, p. 255/267.

EMPFANGSAMPLITUDE UND FADINGVERTIELUNG BEI 10-CM-WELLENLANGE IN ABHANGIGKEIT VON DER AZIMUTALEN ABWEICHUNG VOM GROSSKREIS
(Received Signal Strength and Fading Characteristics at 3000 MC at Various Deviations From A Great Circle Path)
(In German)
R. Schunemannn, et al., Hochfrequenztech. u. ElektAkust, vol. 68, July 1959, p. 37/42.

ATMOSPHERIC TURBULENCE AS A FACTOR IN MICROWAVE STANDARD FREQUENCY BROADCAST SYSTEMS
M. C. Thompson, Jr., et al., Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

NOTE ON MICROWAVE PROPAGATION JUST BEYOND HORIZON IN THE TORRID ZONE
S. Uda, Rep. Res. Inst. Elect. Commun., vol. 11, no. 1, 1959, p. 11/21.

Microwave propagation tests in the 2Gc/s region were carried out between Landour and New Delhi, India, a distance of 224 km. The experiments showed a marked difference between night and daytime propagation. . . .

MICROWAVES AND THEIR USE IN POWER SYSTEMS
S. C. Bartlett, Commun. and Electronics, no. 46, Jan. 1960, p. 1095/1106.

PROPAGATION AT 36,000 MC IN THE LOS ANGELES BASIN
W. L. Flock, IRE Trans. Antennas Propagation, vol. AP-8, no. 3, May 1960, p. 235/241.

APPLYING MICROWAVES TO SPACE PROBLEMS
H. M. Hart, Electronic Industr., vol. 19, no. 4, April 1960, p. 78/82.

THE STATISTICAL DISTRIBUTION OF THE DEPTH OF FADINGS ON SECTIONS IN RADIO RELAY SYSTEMS
A. I. Kalinin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 6, 1960, p. 1/11.

Expressions are given for integral curves to plot the distribution of the depth of fadings on intervals of radio-relay lines under the normal law governing the distribution of the active vertical gradient of the air's dielectric permittivity, together with limiting expressions for the distribution curves. Examples of the integral curves for the distribution of the depth of fadings are given. . . .

ANALYSIS AND DETECTION OF ECHO SIGNALS ON MICROWAVE RADIO PATHS
G. E. Rosman, Proc. Instn. Radio Engrs. Australia, vol. 21, no. 11, Nov. 1960, p. 810/820.

An assessment is made of the echo parameters permissible for a specified maximum distortion in a 600 channel frequency-modulated radio bearer circuit. On the assumption that the echoes result from single reflections the effect of aerial directivity on a system operating at 4,000 Mc/s is assessed for specific aerials used on a 40 mile path. A survey of common testing methods . . . outline of the method of height-gain measurement for echo investigation . . .

SOME FACTORS INFLUENCING 3 CM RADIOWAVE PROPAGATION OVERSEA WITHIN AND BEYOND THE RADIO HORIZON
F. A. Kitchen, et al., Proc. Instn. Elect. Engrs. (GB), (Paper 3501 E), vol. 108 B, May 1961, p. 257/263.

. . . short-term oversea measurements of the variation of received signal level with range from a 10 Gc/s transmitter are presented. It is shown that the variation of signal level within the horizon was rarely that expected for propagation through an atmosphere having a uniform refractive-index gradient. Signal losses of from 5 to 30 dB frequently occured well within the horizon, . . . A well-defined interference pattern usually occurred in the region of reduced signal level. . . . A direct relationship was found to exist between the signal level within the horizon and that propagated well beyond the horizon into the extra-diffraction region.

EXPERIMENTAL STUDIES OF PROPAGATIONAL CHARACTERS OF 8·6 MM WAVE ON THE 24 KM PATH.

K. Funakawa, et al., J. Radio Res. Lab., vol. 9, Sept. 1962, p. 351/367.

The experiments described were carried out nearly all the year round, using a pulse magnetron transmitter with a peak power of 30 kw. . . . measurements determine the relation between signal attenuation and rainfall rate. The results obtained are shown graphically. Some measurements were also made of field-intensity reduction due to water vapor. When there was no rainfall over the whole 24 km path, the received signal level was normally steady, but sometimes severe fading was observed. The fading range was larger in summer than in winter, its maximum value being 17·4 dB. It was usually large in the early morning and at midnight, and small in the daytime. In the winter experiments, correlation between the fading range and the occurrence of temperature inversion was markedly observable.

SOME STATISTICAL CONSIDERATIONS ON TRANSHORIZON PROPAGATIONS OF MICROWAVES - WITH APPLICATION TO RADIO METEROROLOGY. I

K. Naito, Papers in Meteorology and Geophysics, vol. 13, Dec. 1962, p. 207/215, A63-24662.

. . . effect of finite length of sampling time on transhorizon propagation. The transhorizon-propagated microwaves are found to exhibit, for a short sampling time, apparent coherence, which explains the results of Waterman's rapid beam-swinging experiments . . . It is shown that, in most cases, not only scattering due to eddies, but reflections due to wavy layers are important in oversea transhorizon propagation of 3,000 and 300 Mc.

STATISTICAL FLUCTUATION OF AMPLITUDE AND PHASE OF RADIO SIGNALS PASSING THROUGH THE RAIN

T. Oguchi, J. Radio Res. Lab., vol. 9, no. 9, Jan. 1962, p. 51/72.

A comprehensive theoretical treatment of the transmission of wideband signals in the shorter microwave or mm-wave range through rain. Neglecting the effect of multiple scattering among the raindrops, the fluctuations of the amplitude and phase of the received signals are obtained with first-order approximation. Numerical calculations from the theoretical formulae for the case of 8.6 mm wavelength signals indicate the occurence of only very small fluctuations under normal conditions. As the assumption is that rain falls uniformly, the propagation path can never be considered valid for long paths, the fluctuation of the radio waves due to fluctuation of the precipitation rate itself throughout the path must also be considered.

COMPARISON OF SIMULTANEOUS PROPAGATION MEASUREMENTS AT 3480 MC/S AND 9640 MC/S OVER A 173 MILE PATH ADDENDUM

B. L. Angell, et al., General Electric Co., Ltd., Wembley (England), 25 June 1963, 5 p., Rept. no. 13 639C, AD 421 937.

ATMOSPHERIC DISPERSION AND ABSORPTION OF MICROWAVES

O. Fagioli, et al., Florence Univ. (Italy), April 1963, 25 p., AFCRL 63 500, AD-424 730.

PHASE AND AMPLITUDE DIVERSITY IN OVER-WATER TRANSMISSIONS AT TWO MICROWAVE FREQUENCIES

H. B. James, et al., National Bureau of Standards, Boulder, Colo., 26 Feb. 1963, 66 p., (Repts. no. NBS-7656, 8390-12-83491), AD 298 908.

Related Publications:

COMMERCIAL AIRBORNE WEATHER RADAR

A. W. Vose, et al., RCA Rev., vol. 19, no. 2, June 1958, p. 187/207.

. . . factors relating to the detection and penetration of atmospheric precipitation at microwave lengths. Technical design features of both 5.6-centimeter weather penetration and 3.2-centimeter weather avoidance radars used in present-day commercial aircraft are discussed. . . .

SHF ANGULAR DIVERSITY STUDY PROGRAM

Philco Corp., Philadelphia, Pa., Nov. 1959, lv., Final rept., (RADC TR 60-30), AD 234 425.

Angular diversity measurements at 7630 Mcps over a 247 effective-mile tropospheric path show that diversity improvements comparable to theoretical ones are available; that elevation squint is superior to azimuth squint for the system tested; and that essentially uncorrelated signals are received by a parab oloidal antenna with twin feedhorns whose beam separation is one beamwidth. . . .

MICROWAVE SYSTEMS ENGINEERING USING LARGE PASSIVE REFLECTORS

M. L. Norton, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 118/126.

AN AIRBORNE, FOUR-FREQUENCY, FREQUENCY STABILIZED, COHERENT RADAR SYSTEM

N. G. Hamm, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 57/59.

. . . NRL will use this experimental equipment installed in a WV-2 aircraft for target signature work on point targets and area extensive targets such as sea clutter and terrain and as one terminal of a one-way transmission link in anomalous duct propagation investigations.

Section 1.65:
Characteristics of Physical Channels

Physical channels are man-made structures built to guide electrical signals over large distances and to protect them from external distrubances. Lines and cables are the oldest media of long distance communications. Long distance microwave guide transmission media may be important facilities due to their large bandwidth capacility. Their mode conversion problems present particular channel characteristics which call for further investigations before operational systems work satisfactorily (1.655).

Physical channels are only of secondary importance to actual space links, but they are of prime importance to ground support communications networks which feed space operations. Data transmission facilities are in high demand and subdivision 1.650 gives general reviews and surveys of their progress.

Subdivision 1.651 contains references to the analytical procedures for describing the performance of long distance circuits, primarily telephone circuits. The next subdivisions deal with the characteristics of lines, cables and underwater transmission facilities. The importance of the latter, for interconnections between shore stations of missile ranges, is evident.

Subdivision 1.654 refers to characteristics of the equipment in communications plants, as far as they may influence the channel characteristics. Echo suppressors, and companders are typical examples.

The last subdivision, 1.659, reviews the practice of evaluating transmission plants for their ability to handle the traffic load, primarily the large quantities of data which the ground portions of space communications networks must handle.

Ground facilities for special classes of space communications missions will be included in volume 4. Complete surveys of missile ranges are not within the scope of the present series of bibliographies.

1.650: Characteristics of Ground Communication Networks

Included: Capabilities fo the telephone network for data transmission; Speech volumes in telephone circuits; Error statistics for communications networks; Characteristics of voice transmission circuits.

Not Included: Error correction codes (2); Multiplex voice transmission facilities (2); Terminal equipment; Modems.

Cross References: Experimental evaluation of physical channels (1.659); Channel characteristics of radio relay links (1.662); Digital modulation methods (Div. 1.3).

Principal Publications:

PULSE TRANSMISSION STUDY
H. Fiege-Kollmann, Westinghouse Electric Corp., Baltimore, Md., Feb. 1959, lv., AD 211 434.

CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION
A. A. Alexander, et al., Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 431/476.

. . . results of a nationwide data transmission field testing program on the telephone switched message network. Error performance using the FM digital subset is described and basic transmission characteristics such as net loss, bandwidth, envelope delay and noise are given.

DATA TRANSMISSION OVER STANDARD VOICE COMMUNICATION FACILITIES
H. Fiege-Kollmann, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 223/232.

The system described is based upon application of waveshapes. Practical performance in both white and impulsive noise will be discussed . . . certain properties of telephone circuits will be outlined in statistical presentation. . . .

HIGH-SPEED TRANSMISSION OF NUMERICAL DATA OVER TELEPHONE CHANNELS
A. Girinsky, et al., Elect. Commun., vol. 36, no. 4, 1960, p. 248/262.

. . . information is transmitted in the form of binary digits . . . equipments that adjust the speed of transmission to the characteristics of the transmission network. . . . There is no direct-current component in the signaling code that would be lost in passing through a repeater or transformer. . . . the receiver is automatically synchronized by the transmitter to provide good reliability and ready adaptability to all types of telephone systems. . . .

TRANSMISSION FREQUENCY CHARACTERISTICS OF SAMPLE TELEPHONE CIRCUITS
N. N. Ulguray, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 221.

Abstract only.

PHONE LINE DIGITAL TRANSMISSION STUDY
Hughes Aircraft Co., Culver City, Calif., Sept. 1960, 240 p., (RADC TR 60-153), AD-244 193.

An experimental and theoretical study program was undertaken to determine the characteristics of wireline circuits and equipments and their joint capability for supporting data transmission. . . .

ERROR STATISTICS AND CODING FOR BINARY TRANSMISSION OVER TELEPHONE CIRCUITS
A. B. Fontaine, et al., Proc. IRE, vol. 49, no. 6, June 1961, p. 1059/1065.

THE TELEPHONE CHANNEL IN A GLOBAL COMMUNICATIONS SYSTEM
J. W. Halina, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 247/252.

. . . The nominal 4-kc telephone channel is by far the most dominant parameter of contemporary telecommunication networks. . . . This paper is a characterization of the telephone channel to a first order of approximation —its loss, phase and noise characteristics and some related operational factors.

DATA LINE TECHNIQUES
Armour Research Foundation, Chicago, Ill., 1 April 1961, 458 p., 62 refs., AD 263 144.

. . . a review of pertinent theoretical material and a survey of wire line digital communication techniques to support suggestions for improving channel utilization.

FURTHER ANALYSIS OF ERRORS REPORTED IN "CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION"
R. Morris, Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1399/1414.

The recorded error data from a field testing program reported on by Alexander, Gryb, and Nast have been further analyzed. New methods of analysis have given more information on the causes and nature of errors experienced by data in the switched telephone plant. The results obtained will enable workers in the field of error control to use the field test data more effectively. . . .
Effect of Dropouts . . .
Effects of Noise . . .
Role of the Test Word . . .
Relation to Error-Control Schemes . . .

SOME RECENT DEVELOPMENTS IN DATA TRANSMISSION
K. L. Smith, J. Brit. Instn. Radio Engrs., vol. 24, no. 5, Nov. 1962, p. 405/414.

. . . use of the telephone system for data system for data transmission . . . division of responsibility between the data terminal manufacturer and the communication authority . . . A typical range of data transmission systems designed to meet this interface specification is introduced . . . use of error correction and error detection systems are also discussed. . . .

TELEPHONE CIRCUIT EVALUATION FOR DATA TRANSMISSION
K. L. Smith, et al., J. Brit. Instn. Radio Engrs., vol. 24, no. 4, Oct. 1962, p. 297/308, 11 refs.

. . . statistical methods based on extended tests using special measuring equipment and computer-based data reduction methods. From these, mathematical models of the various circuits can be formulated whereby the optimum arrangement of the transmitted data and the effectiveness of various error detection and correction systems, can be determined. . . .

THE SYMPOSIUM ON "DATA TRANSMISSION"
J. Brit. Instn. Radio Engr., vol. 24, no. 2, Aug. 1962, p. 148/152.

A Symposium of seven papers on Data Transmission, . . . was held at the London School of Hygiene and Tropical Medicine on 3rd January 1962. Some 150 engineers were present to hear and discuss the papers which were arranged in two sessions—Line considerations and Terminal Equipment. . . . The papers presented and their dates of publication in the Journal . . .

ERROR STATISTICS AND CODING FOR DIGITAL DATA TRANSMISSION OVER TELEPHONE AND TELETYPE CIRCUITS (Correspondence)
A. B. Fontaine, Proc. IEEE, vol. 51, no. 3, March 1963, p. 474/475.

. . . in an earlier paper where four data systems, A-1, CTDS, Kineplex and Milgo, were used to collect over 2000 hours of error data with toll-grade, private microwave and K-carrier telephone circuits . . . additional data presented here are for two 60-wpm teletype circuits and for two 1200-bit/s telephone circuits; one is a forward propagation tropospheric scatter circuit in Alaska and the other a private wire service in the United Kingdom. . . .

SPEECH VOLUMES ON BELL SYSTEM MESSAGE CIRCUITS–1960 SURVEY
K. L. McAdoo, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 1999/2012.

. . . measured at class 5 offices. Data are presented for intrabuilding, interbuilding, tandem and toll connections. Average speech volumes are lowest for intrabuilding calls and increase in level for the other types of connections, with volumes on toll calls being the highest. In general, volumes on business calls are higher than those on social calls, and men speak louder than women. Speech volumes remain substantially the

same in locations comparable to those in a survey made in 1950.

DATA TRANSMISSION ERRORS: COMPARISON OF LF RADIO WITH TELEPHONE FACILITIES
P. Mertz, RAND Corp., Santa Monica, Calif., Jan. 1963, 33 p., incl. illus., 13 refs., (Memo. no. R,-3413-PR), AD 295 650.

Related Publications:

ERROR CORRECTION DATA TRANSMISSION SYSTEMS
E. R. Aylott, et al., J. Brit. Instn. Radio Engrs., vol. 24, no. 2, Aug. 1962, p. 141/148.

. . . Typical error detection and correction equipments for both the telephone and telex networks are shown . . . methods for the evaluation of the relative efficiencies of the various error correction and detection codes are described. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS (PHASE 2 REPORT)
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Rept. for Jan. 1961 - Jan. 1962, 20 Feb. 1962, 311 p., incl. illus., refs., (Rept. no. UA-1420-S-2), (RADC TDR 62-134), AD 276 847.

. . . analysis of the degradation of performance of noncoherent binary FSK and carrier keyed systems due to a frequency offset of the received signal. Theoptimization of systems operating over dispersive channels in the presence of nonwhite, gaussian noise is treated and the effects of mediumphase perturbations on the performance of digital systems are analyzed. Partial orderings of digital channels specified by their transition probabilities are also investigated.

A 1, 650-BIT-PER-SECOND DATA SYSTEM FOR USE OVER THE SWITCHED TELEPHONE NETWORK
S. Brand, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 652/661.

THE COBI DATA TRANSMISSION MODEM
K. H. Morey, Lincoln Lab., Mass. Inst. of Tech., Lexington, 23 May 1962, 54 p., incl. illus., tables, 9 refs., (Technical rept. no. 263), AD277 501.

The COBI (coded biphase) data transmission modem employs phase-reversal modulation and code translation as a means of transmitting serial digital data over voice-bandwidth telephone circuits . . . a history of data systems leading to COBI, a brief discussion of telephone-circuit characteristics, and a summary of the theory basic to phase-reversal modulation. . . . extensive tests . . . specifications . . . are appended.

1.651: Analytical Procedures for Describing Channel Performance of Transmission Circuits.

Included: Impulse response of transmission circuits; Cross-talk theory; Line attenuation; Standard transmission levels; Transmission losses; Circuit impedances; Amplitude frequency characteristics of transmission circuits; Pareto model for error statistics.

Not Included: Network theory; Filter theory; Theory of transmission lines.

Cross References: Transient response of transmission channels in general (1.622); Distortions in communications channels (Sect. 1.62); Noise and disturbances in telephone plants (Sect. 1.74); Correlated noise (1.742).

Principal Publications:

POLE-ZERO TECHNIQUES APPLIED TO VOICE-FREQUENCY TELEPHONE LINES
P. Fleming, Jr., Commun. Electronics, vol. 80, no. 57, Nov. 1961, p. 482/286.

Most textbooks about transmission lines derive differential equations pertaining to physical phenomena. . . Unfortunately, telephone lines are not lossless, nor is the voice-frequency range of 200 to 4,000 cycles merely a narrow band of 3,800 cycles; instead, it is 4.3 octaves, or 1.3 decades of change. The basic parameters ordinarily undergo the greatest changes in this range; consequently, the analysis of telephone lines is quite rudimentary unless calculations are made at several frequencies. The discussion. . . will demonstrate methods for determining quickly the basic parameters as functions either of frequency or of the distributed constants. Further, interesting conclusions can be drawn about other phenomena, such as the correlation between the impedance at zero and at infinite frequencies. . . .

FREQUENCY ERROR EFFECTS ON A BINARY COMMUNICATION SYSTEM UTILIZING COHERENT INTEGRATORS
H. J. Juda, et al., Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 247/253.

. . . to evaluate the performance of a practical binary communication system and to contrast it to the performance of an ideal system from the standpoint of system error rate degradation (at a given signal-to-noise ratio) as a function of frequency mismatch between the signal and the signal detector. The binary communication system described employs phase shift keying, differential phase coherent detection, and coherent integrators as the basic detector element. . .

TELEPHONE CIRCUIT AND EQUIPMENT IMPEDANCES AS THEY AFFECT TRANSMISSION PERFORMANCE
P. F. Radue, Commun. Electronics, vol. 80, no. 54, May 1961, p. 126/134.

The direct distance dialing (DDD) telecommunications network used throughout the nation and extending into other nations consists of many complex elements. One of the problems involves providing quantity and quality in a talking or data connection. The following good transmission engineering practices will result in providing the grade of service necessary. . . .

PULSE TRANSMISSION BY AM, FM AND PM IN THE PRESENCE OF PHASE DISTORTION
E. D. Sunde, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 353/422.

MATCHED FILTERS AND INTERSYMBOL INTERFERENCE
D. W. Tufts, Cruft Lab., Harvard U., Cambridge, Mass., 20 July 1961, 19 p., Technical rept. no. 345, AD 263 882.

. . . combining the viewpoints which led to the formulation of two tools of proven worth in communication theory—the matched filter and Nyquist's methods for pulse shaping and transmission line equalization.

UBER DEN ENTSTEHUNGSMECHANISMUS DES NEBENSPRECHENS SYMMETRISCHER LEITUNGEN (On the Mechanism of Crosstalk Generation on Symmetrical Lines) (In German)
W. Klein, Arch. Elekt. Uebertragung, vol. 16, Oct. 1962, p. 525/531.

. . . the fundamentals of the nearly-transversal and the non-transversal cross-talk theory. Subsequently the loci of far-end intra-quad crosstalk are derived by reference to the basic formulae of the nearly-transversal crosstalk theory and compared with measurements at frequencies up to 10 Mc/s on a four-pair carrier cable and a twenty-pair local cable. . . .

EFFECT OF AMPLITUDE-FREQUENCY DISTORTION IN TELECOMMUNICATION CHANNELS ON THE TRANSMISSION OF PULSE SIGNALS (Translation)
G. P. Divnogortsev, et al., Telecommun: Radio Engineering, Part I - Telecommunications, Jan. 1963, p. 50/54, A63-21038.

Demonstration that the amplitude-frequency distortion introduced by a communications channel degrades the waveform of the pulse signals being transmitted. This degradation prevents the full exploitation of the effect of applying phase equilization. It is shown that in a telecommunications channel provided with a phase correction having an accuracy equal to the length of a pulse (with more than five networks in the phase equalizing circuit) and an amplitude correction corresponding to 0.1 neper, the amplitude-frequency distortion has almost the same effect as uncorrected phase distortion.

ESTIMATION OF A SYSTEM PULSE TRANSFER FUNCTION IN THE PRESENCE OF NOISE
M. J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1963, 7 p., AD 411 832.

. . . Some adaptive control system carry out measurements of plant parameters during normal operation. In communication systems an analogous situation arises in the utilization of time-varying channels (1). Often the application of a special test signal is undesirable so the information must be obtained from ordinary input output data. The presence of random noise and instrumentation errors can render many measurements schemes ineffective. Statistical estimation theory provides powerful methods for dealing with this type of problem. Some of these methods are applied to the estimation of the pulse transfer function of a linear system.

HARD LINE VS MICROWAVE LINK TRADE-OFF STUDY VAFB/NMFPA DATA TRANSMISSION SYSTEM
R. P. McGarrity, Aerospace Corp., Los Angeles, Calif., Jan. 1964, 20 p., Rept. no. TOR269 4110 03 2., AD 431 743.

. . . Parameters considered in this study were: security, electromagnetic interference, data quality and reliability, total bandwidth capacity, single channel bandwidth capacity, hardness, flexibility, effect of link length, and cost comparison.

DATA TRANSMISSION OVER CHANNELS WITH SINUSOIDAL DELAY
M. A. Rappeport, et al., IEEE Paper, no. 63-432, Feb. 1963, p. 1/16.

ANALYSIS OF THE PARETO MODEL FOR ERROR STATISTICS ON TELEPHONE CIRCUITS
S. M. Sussman, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 213/221.

A statistical model for the occurrence of errors in data transmission over telephone circuits was recently proposed by Berger and Mandelbrot. In their model the intervals between successive errors are distributed independently according to the Pareto distribution $t^{-\alpha}$. This paper presents an analysis based on the Pareto model and compares the results with published measurements on telephone networks. . . . Comparison with experiments indicates that the Pareto distribution provides an excellent representation of the error statistics. . . .

ON THE NEED FOR A TRANSMISSION LOSS IN TRUNK TELEPHONE CIRCUITS
A. W. Thies, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 12, Dec. 1963, p. 877/880.

It is shown that even an ideal two-way trunk circuit cannot be adjusted to give a transmission gain if it is to perform satisfactorily in conjunction with the local telephone network. Transmission losses which are made necessary by the shortcomings of practical trunk circuits are then discussed. . . .

PEGELANGABEN IN DER UBERTRAGUNGS-TECHNIK (Level Indication in Transmission Techniques) (In German)
W. Zaiser, Nachrichtentech. Z., vol. 16, Sept. 1963, p. 461/463, A63-24422.

Description of the new "C-message weighting curve" for signal noise. Reference is made to a nomogram with 14 scales which covers white noise in the low frequency range from 0.3 to 3.4 kc.

Related Publications:

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J. C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . Comparisons are made between systems which have been designed to have no intersymbol interference and those which simply use 'guard' spaces as protection. . .

LIMITING ACCURACY OF THE SIMULTANEOUS ESTIMATION OF TWO SIGNAL PARAMETERS IN THE PRESENCE OF NORMAL NOISE
E. I. Kulikov, Telecommun. Radio Engineering, Part II - Radio Engineering, Jan. 1963, p. 53/61, A63-21045.

. . . simultaneous evaluation of the delay time and frequency shift for the reception of a bell-shaped radio signal in the presence of white noise are calculated, . . .

VOICE-FREQUENCY TELEPHONE CIRCUIT DESIGN BY SIMULATION
T. J. Talley, et al., Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 564/568.

Many present-day voice-frequency telephone circuits require two or more electrically short links in tandem, minimum capital investment, and less than a 2-week completion interval.

. . . A practical design for a transmission-circuit simulator to determine impedance, return loss, and frequency-attenuation characteristic is discussed. . . .

1.652: Characteristics of Lines and Cables

Included: Crosstalk loss in cables; Coaxial cables; Field wire; Communication cables; Loaded cable facilities; Transporsition systems for open wire lines; Phase equalization of lines.

Not Included: Mechanical characteristics of lines and cables; Antenna feeder lines.

Cross References: Delay distortions (1.626).

Principal Publications:

COAXIAL-CABLE SYSTEMS: PAST AND FUTURE
A. W. Montgomery, Elect. Commun., vol. 35, no. 4, 1959, p. 221/229.

. . . to review some of the history of coaxial-cable systems. . .

THE REA-1 TRANSPORTATION SYSTEM
A. G. Chapman, et al., Commun. Electronics, vol. 79, no. 50, Sept. 1960, p. 440/448.

. . . has been employed in many cases for transposing rural open-wire telephone lines. These have been both subscriber lines and trunk lines, voice and carrier. . . . Unpublished data on measurements taken by Rural Electrification Administration (REA) engineers over a frequency range of 40-495 kc have since further confirmed the limitations of the R1 transposition system for multi-system carrier application. . . .

THE EFFECT OF FIELD WIRE STABILITY ON THE MAXIMUM LENGTH OF LOOP
N. W. Feldman, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 147/152.

IMPROVED LINE IMPEDANCE STABILIZATION METHOD
J. Shaw, et al., Stoddart Aircraft Radio Co., Hollywood, Calif., Final rept., Oct. 1960, lv., AD 419 512.

. . . to develop improved or new techniques of measuring RF conducted interference at frequencies ranging from 14 kilocycles to 100 megacycles. . . . new and improved line impedance stabilization methods. . . (a) Application of the two-current-probe method for measuring impedance and current of actual impedance sources . . . (b) Application of the use of half of a current probe for measuring surface currents. . . .

DELAY DISTORTION IN TELEPHONE LINES
A. G. Gatfield, IRE Internat. Conv. Rec., pt. 8, March 1961, p. 109/118.

EFFECTS OF CABLE IRREGULARITIES ON THE OPERATION OF TELEPHONE REPEATERS
S. I. McCaron, Commun. Electronics, vol. 80, no. 55, July 1961, p. 217/224.

Ideal conditions. . . consist essentially of having line facilities with infinite "return loss." In practice, these conditions cannot be achieved . . . All that is actually needed is an adequate degree of balance at all frequencies

of interest between two circuit elements, such as a line and its balancing network, to permit deriving the required amount of repeater gain and still to have a 3 to 6 db (decibel) margin of gain before oscillation or "singing" occurs. . . .

DIE VERZERRUNG VON SIGNALEN IN HOCHFREQUENZKABELN, EIN NEUER WEG ZU IHRER BERECHNUNG
(The Distortions of Signal in RF Cables, a New Method of Computation) (In German)
K. Rihaczek, et al., Nachrichtentech. Z., vol. 14, no. 3, March 1961, p. 119/128.

EXPERIMENTS IN THE IMPROVEMENT OF THE IMPULSE RESPONSE OF TELEPHONE CIRCUITS
H. L. Yudkin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 27 Nov. 1961, 6 p., Rept. No. 25G-4, AD 269 557.

. . . high-pass filtering. . . perfect phase equalization (matched filtering). . . It is also shown that matched filtering results in a more desirable pulse than is obtained by the combination of both matched and high-pass filtering.

SYNTHESIS OF NETWORKS SIMULATING IMPEDANCE OF LOADED CABLE FACILITIES
R. W. DeMonte, Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 623/627.

. . . describes a procedure for designing a network that simulates the image impedance of a loaded cable. The problem is reduced to one of synthesizing three 2-terminal impedances, two at one frequency and the third at three frequencies. . . .

COMPARATIVE TRANSMISSION CHARACTERISTICS OF POLYETHYLENE INSULATED AND PAPER INSULATED COMMUNICATION CABLES
T. G. Henneberger, et al., Commun. Electronics, vol. 81, no. 59, March 1962, p. 27/33.

ELECTRICAL UNIFORMITY AND DEVIATIONS CONTROL IN POLYETHYLENE-INSULATED MULTIPAIRED CABLES
W. L. Roberts, Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 570/577.

. . . Improvements in cable uniformity can never guarantee attainment of a desired set of transmission criteria, but will always augment over-all system quality. . . . Detailed transmission and crosstalk on paired polyethylene cable have been published recently by Eager, Jachimowicz, Kolodny, and Robinson. Also included are data on variation of parameters with temperature and humidity, and measurements of shield parameters on helical and folded corrugated aluminum shields.

This paper is concerned primarily with variations in primary electrical parameters between pairs within a cable (transverse deviations), and variations between different lengths of cable (longitudinal deviations). . . .

A METHOD OF ESTIMATING THE 1% MINIMUM CROSSTALK LOSS FOR VOICE FREQUENCIES IN A PAIRED CABLE, WITHOUT EMPIRICAL DATA
D. Aviv, et al., IEEE Trans. Commun. Electronics no. 69, Nov. 1963, p. 668/673.

. . . A mathematical method for estimating the crosstalk loss corresponding to a probability of occurrence of P% at a specific voice frequency is described. The method requires only the information in a given cable specification regarding unbalanced cable parameters and the cable manufacturer's inspection procedure.

VHF COAXIAL CABLES HAVING AN OUTER CONDUCTOR IN ALUMINUM MANUFACTURE AND MEASUREMENTS AT VHF (In French)
J. Orsini, et al., Onde Electr., vol. 43, no. 430, Jan. 1963, p. 5/24.

. . . These cables must have certain electrical performances over wide range of frequencies. . . We describe the principal electrical tests which we have made up to frequencies as high as 10,000 megacycles. . . interconnection. . . between themselves. . . treatment of the output. . . connectors.

INTERFERENCE REDUCTION IN CABLES
R. F. Ficcki, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 104/114.

. . . a major sub-problem associated with conducted interference is that known as interference reduction in cables. Much has been written about this cable problem; many of the accomplishments of the electronics industry has been reported in the literature. . . . In this paper, no attempt has been made to add new solutions or to point out new problems. The intention here and the objective of this paper is to look at the approaches and the solutions and to bring order to various schemes that have been developed. . . .

TRANSIENT RADIATION EFFECTS IN COAXIAL CABLES DUE TO GAMMA-NEUTRON RADIATION PULSES
H. W. Wicklein, Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 473/483.

Definitive good-geometry tests have been performed on RG-59B/U and RG-174/U coaxial cables at the Kukla pulsed reactor. . . . The responsible mechanisms are Compton scattering, ion pair generation, and secondary emission. . . .

Related References:

AN INTERSYMBOL ADJUSTMENT METHOD OF DISTORTION COMPENSATION
E. D. Gibson, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 196/207.

. . . describes a device capable of simultaneously compensating for both amplitude and delay distortion. . . . is well suited for use as an equalizer of digital or analog transmission systems, a highly adjustable filter, or a laboratory instrument. . . .

1.653: Characteristics of Underwater Cable Facilities

Included: Submarine telephone cables.

Not Included: TASI system of asynchronous speech multiplexing (2); Cable ships; Reliability problems of undersea facilities.

Cross References: Subsurface propagation of electromagnetic waves (1.636).

Principal Publications:

A NOTE ON THE LAYING EFFECT AND AGING OF SUBMARINE TELEPHONE CABLES
R.A. Brockbank, Post Off. Elect. Engrs. J., vol. 54, no. 1, April 1961, p. 20/21.

TIME-DIVISION-MULTIPLEX TELEGRAPHY ON THE TRANSATLANTIC TELEPHONE CABLE
H.E. Evans, et al., Post. Off. Elect. Engrs. J., vol. 54, no. 2, July 1961, p. 113/117.

The use of synchronous time-division working, made possible by the excellent performance of the frequency-modulation voice-frequency telegraph channels and the low noise level of the transmission path, offers a method of doubling the traffic-carrying capacity of telegraph channels on the transatlantic telephone cable. . . .

THE EQUALIZATION DURING LAYING OF THE ANGLO-SWEDISH SUBMARINE TELEPHONE CABLE
F. Scowen, Post Off. Elect. Engrs. J., vol. 54, no. 1, April 1961, p. 48/50.

LOCATION OF REPEATER FAULTS ON SUBMARINE TELEPHONE CABLES
F. Scowen, Post Off. Elect. Engrs. J., vol. 54, no. 4, Jan. 1962, p. 252/256.

CANTAT-A NEW SUBMARINE TELEPHONE CABLE SYSTEM TO CANADA
Post Off. Elect. Engrs. J., vol. 54, no. 4, Jan. 1962, p. 220/222.

SHIPBOARD-ADJUSTABLE SUBMERGED EQUALISER
B.M. Dawidziuk, et al., Elect. Commun., vol. 38, no. 1, 1963, p. 88/105.

. . . system equalization is of paramount importance. . . . the exact properties of the equalizer depend on the characteristics of the cable and repeaters as laid and can therefore be accomplished only during the laying of the cable . . . A detailed description of the type of adjustable submerged equalizer initially developed for the recently completed Scotice and Med-1 projects is given in this paper. . . .

THE ANGLO-CANADIAN TRANSATLANTIC TELEPHONE CABLE SYSTEM (CANTAT)
R.J. Halsey, Post. Off. Elect. Engrs. J., vol. 56, no. 2, July 1963, p. 73/75.

SWITCHING ARRANGEMENTS FOR SEMI-AUTOMATIC OPERATION OF TRANSOCEANIC TELEPHONE-CABLE CIRCUITS
D.L. Heptinstall, et al., Post Off. Elect. Engrs. J., vol. 56, no. 2, July 1963, p. 105/110.

. . . Operator access to the transatlantic telephone circuits is indirect and new register-controlled 4-wire link circuits have been provided for outgoing calls, while for incoming calls a new incoming international register-translator has been installed. . . .

A MAGNETIC AMPLIFIER FOR LOW-LEVEL TELEGRAPH SIGNALS
L.A. Rioual, J. Brit. Inst. Radio Engrs., vol. 25, no. 6, June 1963, p. 541/546.

In the design of submerged repeaters for submarine telegraph cables, the need arises for a circuit capable of amplifying very low frequency signals with great reliability. . . . repeater circuit is described, in which a magnetic amplifier is used for frequency conversion of the telegraph signals. . . .

LINE AND REGISTER SIGNALLING SYSTEMS FOR DIALLING OVER TRANSOCEANIC TELEPHONE CABLES
S. Welch, Post Off. Elect. Engrs. J., vol. 56, no. 2, July.1963, p. 111/118.

Line and register signalling systems have been developed for dialling over transoceanic cables. The systems are compatible with T.A.S.I. equipment and with both 3 kc/s-spaced and 4 kc/s-spaced circuits. This article describes the circuit principles of both signalling systems. . . .

UNITED KINGDOM—FAROES—ICELAND (Scotice) SUBMARINE-CABLE TELEPHONE SYSTEM
M.V. Young, et al., Elect. Commun., vol. 38, no. 1, 1963, p. 76/87.

1.654: Characteristics of Transmission Plant Facilities

Included: Echo suppressors; Compandors; Correctors for distortions.

Not Included: Error correction codes (2); Modems; Terminal equipment; Switching centers; Voice circuit multiplex systems (2).

Cross References: Phase equalization in cables (1.652); Delay distortions in general (1.626); Repeaters for pulse code modulation (1.522).

Principal Publications:

COMPANDOR EFFECTS ON DATA SIGNALS
E. Enriques, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 220.

Abstract Only.

VOICE IMMUNITY OF TONE OPERATED SWITCHING CENTERS
J. H. Guenther, et al., Commun. Electronics, vol. 79, no. 51, Nov. 1960, p. 553/557.

Tone operation of electronic switching centers is the natural outgrowth of 4-wire operation of communication systems using a radio link. . . . to determine what part of the spectrum should be utilized for the control tones. . . . The system here described was . . . for the Army field switchboard. . . . specifications . . .

A HIGHLY VERSATILE CORRECTOR OF DISTORTION AND IMPULSE NOISE
E. D. Gibson, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 343.

. . . utilizes a "scrambler" (or predistorter) . . . called the ISIC (Inter-Symbol Interference Corrector) and a fixed, "smear" filter. The descrambler consists of another ISIC and a "desmear" filter.

CORRECTING ERRORS IN DATA TRANSMISSION BETWEEN STATIONS OF THE SATELLITE CONTROL FACILITY
H. Reid, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 180/187.

. . . reliable transmission of digital data over voice frequency telephone lines. . . . This paper describes the Data Line Translator (DLT) which was developed in cooperation with the U.S. Air Force, Lockheed Missiles and Space Company and Philco Corp. to meet an Air Force requirement for error-free digital transmission via transcontinental voice band telephone service between stations of the Satellite Control Facility. . . .

THE EFFECTS OF TIME DELAY AND ECHOES ON TELEPHONE CONVERSATIONS
J. W. Emling, et al., Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2869/2891.

. . . brief history . . . Actual delays involved in typical circuits . . . discussion of the effects of delay only on typical conversations . . . sources of echo . . . measures . . . to reduce echo by improving return loss . . . introduction to echo suppressors and some of the new problems they introduce.

EFFECTS OF TIME DELAY AND ECHOES ON TELEPHONE CONVERSATIONS
J. W. Emling, et al., IRE Internat. Conv. Rec., Part 8, vol. 10, March 1962, p. 122.

Abstract Only.

A CARRIER-OPERATED ECHO SUPPRESSOR AND CONTROL DEVICE
T. F. Benewicz, IRE Trans. Commun. Systems, vol. CS-10, no. 2, June 1962, p. 208/214.

Of the numerous distortions affecting high quality facsimile reception, noise and echo represent the most troublesome offenders. This paper describes a device which fills the critical need for suppression of noise and echo currents on two-way multipoint facsimile networks. . . .

TRANSMISSION CHARACTERISTICS OF BELL SYSTEM SUBSCRIBER LOOP PLANT
R. G. Hinderliter, IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 464/470.

. . . This paper discusses some principal results of a recent Bell System subscriber loop survey. Statistically sound estimates of various physical and transmission characteristics of the loop plant are presented.

SUBJECTIVE EVALUATION OF DELAY AND ECHO SUPPRESSORS IN TELEPHONE COMMUNICATIONS
R. R. Reisz, et al., Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2919/2941.

The effect of transmission delay upon the quality of a telephone circuit was investigated using naturally occurring telephone conversations. Round-trip delays of 600 and 1200 msec went almost unnoticed at first when no echo sources or echo suppressors were present in the circuit. After exposure to pure delays of up to 2400 msec, considerable dissatisfaction, indicated by rejection of the circuit, developed with the 600- and 1200-msec delays. When echo sources and echo suppressors were added to the circuit, some dissatisfaction developed immediately for round-trip

delays of 600 and 1200 msec. No adaptation to the effects of delay occurred; in fact dissatisfaction increased with experience under certain conditions.

Related Publications:

SIGNALING SYSTEMS FOR CONTROL OF TELEPHONE SWITCHING
C. Breen, et al., Bell Syst. Tech. J., vol. 39, no. 6, Nov. 1960, p. 1381/1444.

Telephone signaling is basically a matter of transferring information between machines, and between humans and machines. . . . history of . . . . systems used between central offices of the nationwide telephone network . . . influence on such systems of the characteristics of switching systems and their information requirements, the transmission media and the compatibility problem. . . . some of the . . . systems presently in use. . . . problem of signaling between Bell System and overseas telephone systems . . . new transmission media. . . . some speculation is made on the future trends of telephone signaling systems. . . .

K24A SYNCROPLEX TELEPHONE CARRIER SYSTEM
B. G. Coetsee, et al., Elect. Commun., vol. 36, no. 4, 1960, p. 230/247.

. . . exchange carrier system . . . electrical characteristics of typical exchange lines . . . application on line lengths between 5 and 20 miles . . . attenuations of the order of 200 decibels at 500 kilocycles per second. . . . Repeaters with slope equalization . . . from a few decibels to a maximum of approximately 16 decibels. . . . Adequate system regulation for 15-to-18-decibel variation . . .

AUTOMATIC ERROR-DETECTION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUIT DATA TRANSMISSION
W. G. Schmidt, Lincoln Lab., Mass. Inst. of Tech., Lexington, 27 Nov. 1961, 11 p., (Rept. no. 25G-5), AD 268 128.

. . . error rate . . . function of terminal equipment reliability and . . . synchronization . . . The general system, the logical design considerations, the hazards encountered, and the debugging and test methods used are described. . . .

APPLICATION OF CARRIER SYSTEMS TO EXCHANGE TRUNK PLANT IN CANADA
A. Curran, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 116/120.

. . . demand for relatively long exchange trunk circuits . . . requirement . . . that is may be operated over existing exchange trunk cables. . . . results of tests conducted to determine the range of attenuation, crosstalk coupling loss, and noise liable to be encountered on existing cables. . . . shows how the observed values were used in the design of the NX-1 Exchange Trunk Carrier System. . . .

1.655: Characteristics of Long Distance Waveguide Plants

Included: Mode conversion problems; Dispersion in waveguides; Multi-mode transmission lines; Multi-mode distortions.

Not Included: Electromagnetic theory of transmission lines.

Cross References: Distortions in communications channels (Sect. 1.62).

Principal Publications:

RELATION ENTRE LES VARIATIONS D'AMPLITUDE ET DE PHASE D'UNE ONDE ELECTROMAGNETIQUE (Relations Between Amplitude and Phase Variations of an Electromagnetic Wave) (In French)
P. G. Broussaud, Annales de Radioelectricite, vol. 14, July 1959, p. 250/259.

When energy is extracted from a guided electromagnetic wave a phase shift occurs with a sign which is often one of the main characteristics. . . . in a number of special cases of considerable practical importance (constant factor of asymmetry process) the phase shift is almost always a phase lead for series type coupling and a lag for shunt type coupling.

SYSTEM ASPECTS OF LONG-DISTANCE COMMUNICATION BY WAVEGUIDE
A. E. Karbowiak, Proc. Instn. Elect. Engrs., London (Part B), vol. 109, no. 46, July 1962, p. 336/344.

A brief summary of the principal features of waveguide characteristics . . . The effect of attenuation and dispersion . . . a new approach to mode conversion-reconversion phenomena . . .

MEASUREMENT OF THE LOSS OF UNWANTED MODES IN WAVEGUIDE FOR LONG-DISTANCE TRANSMISSION
R. F. Skedd, Proc. Instn. Elect. Engrs., London (Part B), vol. 109, no. 48, Nov. 1962, p. 515/518.

Long-distance, high-capacity transmission via the TE_{01} mode in circular waveguide is an attractive goal because the theoretical attenuation caused by heat loss decreases monotonically as the frequency of operation increases. However, continuous random mode conversion caused by the manufacturing or the laying of the waveguide causes severe random fluctuations with frequency in the transfer function of present-day waveguide, a fact which apparently eliminates all but the "toughest" modulation schemes, such as pulse code modulation and angle modulation.

In this paper, we present the derivation of a technique for analyzing the effects of continuous random mode conversion on an angle-modulated wave . . . The examples use typical state-of-the-art data and are significant in that they demonstrate that FM appears to be an attractive modulation scheme . . .

THE NATURE OF AND SYSTEM INFERENCES OF DELAY DISTORTION DUE TO MODE CONVERSION IN MULTIMODE TRANSMISSION SYSTEMS

S. E. Miller, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2741/2760.

Quantitative estimates of delay distortion due to mode conversion in a multimode medium are made using an analysis based on modes coupled through power-transfer coefficients. This results in a simple translation from the spatial distribution of mode conversion to delay distortion without an intermediate step in the frequency domain . . .

. . . For PCM in an all-helix waveguide, it is concluded that a pulse rate up to 5000 megabits and up to 746 miles between regenerators is permitted by mode conversion effect . . .

For transmission of frequency division multiplex via a frequency-modulated carrier (FDM-FM), estimates based on the discrete-echo theory of Bennett, Curtis and Rice suggest that 4000-mile transmission of 2000 channel groups is possible in all-helix waveguide . . .

Separate consideration is being given to delay distortion due to wave-guide cutoff dispersion, which will be appreciable in some configurations described and will require equalization.

MODEL FOR RELATING COUPLED POWER EQUATIONS TO COUPLED AMPLITUDE EQUATIONS

D. T. Young, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2761/2764.

. . . The equations may allow one to approach coupled-mode problems directly for statistical results.

EFFECT OF DIFFERENTIAL LOSS ON APPROXIMATE SOLUTIONS TO THE COUPLED LINE EQUATIONS

D. T. Young, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2787/2793.

The assumption of zero differential loss between coupling modes in a multi-mode transmission line reduces the complexity of theoretical analysis. Here we show . . . approximate solution . . .

1.659: Experimental Evaluation of Transmission Circuits

Included: Subscriber loop testing; Telephone echo tests; Recording of transmission errors.

Not Included: Error correcting codes (2).

Cross References: Summaries of plant evaluation (1.650); Measurements of time-variant channels (1.619); Experimental evaluation of propagation media (1.639); Simulation of time-variant channels (1.619); Pulse noise evaluation (1.717).

Principal Publications:

MEASUREMENT OF TIME-VARYING TELEPHONE LINE CHARACTERISTICS

R. G. Gallager, Lincoln Lab., Mass. Inst. of Tech., Lexington, Sept. 1959, 11 p., (Group rept. no. 25G-0003), AD 230 432.

The general problem of measuring time-varying telephone line characteristics is discussed. An apparatus built to measure these characteristics is described. The apparatus is criticized and recommendations are made for an improved model.

NOTES ON TRANSMISSION OF DATA AT 750 BAUDS OVER PRACTICAL CIRCUITS

P. A. Chittenden, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 22/28.

Experience of using a 750 baud phase-modulated data transmission equipment over commercial trunk circuits is described. The results show that short interruptions of the transmission path (which would in general be unnoticed on speech) rather than noise, is the most serious impairment with which the equipment has to contend, particularly since the interruptions are very difficult to locate.

This leads to the conclusions that . . . the quality of a data path based on an average number of digit errors is unrealistic, and that error detection with repetition is . . . an equally effective . . . method . . .

DATA TRANSMISSION PERFORMANCE ON LONG-HAUL TELEPHONE FACILITIES

P. V. Dimock, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 29/36.

The effects on data transmission over circuits several thousand miles long on common types of long-haul voice transmission facilities have been investigated. Data signals were transmitted by frequency modulation at a rate of 750 bits per second, well within the bandwidth limitations of the circuits employed, and average noise was not a significant factor. Several hundreds of hours of continuous performance tests were made on each of the following types of facilities: multi-pair cable carrier systems (Type K), coaxial cable carrier systems (Type L), and microwave relay systems (TD-2).

It was found that the performance was generally characterized by periods of error-free

transmission interposed by catastrophic degradations—or interruptions—of variable duration ranging from milliseconds to minutes. . . . curves showing the number of disturbances per 100 hours per 1000 miles that exceed various durations for the three types of facilities. . . .

THE TESTING OF DIGITAL DATA TRANSMISSION CHANNELS AND CIRCUITS
R. G. Enticknap, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 66/71.

. . . concentrated primarily on telephone circuits of a type generally available, aims at a better understanding of these transmission media, particularly in respect of the additive and multiplicative noise which appears to constitute the major source of errors in current data transmission systems.

MEASURED ERROR DISTRIBUTIONS ON THE BELL A-1 FACILITY OVER VARIOUS MEDIA
E. J. Hofmann, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 37/44.

Error distributions have been obtained by experiments carried out using an automatic digital data error recorder which is described. Media include several land line telephone circuits and the Hawaiian cable. Both data and sync errors rates are shown, and their temporal and amplitude characteristics are examined. . . . The effectiveness of parity checking as an error-detecting device is also evaluated. . . .

TELEPHONE ECHO TESTS
D. L. Richards, et al., Proc. Instn. Elect. Engrs. Part B (London), vol. 107, no. 36, Nov. 1960, p. 553/556.

Electrical reflection on telephone circuits having appreciable times of propagation can cause delayed sidetone effects subjectively similar to echo. The variations in subjects' tolerance of this echo is examined experimentally as a function of echo attenuation and delay. The dispersion of tolerance between subjects is also considered . . .

SOME RESULTS ON THE EFFECTIVENESS OF ERROR-CONTROL PROCEDURES IN DIGITAL DATA TRANSMISSION
W. R. Bennett, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 58/65.

A number of error-correcting methods are evaluated by a computer simulation technique using the parameters of several hypothetical transmission channels which might be representative of telephone circuits.

AIR WEAPONS CONTROL SYSTEM 412L. INTRODUCTION TO FSK DATA TRANSMISSION
General Electric Co., Syracuse, N. Y., 30 Sept. 1961, 58 p., 7 refs., (Rept. no. AWCS-CS-3), AD 272 108.

. . . effect of envelope delay on the FSK signal is analytically examined . . . theoretical prediction of error rate versus signal-to-noise ratio is compared to experimental results obtained by laboratory simulation . . .

RECORDING AND VISUAL ANALYSIS OF NOISE ERRORS
A. E. Johanson, Commun. Electronics, vol. 81, no. 60, May, 1962, p. 90/94.

. . . In a recent data transmission test, a method for visually evaluating the causes of errors was tried. Photographic reproductions of error messages were produced by the combined use of a magnetic tape recorder and a recording oscillograph. These were analyzed visually and the errors classified by cause into eight categories. In several of these categories, the fault lies in the terminal equipment, in the rest, apparently in the transmission channel. Examples are given of various types of errors encountered. . . .

INVESTIGATION OF THE ERROR STATISTICS OF PULSE DATA UNDER NON GAUSSIAN NOISE CONDITIONS
K. Kupfmuller, Technische Hoschule, Darmstadt (Germany). Final technical rept., 1 Oct. 1961-30 Sept. 1962, 30 Sept. 1962, 7 p., AD 294 828.

. . . Noise recorded from heavily disturbed subscriber's lines was investigated. A data transmission system using amplitude modulation and a transmission speed of 1800 baud was built up and tests were carried out in the presence of noise to study the receiver error rates.

DATA TRANSMISSION TESTING FROM DONNELLY FLATS, ALASKA, TO SUNNYVALE, CALIFORNIA OVER A NETWORK OF CARRIER EQUIPMENT
P. L. Grant, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 21, 1963, 30 p., 2 refs., (Rept. 256-11) N63-22083.

. . . evaluating the coded diphase data modem over a combination of K-carrier TD-2 (microwave), and submarine cable from Donnelly Flats, Alaska, to Sunnyvale, California. Occurrence of errors is related as much as possible to the daily log and the record of equipment failures, interruptions, and circuit failures.

ENGINEERING CONSIDERATIONS OF SUBSCRIBER LOOP TESTING
G. K. Helder, IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 164/168.

. . . It is shown that insertion loss can be used as a criterion for detecting loops which have violated the rules.

RESULTS OF DATA TRANSMISSION TESTS OVER TELEPHONE LINKS (In French)
J. Labeyrie, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 94/105.

. . . outlines the results of data transmission tests which have been carried out under the direction or with the cooperation of the C.N.E.T., over both normal and special telephone links. . . . statistical analysis of recordings . . . pattern of errors (interval between errors, size of error groups, interval between erroneous blocks of numbers, etc.).

Section 1.66
Point-to-Point Radio Channels

This section has references to radio communications channels between fixed terminals, usually called point-to-point links. There is one exception: Short wave point-to-point links are discussed in subdivision 1.644 under short wave propagation characteristics.

The radio channels discussed in this section have multipath problems and all but the microwave line-of-sight channels (1.662) are dispersive channels, usually designated as scatter channels. This is why the first two subdivisions of this section discuss the common aspects of scatter channels.

Subdivision 1.662 offers a selection of references to line-of-sight microwave links; interest is concentrated on the channel characteristics. The multiplex problems of microwave links will be discussed in volume 2.

The remaining subdivisions deal with ionospheric, tropospheric meteoric scatter channels and with two space communications channels: The orbital dipole channel and the Moon relays. In these subdivisions only those references which convey information on channel characteristics are included. Equipment problems and mission considerations for the last two subdivisions are included in subject 4A.

1.660: Radio Channels Between Fixed Terminals

Included: Scatter communications in general; Point-to-point radio communications; Surveys of communications methods for multipath channels.

Not Included: Adaptive point-to-point channels (2).

Cross References: Analysis of multipath and fading channels (1.612); HF point-to-point links (1.644).

Principal Publications:

TROPOSPHERIC SCATTER PROPAGATION—A SUMMARY OF RECENT PROGRESS
H. Staras, RCA Rev., vol. 19, no. 1, March 1958, p. 3/18.

NEW SYSTEM DEFEATS MULTIPATH EFFECT
G.A. Scheer, Electronic Industr., vol. 19, May 1960, p. 150/153+.

ERROR PROBABILITIES FOR DATA TRANSMISSION OVER FADING RADIO PATHS
B.B. Barrow, SHAPE Air Defense Technical Center, The Hague (Netherlands), Feb. 1962, 148 p., incl. illus., talbes., refs., (SADTC Technical memo. no. TM-26), AD 273 846.

. . . Theoretical results. . . . various receiving systems, including some that use diversity reception, are examined. The models used are most appropriate for scatter propagation . . . Various methods of keying are considered with particular emphasis on frequency-shift keying.

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Stanford Electronics Labs., Stanford U., Calif., April 1962, 89 p. incl. illus., 24 refs., (Technical rept. no. 1002-2), AD 291 447.

. . . Analysis is undertaken in sufficient depth to give guidance in the selection of design parameters of various types of systems. . . . comparisons . . . of the performance potentials of different communication techniques. Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sounding effort, the signal characteristics, and the channel characteristics. . . . The performance characteristics of a class of radiometric signal-detection techniques that require no channel-sounding provisions are analyzed. . . . The results appear to be very attractive when relatively large channel bandwidths are available. . . . For many types of multipath channels, the advantages of seeking generally optimum communication techniques are somewhat limited.

MULTIPATH AND SCATTER COMMUNICATION TECHNIQUES
D. P. Harris, IRE Internat. Conv. Rec., pt. 8, vol. 10, March 1962, p. 161, 16 refs.

. . . results of an investigation of random-multipath and scatter communication channels and of communication techniques applicable to such channels. The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channel models. . . .

COMMUNICATION PROCESSES IN RANDOM MULTIPATH CHANNELS
C. K. Rushforth, Stanford Electronics Labs., Stanford U., Calif., April 1962, 31 p., incl. illus., 11 refs., (Rept. no. SEL-62-063; Technical rept. no. 2004-5), AD276 688. AD 276 688.

. . . channels whose exact nature is not known a priori . . . Two criteria . . . the probability of error and the divergence between statistical hypotheses. . . . The adaptive behavior of a receiver is considered with memory making a sequence of observations. It is shown for a particular case that the optimum receiver evolves from one using estimates of the channel output to the classical matched filter or correlation detector using a known channel output.

ADVANCED COMMUNICATION THEORY TECHNIQUES
J. C. Hancock, et al., Purdue Research Foundation, LaFayette, Ind., March 1963, 253 p., ASD TDR63 186, AD 405 154.

. . . channels are characterized by a model which accounts for both multiplicative and additive disturbances. A large amount of experimental data pertaining to radio disturbances is evaluated and correlated. The importance of the Rayleigh fading channel is emphasized and previous work is extended to determine the capacity and efficiency of the Rayleigh channel. . . .

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., 6 July 1963, 96 p., AD 410 286.

. . . some specific techniques for communicating through noisy, randomly time-varying multipath channels are considered . . . Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sound effort, the signal characteristics, and the channel characteristics. The performance characteristics of a class of radiometric signal detection techniques that require no channel sounding provisions are analyzed . . .

COMMUNICATION THROUGH RANDOMLY VARYING MEDIA
G. L. Turin, IN: RADIO WAVES AND CIRCUITS; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 201/207, 10 refs., A64-10834.

Summary of several results concerning communication through a fading, noisy, multi-diversity channel. In particular, the form of the optimum receiver for such a channel is outlined. The behavior of the error probability for this receiver is discussed for the binary case, for various types of fading and orders of diversity. A special case is a frequency-shift telegraph channel.

1.661: Scatter Systems Design Information

Included: Design of wideband scatter systems; Data transmission over scatter systems; Analytical description of scatter channels in general.

Not Included: Terminal design for scatter systems.

Cross References: Analysis of multipath and fading channels (1.612); Performance of HF communications channels (1.644); Analysis of ionospheric scatter channels (1.663); Analysis of tropospheric scatter channels (1.664).

Principal Publications:

APPLICATION OF INFORMATION THEORY TO VARIABLE RATE SCATTER COMMUNICATIONS
H. Blasbalg, 2nd Nat. Symp. Global Commun., Dec. 1958, p. 1/35.

THE DESIGN OF WIDEBAND SCATTER SYSTEMS
M. O. Felix, IRE WESCON Conv. Rec., Pt. 7, vol. 3, 1959, p. 33/40.

REMARKS ON THE FADING OF SCATTERED RADIO WAVES
R. A. Silverman, IRE Trans. Antennas Propagation, vol. AP-6, Oct. 1958, p. 378/380.

PRELIMITING BANDPASS FILTERING ON FADING RADIO CIRCUITS
C. Buff, IRE Trans. Commun. Syst., vol. CS-7, May 1959, p. 42/46.

On channels subject to multipath propagation, minimum-loss, flat-topped filters create serious transient effects which add greatly to the error rate in data transmission. Because of adjacent channel requirements, an over-all Gaussian response is not applicable. A practical solution is considered to be a rounded-top filter composed of a series of synchronous-tuned single circuits in cascade. Observations on an independent side band (ISB) telegraph circuit. A threefold improvement in the error rate of 45-baud printer operation.

THE DESIGN OF WIDE-BAND SCATTER SYSTEMS
M. O. Felix, IRE Trans. Commun. Systems, vol. CS-8, no. 3, Sept. 1960, p. 177/182.

The modulation bandwidth that a scatter system can handle is mainly determined by the transmitting and receiving antenna beamwidths.

. . . By wide band it is meant, a system handling frequencies of several megacycles, in which waveform and, therefore, delay equalization, is important.

THE SUM OF LOG-NORMAL PROBABILITY DISTRIBUTIONS IN SCATTER TRANSMISSION SYSTEMS
L. F. Fenton, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 37/67.

STATISTICAL ANALYSIS OF MULTIPATH JITTER
J. J. Brandinger, et al., RCA Rev., vol. 22, no. 3, Sept. 1961, p. 487/507.

. . . determining the time stability of multipath jitter. . . . a summary of first-order statistics is presented, followed by a determination of the autocorrelation and power spectral density functions . . . the relation of multipath jitter to the performance of communications system is briefly discussed.

THE TRACKING ANTENNA—A PROMISING CONCEPT FOR SCATTER COMMUNICATIONS
D. E. Johansen, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 134/149.

ERROR PROBABILITIES FOR DATA TRANSMISSION OVER FADING RADIO PATHS
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague (Netherlands), Feb. 1962, 148 p. incl. illus., tables, refs., SADTC Technical memo. no. TM-26, AD 273 846.

. . . The models used are most appropriate for scatter propagation, . . . Various methods of keying are considered, with particular emphasis on frequency-shift keying.

A COMPARATIVE STUDY OF THE CORRELATION OF SEASONAL AND DIURNAL CYCLES OF TRANSHORIZON RADIO TRANSMISSION LOSS AND SURFACE REFRACTIVITY
B. R. Bean, J. Res. Nat. Bur. Stand., vol. 66D, no. 5, Sept.-Oct. 1962, p. 593/599.

EFFECTS OF AMPLITUDE AND PHASE FLUCTUATIONS ON THE PERFORMANCE OF DIGITAL DATA SYSTEMS IN FADING FDM-FM AND FDM-SSB SYSTEMS
H. D. Becker, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 93/100.

. . . Emphasis is placed on the theoretical performance of differentially coherent phase-shift keyed (DCPSK) systems in which DCPSK data is transmitted on subcarriers over a frequency-division multiplex single-sideband (FDM-SSB) or an FDM-FM transmission system, such as employed in typical tropospheric scatter links. . . .

COORDINATING ANTENNA PERFORMANCE OF COMMUNICATION CIRCUIT REQUIREMENTS
S. Perlman, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 179/183.

. . . for HF signals beyond the horizon, complex changes in propagation phenomena affect in particular, the vertical (elevation) angle of the ray path with the passing hours of the day, season, and portion of the sun-spot cycle. More than one mode of Arrival" studies . . . for a particular point-to-point circuit over the period of a sun-spot cycle. The results have been used in selecting the performance requirements of the antennas when the frequency assignments are known. . . .

LINK EVALUATION AND TAPE MERGING COMPUTER PROGRAMS
B. M. Sifford, Stanford Research Inst., Menlo Park, Calif., Final rept., Dec. 1962, 60 p., Rept. no. TR7, AD 434 833.

. . . computer program designed to predict the performance of communication networks using HF, ionospheric scatter, and tropospheric scatter propagation modes. The present report outlines the models and procedures used to write a computer routine to convert signal-to-noise predictions into a teletype character error rate for a channel and to estimate the useable number of teletype channels the circuit can support. The conversion considers such circuit parameters as teletype speed, teletype code, diversity reception, modulation and detection techniques.

ON OPTIMAL DIVERSITY RECEPTION, II
G. L. Turin, IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 22/32.

. . . Since the optimal receiver may be difficult to implement, a more easily implemented "square-low combining" receiver is . . . considered, and it is shown that for all practical purposes this simpler receiver behaves optimally. . . .

CHARACTERIZATION OF RANDOMLY TIME-VARIANT LINEAR CHANNELS
P. A. Bello, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 360/393.

. . . considering three classes of practically interesting channels. These are the wide-sense stationary (WSS) channel, the uncorrelated scattering (US) channel, and the wide-sense stationary uncorrelated scattering (WSSUS) channel. . . . All real-life channels and signals have an essentially finite number of degrees of freedom due to restrictions on time duration and bandwidth. This fact may be used to derive useful canonical channel models . . .

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING. VOLUME II. POLARIZATION SYSTEMS ANALYSIS

R. S. Berkowitz, et al., Moore School of Electrical Engineering, U. of Pennsylvania, Philadelphia, Jan. 1964, 74 p., Rept. no. 64 02, RADC TDR 63 396, vol. 2, AD 430 249.

. . . The troposcatter propagation factors affecting a polarization programming system are presented. . . . Two appendices discuss a statistical model of a fading channel and a specific system incorporating one of the given design philosphies, respectively. The application of polarization programming to an over-the-horizon troposcatter link seems to be feasible, it should lie in the range of 1 to 10 kilomegacycles per second.

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING

R. S. Berkowitz, et al., Moore School of Electrical Engineering, U. of Penn., Philadelphia, Interim rept., Rept. no. 64 08, 2, RADC TDR 63 542, AD 431 882.

. . . construction of a statistical model of the propagation medium consistent with our knowledge of scatter propagation characteristics that can be used as the basis of system design. Such a channel model incorporating random fading statistics has been set up.

ON THE STABILITY ANALYSIS OF A TWO-WAY CONTROLLED CARRIER TRANSMISSION SYSTEM

N. J. Bershad, Air Force Cambridge Research Labs., Bedford, Mass., Data Sciences Lab., Dec. 1963, 16 p., refs., AFCRL-63-586; AD 428 435, N64-16803.

A mathematical model of a linear controlled-carrier tropospheric communication system is analyzed for tropospheric gain variations with a white-noise power spectral density. The stability of the first moment of the impulse response of the closed-loop control system is determined as a function of the linear controllers and the statistical characteristics of the troposphere.

ERROR PROBABILITIES FOR RICIAN FADING MULTICHANNEL RECEPTION OF BINARY AND N-ARY SIGNALS

W. C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, June 3, 1963, 24 p., 26 refs., NASA CR-51853, JPL Tech. Rept. 32-450, N63-22895.

. . . derived for two different forms of multi-receivers (the coherent and noncoherent), which are used with binary and N-ary signaling through the Rician fading multichannel . . .

MICROWAVE RADIO RELAY. IONOSPHERIC TRANSMISSION MODELS. TASK 5. CORRELATION BETWEEN TRANSMISSION PARAMETERS OF DISPERSIVE CIRCUITS AND SYSTEM PERFORMANCE FOR APPLICATION TO ADAPTIVE COMMUNICATIONS SYSTEMS

M. Masonson, et al., RCA Defense Electronic Products, New York, Final rept., 28 March-30 Sept. 1963, 30 Sept. 1963, 256 p., Rept. no. CR 63 419 12, AD 436 390.

The performance of PSK and FSK data systems was determined over dispersive, randomizing transmission circuits. The principal objective is to develop suitable models, or concepts of transmission, via HF ionospheric links, on which to base predictions of performance given the expected channel conditions.

THE APERTURE-TO-MEDIUM COUPLING LOSS IN TROPOSPHERIC SCATTER SYSTEMS (Correspondence)

C. A. Parry, Proc. IEEE, vol. 51, no. 6, June 1963, p. 933/934.

In recent analysis it was pointed out that a predictable relationship may exist between the bandwidth and intermodulation noise in FM tropospheric scatter links. On this basis, it was postulated that high-quality wide-band transmission may be feasible, provided that the antenna beamwidth is sufficiently narrow. This possibility raises the question of the so-called aperture-to-medium coupling loss . . .

STUDY OF FINE GRAIN FADING AND PHASE STABILITY OF MULTIPLE CW SIGNALS

G. C. Porter, et al., General Dynamics/Electronics, Rochester, N. Y., Interim technical rept., 1 Jan. 1961-Aug. 1962, March 1963, 1 v., Rept. no. 3, AD 400 714.

SCATTER COMMUNICATION MODELS FOR SPACE VEHICLES

R. A. Scholtz, University of Southern Calif., Engineering Center, Los Angeles, Jan. 1964, 38 p., Rept. no. 104, AD 433 717.

. . . Multipath communications are characterized by imperfect knowledge of signal waveforms when they arrive at a receiver. Under the assumption that this signal waveform is a sample function of a Gaussian random process, a pulse-amplitude-modulation communication system is designed. Optimum receiver data processing and optimum message encoding procedures are derived as a function of the signal and additive noise statistics. When the mean of the pulse signal waveform at the receiver is zero, the optimum code is orthogonal. On the other hand, when the covariance function of the Gaussian signal approaches zero, a regular simplex code provides optimum communications.

Related Publications:

DISTRIBUTION OF THE DURATION OF FADES IN RADIO TRANSMISSION: Gaussian Noise Model
S. O. Rice, Bell Syst. Tech. J., vol. 37, no. 3, May 1958, p. 581/635.

THE SPEED OF TRANSMISSION OF INFORMATION AND THE CARRYING CAPACITY OF A MULTIPATH SYSTEM AND RECEPTION BY THE LINEAR OPERATOR CONVERSION METHOD
I. A. Ovseyevich, et al., Radio Engrg., vol. 14, no. 3, 1959, p. 13/29.

POSITIVE REAL FUNCTIONS OF SEVERAL VARIABLES AND THEIR APPLICATIONS TO VARIABLE NETWORKS
H. Ozaki, et al., IRE Trans. Circuit Theory, vol. CT-7, no. 3, Sept. 1960, p. 251/260.

SIGNAL PROCESSING IN RADAR ASTRONOMY, COMMUNICATION VIA FLUCTUATING MULTIPATH MEDIA
R. Price, et al., Lincoln Lab., MIT, Lexington, 6 Oct. 1960, AD 246 782.

. . . the results are equally applicable to communication problems in which the propagation medium has significant multipath spread and fluctuation rate.

THE OPTIMUM BIT LENGTH FOR HF DATA TRANSMISSION
H. Fiege-Kollmann, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 108/115, 13 refs.

SIMULATION OF A FADING MEDIUM
R. Krulee, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 233/240.

Despite the extensive use of HF and scatter techniques on long-haul circuits, surprisingly little is yet understood about the actual performance of such circuits during the deep fading situations which limit the performance . . . In this paper a model that is consistent with observed experimental data is developed for a fading circuit. The instrumentation necessary to allow laboratory simulation and testing under exactly those conditions which are most critical for satisfactory system design is discussed. . . .

GENERALIZED FREQUENCY-RESPONSE CONCEPTS FOR TIME-VARYING DISCRETE-TIME LINEAR SYSTEMS
A. W. Naylor, Institute of Science and Tech., U. of Michigan, Ann Arbor, Feb. 1963, 30 p., Rept. no. 4563-32-T, AD 297 536.

ON THE PREDICTION OF THE INHERENT BANDWIDTH CAPABILITY OF THE TROPOSPHERIC SCATTER LINK
C. A. Parry, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 215/232, 27 refs.

. . . An approach is suggested using classical equations relating echo phenomena to intermodulation, using a white noise modulation spectrum. Transmission constants for these equations are derived by an empirical process. Formulas are then developed relating bandwidth, intermodulation noise, path length, antenna beamwidth, deviation and diversity.

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS-COMMUNICATION TYPE
C. W. Stuckey, et al., Georgia Inst. of Tech. Engineering Experiment Station, Atlanta, Quarterly rept. no. 3, 15 Aug.-1 Nov. 1963, 15 Nov. 1963, 56 p., Rept. no. 24, AD 433 705.

The effects of multipath inteference on the intelligibility of speech transmitted over an FM system employing time division multiplexing are reported. Predicted intelligibility measurements based on audio output S/N ratios indicate that significant degradation in intelligibility will exist for the FM/TDM system tested when multipath signals of equal strength are received over paths which differ in length by as little as 0.15 mile. . . .

1.662: Microwave Radio Relay Links

Included: Passive repeaters in radio relay links; Microwave line-of-sight links; Hertzian cables.

Not Included: Multiplex problems in RRL (2).

Cross References: Microwave propagation characteristics (1.646); Terrain influences on wave propagation (1.635).

Principal Publications:

MULTIPATH PROPAGATION OF MICROWAVES
T. Omori, et al., Rep. Elec. Commun. Lab., vol. 6, Jan. 1958, p. 1/11.

SYNCHRONIZATION OF SINGLE-SIDEBAND CARRIER SYSTEMS FOR HIGH-SPEED DATA TRANSMISSION
T. Combellick, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 110/114.

PROBABILITY DISTRIBUTION OF NOISE DUE TO FADING ON MULTISECTION FM MICROWAVE SYSTEMS
H. E. Curtis, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 161/167.

The probability distribution of expected baseband noise during fading at the end of a multisection microwave radio system is an important consideration in the engineering of a long system. . . .

INFLUENCE OF AN ATMOSPHERIC DUCT ON MICROWAVE FADING
F. Ikegami, IRE Trans. Antennas Propagation, vol. AP-7, no. 3, July 1959, p. 252/257.

FADING OF MICROWAVE RELAY LINKS (In Japanese)
K. Morita, J. Inst. Elect. Commun. Engrs., vol. 42, no. 10, Oct. 1959, p. 923/929.

THE STATISTICAL DISTRIBUTION OF THE DEPTH OF FADINGS ON SECTIONS IN RADIO RELAY SYSTEMS
A. I. Kalinin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 6, 1960, p. 1/11.

Expressions are given for integral curves to plot the distribution of the depth of fadings on intervals of radio-relay lines under the normal law governing the distribution of the active vertical gradient of the air's dielectric permittivity, together with limiting expressions for the distribution curves. Examples of the integral curves for the distribution of the depth of fadings are given. . . .

DATA TRANSMISSION TESTS, SERIES 3: TRIALS OVER AN 800-Mc RADIO LINK
M. L. Delahais, et al., SHAPE Air Defense Tech. Ctr., The Hague (Netherlands), Oct. 1961, 22 p., SADTC Tech. memo TM-17, AD 266 839.

. . . at a speed of 1500 bauds using frequency-shift keying as a modulation of four line-of-sight sections plus two tails of unloaded cable . . . Nearly 11 million transmission frames were sent. Each frame consisted of 128 bits . . . During the second part of the tests, one frame error occurred, on the average, in every 3000 frames. This figure ignores line interruptions, which were not numerous. The radio path was, however, significantly affected by fading.

SOME FACTORS INFLUENCING 3 CM RADIO-WAVE PROPAGATION OVERSEA WITHIN AND BEYOND THE RADIO HORIZON
F. A. Kitchen, et al., Proc. Instn. Electr. Engrs. Pt. B. (London), vol. 108, no. 39, May 1961, p. 257/263.

. . . results of a number of short-term oversea measurements . . . from a 10 Gc/s transmitter . . . It is shown that the variation of signal level within the horizon was rarely that expected for propagation through an atmosphere having a uniform refractive-index gradient. Signal losses of from 5 to 30 dB frequently occurred well within the horizon, these losses being recovered when the range between transmitter and receiver was sufficiently reduced. A well-defined interference pattern usually occurred in the region of reduced signal level. . . . A direct relationship was found to exist between the signal level within the horizon and that propagated well beyond the horizon into the extra-diffraction region. . . .

THEORETICAL STUDY OF THE BANDWIDTH CAPABILITIES OF RADIO PROPAGATION MEDIA
B. M. Fannin, Electrical Engineering Research Lab., U. of Texas, Austin, 31 Aug. 1962, 41 p. incl. illus., 21 refs., Rept. no. 6-49, AFCRL 62-584, AD 286 387.

The question of what limitations the atmosphere may impose on the useful bandwidth for line-of-sight propagation in the centimetric-millimetric wavelength region was investigated. . . . definition of a really suitable, unique parameter to be taken as the bandwidth of a time-varying system. . . . results nor the existing theories based on a multiple-scatter mechanism furnish an adequate base for performing bandwidth calculations.

EXPERIMENTAL STUDIES OF PROPAGATIONAL CHARACTERS OF 8.6 MM WAVE ON THE 24 KM PATH
K. Funakawa, et al., J. Radio Res. Lab., vol. 9, Sept. 1962, p. 351/367.

The experiments described were carried out nearly all the year round, using a pulse magnetron transmitter with a peak power of 30 kW. . . . measurements determine the relation between signal attenuation and rainfall rate. The results obtained are shown graphically. Some measurements were also made of field-intensity reduction due to water vapour. When there was no rainfall over the whole 24 km path, the received signal level was normally steady, but sometimes severe fading was observed. The fading range was larger in summer than in winter, its maximum value being 17.4 dB. It was usually large in the early morning and at midnight, and small in the daytime. In the winter experiments, correlation between the fading range and the occurrence of temperature inversion was markedly observable.

PROPAGATION INFLUENCES IN MICROWAVE LINK OPERATION
M. W. Gough, J. Brit. Instn. Radio Engrs., vol. 24, no. 1, July 1962, p. 53/72, 33 refs.

. . . Basic characteristics of ground-to-ground propagation in the frequency band 50-10,000 mc/s are discussed, with emphasis on the operation of point-to-point radio links. . . . Ground reflections are shown to be a key factor in the performance of very short wave radio links and the influence of inhomogeneities in the lower atmosphere is also stressed. It is pointed out how statistical analysis of temporal and spatial signal strength variations can often reveal the nature of the propagation mechanism at work, while at the same time pointing the way to improvements in circuit reliability. . . .

MICROWAVE SYSTEM ENGINEERING USING LARGE PASSIVE REFLECTORS
M. L. Norton, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 304/311.

. . . Small passive reflectors of the "periscope type" have been used for many years . . .

Large passive reflectors have . . . been used but to a . . . lesser degree. . . . This paper describes their use in both the "near" and "far fields" in line-of-sight systems and describes how they may be used on non-line-of-sight systems (tropospheric scatter and diffraction systems). Formulas are developed and graphs provided which will enable the microwave engineer to determine the path loss of multihop passive reflector systems. . . .

FAISCEAUX HERTZIENS TRANSHORIZON DE FAIBLE LONGUEUR (Transhorizon Radio Links of Short Distance) (In French)
J. Battesti, Ann. Telecomm., vol. 18, no. 3-4, March/April 1963, p. 72/77.

. . . A method to determine the path attenuation of links which do not extend for more than 100 Km beyond line-of-sight. . . .

EXPERIMENTAL RESEARCH ON THE BEHAVIOR OF PASSIVE REPEATERS
C. Colavito, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1423/1430.

. . . series of experimental tests . . . Emphasis has been given to the influence of propagation and the effects of the ground surrounding the mirror . . . much use has been made of passive repeaters in radio-links working on a 7000-Mc band. Nearly one hundred have been installed in Italy alone. . . .

A 6-GIGACYCLE PROPAGATION STUDY TO EVALUATE SYSTEM ENGINEERING CONSIDERATIONS IN TRAVERSING DIFFICULT TERRAIN
L. T. Hearson, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 51/59.

The engineering of microwave systems traversing extensive water surfaces and flat terrain has always presented a challenging problem. The new and more sophisticated 6-gc (gigacycle) equipments present new and interesting variations to the problem. The TH system . . . is such a system. . . . to evaluate the particular factors in engineering such a system across the Great Salt Lake desert in Utah. . . .

MOP-UP EQUALIZER FOR AMPLITUDE AND DELAY DISTORTION IN IF BAND FOR 6GC 1800 CHANNEL SYSTEM
T. Kawahashi, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 163/176.

. . . To accomplish high capacity radio transmission, that is, a multi-channel radio relay system capable of carrying 1800 telephone channels . . . it has become necessary to equalize the 3rd and 4th order distortion components of the amplitude-frequency response in the IF stage, not to speak about the residual delay distortion in the FM transmission path.

In order to meet the said requirement . . . we have developed two types of the IF mop-up equalizer: one is the amplitude equalizer . . . and the other is the delay equalizer . . .

When operated as part of the IF stage of the existing Tokyo-Osaka 6GC-1200 channel system, these equalizers have proved to be effective enough to convert the existing system into a 1800 channel system conforming to the CCIR Recommendation . . .

Related Publications:

A METHOD OF I.F. SWITCHING FOR A MICROWAVE DIVERSITY SYSTEM
D. R. Bester, J. Brit. Instn. Radio Engrs., vol. 24, no. 2, Aug. 1962, p. 171/179.

MULTIPLE ECHO DISTORTION IN FREQUENCY-MODULATION, FREQUENCY-DIVISION,—MULTIPLEX TRUNK RADIO SYSTEMS

R. G. Medhurst, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 61/71.

1.663: Ionospheric Scatter Channels

Included: Ionospheric forward scattering channels; VHF ionospheric scatter channels; VHF scatter systems.

Not Included: Antennas for VHF scatter systems; Equipment problems; Adaptive communications systems (2).

Cross References: Ionospheric forward scattering effects (1.632); Mathematical models of scatter channels (1.612).

Principal Publications:

THE ANGULAR DISTRIBUTION OF ENERGY RECEIVED BY IONOSPHERIC FORWARD SCATTERING AT VERY HIGH FREQUENCIES
W. C. Bain, Symp. Long Dist. Prop. Above 30 mc, Jan. 1958, Paper No. 2487.

ENGINEERING STUDIES IN IONOSPHERIC COMMUNICATION SYSTEMS
J. C. Blair, et al., Nat. Bur. Stands., Oct. 1958, p. 1/17.

AMPLITUDE OF VERY-HIGH-FREQUENCY SIGNALS REFLECTED FROM THE SPORADIC-E LAYER IN NORTH-WEST EUROPE
P. J. Brice, Symp. Long Dist. Prop. Above 30 mc, Jan. 1958, 3 p., Paper No. 2514.

A SCATTER-SIGNAL ANALYSER
P. H. Cutler, et al., Symp. Long Distance Prop. above 30 mc, Jan. 1958, 5 p., Paper No. 2531.

SIMULTANEOUS VARIATION OF AMPLITUDE AND PHASE OF GAUSSIAN NOISE, WITH APPLICATIONS TO IONOSPHERIC FORWARD-SCATTER SIGNALS
T. Hagfors, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 105, Nov. 1958, p. 555/559.

ANALYSIS OF GIBRALTAR-UNITED KINGDOM IONOSPHERIC SCATTER SIGNAL RECORDINGS
G. A. Isted, Symp. Long Dist. Prop. Above 30 mc, Jan. 1958, 9 p., Paper No. 2523.

RADIO INTERFERENCE AS A FACTOR IN IONOSPHERIC SCATTER COMMUNICATION
G. A. Isted, Symp. Long. Dist. Prop. Above 30 mc, Jan. 1958, 9 p., Paper No. 2527.

ENGINEERING STUDIES IN VHF IONOSPHERIC SCATTERING PROJECTS 8780, 8781, 8785, 8786, 8787 (AACS)
R. C. Kirby, et al., National Bur. of Standards, Boulder, Colo., Feb. 1958, 17 p., Quarterly rept., 1 July - 31 Dec. 1957, (NBS rept. no. 5554), AD 221 489.

Modulation techniques
Frequency dependence
Construction of field units for propagation measurements.

EXTREME USEFUL RANGE OF VHF TRANSMISSION BY SCATTERING FROM THE LOWER IONOSPHERE
R. C. Kirby, IRE Nat. Conv. Rec., Pt. 1, March 1958.

SURVEY OF THE GIBRALTAR-UNITED KINGDOM IONOSPHERIC SCATTER MEASUREMENTS
F. A. Kitchen, et al., Symp. Long Dist. Prop. Above 30 Mc, Jan. 1958, 5 p., Paper No. 2519.

MODULATION STUDIES FOR VHF IONOSPHERIC SCATTERING
J. W. Koch, Nat'l. Bureau of Standards, Boulder, Colo., Aug. 1958, 35 p., (NBS rept. no. 5597), AD 221 490.

The experiments carried out at approximately 50 Mc/s, were designed to determine the communication capacity of ionospheric forward scatter paths using prototype modulation techniques for frequency-shift-keyed teletype, and radiotelephone. Binary error rate studies were made to determine required signal-to-noise ratios for specified error rates.

THE STRUCTURE OF HIGH-FREQUENCY IONOSPHERIC SCATTER SIGNALS
D. Williams, Symp. Long Dist. Prop. above 30 Mc, Jan. 1958, 8 p., Paper No. 2529.

PROJECT TEST RANGE TEST PROGRAM, IONOSPHERIC-SCATTER AND METEORIC-BURST EVALUATION
Page Commun., Aug. 1958, p. 1/28.

SOME CHARACTERISTICS OF PERSISTENT VHF RADIOWAVE FIELD STRENGTHS FAR BEYOND THE RADIO HORIZON
L. A. Ames, et al., Proc. IRE, vol. 47, May 1959, p. 769/777.

EVIDENCE FOR A 200-MEGACYCLES-PER-SECOND IONOSPHERIC FORWARD-SCATTER MODE ASSOCIATED WITH THE EARTH'S MAGNETIC FIELD
J. L. Heritage, et al., J. Geophys. Res., vol. 64, Sept. 1959, p. 1235/1241.

REDUCTION OF DOPPLER-SHIFT ERRORS IN IONOSPHERIC-SCATTER FSK COMMUNICATIONS
J. W. Koch, National Bureau of Standards, Boulder, Colo., May 1959, 8 p., (NBS rept. no. 6053), AD 232 739.

Meteoric Doppler frequency shifts of signals propagated via ionospheric scattering cause errors in narow-band FSK communications. A simple method of reducing the Doppler-shift errors has been tried. The principle of operation consists of locking out the mark channel when a space signal is present. The experimental results show a useful reduction in error rate when the Doppler lock-out circuitry is used.

STUDY OF PHASE STABILITY FOR PHASE-KEYING APPLICATIONS IN VHF IONOSPHERIC-SCATTER COMMUNICATIONS
J. W. Koch, Nat'l Bureau of Standards, Boulder, Colo., April 1959, 15 p., NBS rept. no. 6051, AD 232 738.

FACTORS AFFECTING MODULATION TECHNIQUES FOR VHF SCATTER SYSTEMS
J. W. Koch, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 77/91.

OPTIMUM ANTENNA HEIGHT FOR IONOSPHERIC SCATTER PROPAGATION
R. G. Merrill, Nat. Bureau of Standards, Boulder, Colo., March 1959, 22 p., (NBS rept. no. 6047), AD 232 737.

CHARACTERISTICS OF CONTINUOUS VHF IONOSPHERE SCATTER PROPAGATION OF CONCERN IN THE DESIGN OF RELIABLE LONG-DISTANCE COMMUNICATIONS CIRCUITS
T. F. Rogers, Air Force Cambridge Research Center, Bedford, Mass., March

1959, 64 p., (Rept. no. AFCRC TR-59-122), AD 211 932.

THE SUM OF LOG-NORMAL PROBABILITY DISTRIBUTIONS IN SCATTER TRANSMISSION SYSTEMS
L. F. Fenton, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 37/67.

OPTIMUM ANTENNA HEIGHT FOR IONOSPHERIC SCATTER COMMUNICATION
R. G. Merrill, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 14/19.

IONOSPHERIC DISPERSION EFFECTS ON VHF PULSES
N. B. Miller, HRB-Singer, Inc., State College, Pa., Final engineering rept., 14 Nov. 1960, AD 250 187.

. . . VHF pulse distortion was analyzed by calculating the shape of a pulse after transmission through the ionosphere. Calculations were performed for the case of vertical incidence. . . . The calculations were performed for initial pulses of the same width but of several different carrier frequencies and two bandwidths. For a bandwidth of 1.6 Mc, carrier frequencies of 30, 35, 40, and 50 Mc were used. For a bandwidth of 6.4 Mc, carrier frequencies of 40, 60, 80, and 100 Mc were used.

IONOSPHERIC SCATTER TRANSMISSION
Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 5/29.

. . . general "State-of-the-Art" report. . . .

THE FADING OF RADIO WAVES REFLECTED FROM THE IONOSPHERE AT OBLIQUE INCIDENCE
O. Awe, J. Atmos. Terrest. Phys. (GB), vol. 21, no. 2-3, June 1961, p. 120/141.

. . . studied by the use of pulse transmissions on frequencies near 2 Mc/s. It is found that echoes reflected from a height of about 90 KM have a fading period of about 1 min. Echoes from a greater height of about 120 km, which usually appear only during or immediately after magnetic disturbances, have a shorter fading period of about 6 sec. . . .

THE FADING OF RADIO WAVES WEAKLY SCATTERED AT VERTICAL INCIDENCE FROM HEIGHTS NEAR 90 km.
O. Awe, J. Atmos. Terrest. Phys. (GB), vol. 21, no. 2-3, June 1961, p. 142/156.

The fading of radio waves weakly scattered at vertical incidence from heights near 90 km was studied. Frequencies between 2 and 3 Mc/s were used. The fading rate was found to be of the order of 20 maxima/min. considerably faster than the fading rate for echoes from the normal E-region observed with the same frequency. . . . It is shown that the fading is mainly due to random movements of the scattering elements, rather than a steady drift, and the root-mean-square velocity of the scatterers is found to be about 13 m/sec. . . .

DIRECTIONAL OBSERVATIONS ON DELAYED SIGNALS ON AN IONOSPHERIC FORWARD-SCATTER CIRCUIT
W. C. Bain, Proc. Instn. Electr. Engrs. Pt. B, (London), vol. 108, no. 39, May 1961, p. 253/256.

. . . A study of delayed signals reaching Flough from a transmitter at Gibraltar on 37 Mc/s in the winter of 1956-57. The mean bearing of the first signal to arrive after that due to ionospheric forward-scatter was found to vary between 250° and 290° during the day; the spread of energy in bearing is also considered. It is shown that the radiation from the transmitter aerial must be stronger to the west than to the south. Results for the second delayed signal are also given. Round-the-world echoes were occasionally observed, but these did not arrive from the direction of the great circle containing Gibraltar and Slough. . . .

STUDIES OF IONOSPHERIC FORWARD SCATTERING USING MEASUREMENTS OF ENERGY DISTRIBUTION IN AZIMUTH
W. C. Bain, Proc. Instn. Elect. Engrs. Pt. B, London, vol. 108, no. 39, May 1961, p. 241/252.

Measurements of phase and amplitude have been carried out on signals on 37 Mc/s received from a transmitter at Gibraltar. The receiving sites were at Slough and Castlemartin, which are each about 1740 km from Gibraltar, and were equipped with pairs of aerials whose spacing could be varied from λ to 10 λ. The results were not consistent with the idea that the forward-scattered signal was due to the combination of many randomly-phased radio waves. Frequently one signal appeared to be dominant, as might be expected if reflections from meteor trails formed an important part of the resultant signal. . . . A comparison with observations at Castlemartin in Wales suggests that the scattering process is due almost entirely to meteor reflections by night but that during the day there is also present a component due to turbulent scattering which contributes rather more than half the total energy. . . .

THE RECEIVED-AMPLITUDE DISTRIBUTION PRODUCED BY RADIO SOURCES OF RANDOM OCCURRENCE AND PHASE
W. C. Bain, Proc. Instn. Elect. Engrs. Pt. C, (London), vol. 108, no. 13, March 1961, p. 20/24.

A theoretical calculation. . . of the amplitude probability distribution to be expected on an ionospheric v. h. f. forward-scatter circuit due to reflections from meteor trails alone. The analysis is based on the addition of a large

number of signals with a frequency of occurrence inversely proportional to the square of their amplitude . . . a method is outlined for deriving the relative proportion of meteoric and turbulent-scattering components in the signal. . . .

COMPUTATIONAL PROCEDURES FOR DETERMINATION OF RECEIVED POWER AND RELIABILITY OF IONOSPHERIC SCATTER COMMUNICATION SYSTEMS

B. M. Sifford, Stanford Research Inst., Menlo Park, Calif., Final technical no. 4, Aug. 1961, 53 p., incl. illus., tables, 16 refs., AD 291 176.

Prediction equations for the ionospheric scatter mode of radio wave propagation are formulated from the most consistent contemporary theories and from the results of available propagation experiments. The turbulent and meteor mode components of the scatter signal are considered separately. . . . used to write a computer program from which the reliability of ionospheric scatter communications links can be predicted.

MEASUREMENT OF IONOSPHERIC PATHS AS A TIME-VARYING NETWORK

A. E. Laemmel, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Scientific rept. no. 2, 13 Dec. 1962, 7 p., (Research rept. no. PIBMRI-1102-62), (AFCRL 63-14), AD 298 298.

A STUDY OF PHASE FADING OF IONOSPHERIC REFLECTIONS

P. E. Monro, Austral. J. Phys., vol. 15, no. 3, Sept. 1962, p. 387/404.

Pulsed 2. 28 Mc/s radio waves were transmitted and measurements were made on the first-hop, vertically-incident reflections from the ionosphere. A method of continuously recording the changes of phase difference between the signals at two aerials is described. . . . it is shown that the quasi-periodic type of fading can be explained in terms of two component rays being reflected from two reflecting areas of the ionosphere and interfering at the receiving aerials. The horizontal separation of the two regions is about 50 km in the case analysed. . . .

IONOSPHERIC IRREGULARITIES DETECTABLE IN V. H. F. IONOSPHERIC PROPAGATION

K. Tao, Rep. Ionosphere Space Res., vol. 16, no. 2, June 1962, p. 275/278.

It is suggested that it may be possible to investigate the irregularities in the ionosphere corresponding to D-scatter, sporadic-E, and F-scatter signals from observations of v. h. f. ionospheric propagation.

VHF SCATTER COMMUNICATIONS: NEW DESIGN CONCEPTS AND EXPERIMENTAL RESULTS

S. Browne, et al., Shape Air Defense Technical Center, the Hague (Netherlands), June 1963, 56 p., SADTC TM56, AD 417 330.

. . . tests. . . carried out by SADTC on an ionoscatter telegraphy system set up over a distance of 1000 km between Holland and Southern France. The purpose of this experimental circuit was to investigate Automatic Request (ARQ) techniques and to assess the advantages of multiple-diversity reception. . . . conclusion. . . that ionoscatter communication systems over distances up to 1000 km do not necessarily require high transmission power and costly antenna structures. With a 5 kW transmitter and simple Yagi antenna arrays the specified system performance is met for 99.9% on a four-channel telegraph system.

IONOSPHERIC VHF SCATTERING NEAR THE MAGNETIC EQUATOR DURING THE INTERNATIONAL GEOPHYSICAL YEAR

R. Cohen, et al., Journal of Research, Section D - Radio Propagation, vol. 67D, Sept.—Oct. 1963, p. 459/480, 21 refs., A63-25321.

. . . The equatorial scatter signals were usually stronger than their counterparts at temperate latitudes. Scattering was observed comparable to the D-region scatter propagation familiar elsewhere, but usually the E-region scatter predominated. Scattering via F-region irregularities was observed at nighttime over a 2,580-km path centered about the magnetic equator.

DISTORTION OF SIGNALS TRANSMITTED THROUGH THE IONOSPHERE

R. L. Greenspan, MITRE Corp., Bedford, Mass., Aug. 1963, 23 p., Rept. no. W5810, ESD TDR 63 289, AD 415 013.

. . . The effect of the ionosphere on signal transmission is obtained by inversion of a Fourier integral, and the relevance of group velocity, signal velocity, and time delay concepts is examined. The dispersions decreases the output signal of a typical UHF correlation receiver by less than 3 db for normal ionospheric conditions.

(No Title)

H. R. Machin, (editor), Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., Quarterly progress rept. no. 7, Jan.- March 1963, March 1963, 116 p., NBS Rept. no. 7694, AD 419 303.

. . . In the modulation research program an analysis has been made of ionospheric-scatter transmissions using a voice signal to frequency-modulate the transmitter with maximum deviations of 1, 3, 5, and 15 kc/s. . . .

AN EXPERIMENTAL AIRBORNE 50-MC IONOSPHERIC SCATTER COMMUNICATION CIRCUIT
A. S. Orange, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 124/137.

VHF air-ground-air teletype communications by ionospheric scatter propagation have been shown to be feasible. Field strength measurements and band error data were obtained over a 1500 statute mile flight path across the auroral zone. . . . No degradation of system performance during periods of intense magnetic disturbances was observed . . . System performance was evaluated using three orders of frequency diversity and up to six orders of space diversity. Successful teletype operation requires at least two orders of diversity to overcome the severe rapid fading inherent in ionospheric scatter propagation. . . .

Related Publications:

HIGH GAIN, LOW SIDE-LOBE VHF ANTENNA FOR IONOSPHERIC SCATTER COMMUNICATION REQUIREMENTS AT "RICE CAKE"
A. C. Wilson, et al., Nat. Bur. Stands., Dec. 1958, p. 1/15.

ON THE DESIGN OF A HIGHLY RELIABLE HF DIGITAL COMMUNICATION SYSTEM. PROBLEMS, DESIGN PROCEDURES AND THE DESCRIPTION OF A PROPOSED DESIGN
K. Otten, National Cash Register Co., Dayton, Ohio, Oct. 1961, 38 p., Rept. 3-4S, AD 269 891.

STUDY OF HF FREQUENCIES FOR EXO- AND ENDO-IONOSPHERIC COMMUNICATIONS
M. D. Grossi, et al., Raytheon Co., Bedford, Mass., Interim rept. no. 1, 28 March-28 June 1962, 12 July 1962, 66 p., incl. illus., tables, 23 refs., (Rept. no. BR-1855), AD 278 296.

. . . searching for wave-guidance modes in the upper ionosphere, across the F2 layer, and below it. . .

H-F PROPAGATION SIMULATION
R. Mather, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., Nov. 1962, 21 p., incl. 6 refs., (Rept. no. RADC TDR 62-473), AD 288 924.

INFORMATION CAPACITY OF FADING CHANNELS UNDER CONDITIONS OF INTENSE INTERFERENCE
J. P. Costas, Proc. IEEE, vol. 51, no. 3, March 1963, p. 451/461.

ON THE THEORY OF RADIO COMMUNICATION CHANNELS WITH RANDOMLY VARYING PARAMETERS
V. I. Siforov, IN: RADIO WAVES AND CIRCUITS; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 164/194., 11 refs., A64-10832.

. . . classified into type I and type II with respect to their capacity at a low additive noise level. The concepts of self capacity and conditional capacity for a channel are introduced. It is proved that the capacity drops by not more than 17% for slow random variations in the parameters of a multi-path channel for any signal-to-noise ratio. . . .

TRANSEQUATORIAL F-LAYER PROPAGATION STUDY
C. L. Washburn, et al., ITT Federal Labs., Nutley, N. J., Final rept., July - Oct. 1962, 14 June 1963, 1v., RADC TDR63 178, AD 411 242.

. . . transequatorial F-layer propagation (TEF) in the 30 Mc to 100 Mc frequency range. . . characteristics of one-way transmission in the Western Hemisphere during July to October 1962. . . .

1.664: Tropospheric Scatter Channels

Included: UHF scatter systems; Digital transmission over troposcatter circuits.

Not Included: Equipment descriptions; Multiplex systems (2).

Cross References: Mathematical models of scatter channels (1.612); Knife edge communications links (1.635); Tropospheric propagation characteristics (1.634); UHF propagation characteristics (1.645).

Principal Publications:

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J. B. Atwood, et al., RCA Rev., vol. 19, no. 3, Sept. 1958, p. 321/333.

Daytime field-strength recordings . . . path from Covey Hill, P. Q., Canada to Riverhead, New York during the period September 1955 to December 1956. . . . to determine the path loss and its seasonal variations. . . . The typical fast fading rate over this scatter path was on the order of 30 fades per minute

and the slow fading rate was on the order of 5 fades per minute. . . .

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T. R. Carr, et al., Naval Air Missile Test Center, California, 1958, 54 p., Tech. Memo. no. 112, AD 200 406.

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J. H. Chisholm, et al., IRE Trans. Antennas Propagation, vol. AP-6, Oct. 1958, p. 377/378.

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M. W. Gough, Marconi Review, vol. 21, 1958, p. 198/212.

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C. R. Graf, Proc. IRE, vol. 46, May 1958, p. 915.

TROPOSPHERIC SCATTER COMMUNICATION
G. L. Grisdale, Electronic Engr., vol. 30, May 1958, p. 272/275.

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A. H. Hausman, IRE Trans. Commun. Syst., vol. CS-6, Dec. 1958, p. 35/38.

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B. Josephson, et al., IRE Trans. Antennas Propagation, vol AP-6, April 1958, p. 176/178.

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B. Josephson, et al., IRE Trans. Antennas Propagation, vol. AP-6, April 1958, p. 173/175.

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C. N. Lawrence, IRE Nat. Conv. Rec., vol. 3, March 1958, p. 292/297.

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G. L. Mellen, et al., MIT, Lincoln Lab., July 1958, AD 133 863.

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B. Peroni, et al., Note Recensioni Notiz, vol. 7, March - April 1958, p. 147/180.

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G. C. Rider, Marconi Review, vol. 21, 1958, p. 184/197.

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K. P. Stiles, Rec. Nat. Symp. Ext. Range and Space Commun. Washington, D. C., Oct. 1958, p. 75/78.

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M. Telford, J. Brit. Instn. Radio Engrs., vol. 18, Sept. 1958, p. 511/523.

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A. T. Waterman, IRE Trans. Antennas Propagation, vol. AP-6, Oct. 1958, p. 338/340.

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L. G. Abraham, Jr., et al., General Electric Co., Syracuse, N. Y., Oct. 1959, 129 p., Final Rept., (AFCRC TR-59-353), AD 232 924.
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Long-term signal magnitude observations and basic instrumentation
Time lapsed picture and midpoint observation
Correlation of meteorological parameters with hourly median values of the received signal
Fading spectra
The distribution of signal amplitude over short records
Airplane doppler patterns
Effective bandwidth experiments

THE USE OF MEASUREMENTS IN PREDICTING THE PERFORMANCE OF TROPOSPHERIC COMMUNICATION CIRCUITS
A. P. Barsis, et al., National Bureau of Standards, Boulder, Colo., Feb. 1959, (NBS rept. no. 6043), AD 217 791.

The uncertainty in predicting the performance of tropospheric communication circuits may be expressed by a variance. A log-normal distribution of the differences between calculated and measure values of field strength or basic transmission loss must be assumed if a number of paths with identical geometrical and other prediction parameters are considered. (See also AD 210 359).

WAVELENGTH DEPENDENCE IN TRANS-HORIZON PROPAGATION
R. Bolgiano, Jr., Proc. IRE, vol. 47, Feb. 1959, p. 331/332.

ON THE QUESTION OF MULTIPLE SCATTERING IN THE TROPOSPHERE
D. S. Bugnolo, Columbia U. School of Engineering, New York, Nov. 1959, 16 p., Technical report no. T-4/D, AD 203 877.

. . . the question to be answered is: What is the probability that any ray of the incident field will be scattered at least twice in a distance R?

SUCCESSFUL VHF COMMUNICATIONS FOR 2540 MILES AT 144 MC AND 222 MC
J. T. Chambers, Paper form IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

ANGULAR DIVERSITY RECEPTION AT 2290 MC OVER A 188-MILE PATH
J. H. Chisholm, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 195/201.

. . . over the 188-mile Round Hill - Crawfords Hill path . . . to determine the feasibility of using angular diversity reception in a tropospheric scatter system. Using a 28-foot reflector, two beams were produced with two separate feed systems. The correlation of the signals received on one of the two beams with that received or the other was determined for various spacing of the beams, as well as for the azimuthal position of the antenna. . . .

STUDIES IN TROPOSPHERIC PROPAGATION BEYOND THE HORIZON
A. B. Crawford, et al., Bell Syst. Tech. J., vol. 38, no. 5, Sept. 1959, p. 1067/1178.

. . . extended series of experiments in beyond-the-horizon propagation on a 171-mile overland path using 460 and 4110 mc. . . . effect of antenna size on signal level and fading characteristics, wavelength dependence, seasonal and diurnal effects, a new form of diversity reception, the bandwidth capability of the medium.

A 215-MILE 2720-MC RADIO LINK
L. H. Doherty, et al., IRE Trans. Antennas Propagation, vol. AP-7, April 1959, p. 117/126.

The link was operated for a period of twenty months. The yearly median signal level was 79 db below free space with a seasonal variation between 12 and 14 db in the hourly medians. The purpose of the link was to determine some of the paramenters involved in the transmission of radio waves at a microwave frequency to distances far beyond the horizon. No attempt was made to transmit information over the link.

SHORT-TIME STATISTICS OF TROPOSPHERIC RADIO WAVE PROPAGATION
R. G. Finney, Proc. IRE, vol. 47, Jan. 1959, p. 84/85.

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S. J. Goodman, et al., Paper from IRE-URSI Joint, Meeting - Oct. 19-21, 1959, San Diego, Calif.

REFRACTIVE INDEX OF THE ATMOSPHERE AS A FACTOR IN TROPOSPHERIC PROPAGATION FAR BEYOND THE HORIZON
R. E. Gray, Elect. Commun. vol. 36, no. 1, 1959, p. 60/69.

APPARENT CORRELATION BETWEEN TROPOPAUSE HEIGHT AND LONG-DISTANCE TRANSMISSION LOSS AT 490 MC

D. R. Hay, Proc. IRE, vol. 47, June 1959, p. 1144/1145.

. . . over a 640 mile path, UHF transmissions.

A STUDY OF SIGNAL FADING-RATE IN 500 MC/S SCATTER TRANSMISSIONS
D. R. Hay, et al., Defence Research Telecommun. Establishment, Canada, June 1959, 15 p., DRTE Rept. no. 1013, Encl. no. 6 to Air Attache, Otawa Rept. No. TL97-59, AD 219 530.

The signal fading-rate in 500 Mc/s transmissions over an 85 mile path near Ottawa has been studied for two years.

FACTORS AFFECTING MODULATION TECHNIQUES FOR VHF SCATTER SYSTEMS
J. W. Koch, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 77/91.

SYSTEM LOSS IN RADIO WAVE PROPAGATION
K. A. Norton, J. Res. Nat. Bur. Stands., vol. 63D, July, Aug. 1959, p. 53/73.

. . . Examples are given which include calculations of losses for tropospheric forward scatter and ground-wave propagation, together with an analysis of the variation of path antenna gain with time in ionospheric scatter propagation. For a note on a C.C.I.R. recommendation relating to transmission loss, see Proc IRE, vol. 47, p. 1661/1662, Sept. 1959.

A FORMALIZED PROCEDURE FOR THE PREDICTION AND ANALYSIS OF MULTI-CHANNEL TROPOSPHERIC SCATTER CIRCUITS
C. A Parry, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 211/221.

In order to evaluate the potentialities of the scatter link and to minimize the financial risk involved in its implemantation, examination of many combinations of path, sites, and system configurations is desirable. . . . A step-by-step process . . . site evaluation. . . . median path loss . . . traffic loading, instantaneous fading, SNR, error rates, bandwidth and power. A performance index for path evaluation is used so that an optimum path-site combination may be selected. . . .

THE ULTIMATE LONG HAUL CAPABILITY OF THE TROPOSPHERIC SCATTER MECHANISM
C. A. Parry, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 121/127.

Prodecures for the prediction of tropospheric scatter circuits are now sufficiently accurate for an estimation of the message circuit capability of long spans, in excess of about 500 miles. 'Capability' is established by an equation of 2 terms. One of these is determined by the state of the art, and the other - refered to as an Index of Capability, - by the medium. . . .

EXPERIMENTAL INVESTIGATION OF THE LONG RANGE TROPOSPHERIC PROPAGATION OF ULTRA-SHORT WAVES IN DOUBLE RECEPTION CONDITIONS
A. V. Prosin, et al., Radio Engrg., vol. 14, no. 10, 1959, p. 1/18.

An account is given of the results of an experiment conducted at a frequency of 3000 Mc/s and over a route 275 km in extent. The signals were received simultaneously by two antennas located in a direction normal to the route.

INVESTIGATION OF THE CHARACTER OF RAPIDLY FADING RADIO SIGNALS ALONG A TRANSMISSION PATH OF MEDIUM LENGTH ABOVE THE EARTH'S SURFACE (In Russian)
A. A. Semenov, et al., Radiotekhnika i Elektronika, vol. 4, Feb. 1959, p. 187/194.

THE FILLING IN OF AN ANTENNA NULL BY OFF-PATH SCATTERING ON A TROPOSPHERIC SCATTER CIRCUIT
H. Staras, IRE Trans. Antennas Propagation, vol. AP-7, no. 3, July 1959, p. 277/279.

. . . Antenna-to-Medium Coupling loss . . . is not significant unless the beamwidth of the antenna becomes equal to or less than the angular width of the scatter volume as seen from the antenna. An inverse phenomenon occurs if one tries to design an antenna null to protect a given location beyond the horizon . . . This paper outlines the analysis used in evaluating the "filling in" of the antenna null by off-path scattering and presents curves which should prove useful in obtaining quantitative estimates.

TROPOSPHERIC SCATTER PATH LOSS TESTS—FLORIDA BAHAMAS
K. P. Stiles, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 205/208.

Telephone service between the United States and the Bahama Islands is now provided by measn of high-frequency radio systems working in the 2-7 mc range. . . . The fact that the present Miami-Havana tropospheric scatter system is performing so well . . . made this type of system very attractive. . . . tubes capable of high output levels at frequencies above 2000 mc have been developed . . . Path loss tests were made over a nine-week period on the Florida-Nassau path using a frequency of 1970 mc. . . . The Nassau tests indicated that a satisfactory 60-channel radio system could be provided through use of 10-kw transmitters and 30-foot parabolic antennas. . . .

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TROPOSPHERIC PATH LOSS IN THE ARCTIC OVER HIGH-ALTITUDE PATHS
A. E. Teachman, Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

TROPOSPHERIC SCATTER SYSTEM USING ANGLE DIVERSITY
J. H. Vogelman, et al., Proc. IRE, vol. 47, May 1959, p. 688/696.

SELECTIVE FADING EFFECTS ON UHF TROPOSPHERIC SCATTER PATHS (Correspondence)
H. J. von Baeyer, Proc. IRE, vol. 47, Nov. 1959, p. 2021/2022.

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Angular diversity measurements at 7630 Mcps over a 247 effective-mile tropospheric path show that diversity improvements comparable to theoretical ones are available; that elevation squint is superior to azimuth squint for the system tested; and that essentially uncorrelated signals are received by a paraboloidal antenna with twin feedhorns whose beam separation is one beamwidth. . . .

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J. M. Dixon, Proc. Instn. Radio Engrs., Australia, vol. 21, June 1960, p. 398/406.

MEASURED STATISTICAL CHARACTERISTICS AND NARROW-BAND TELETYPE MESSAGE ERRORS ON A SINGLE-SIDEBAND 600-MILE LONG ULTRAHIGH-FREQUENCY TROPOSPHERIC RADIO LINK
E. F. Florman, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 2, March, April 1960, p. 125/133.

PROPAGATION MEASUREMENTS AT 3480 AND 9640 MC/S BEYOND THE RADIO HORIZON
G. V. Geiger, et al., Proc. Instn. Elect. Engrs. Part B (London), vol. 107, no. 36, Nov. 1960, p. 531/546.

. . . account of scatter-propagation measurements made at S- and X-band during the period May, 1957 to May, 1959. . . . The S-band transmitter, using a 3.480 Gc/s c. w. magnetron with a power output of 500 watts, was established at Start Point in Devon. Receiving terminals were set up at Wembley, Middlesex, and Witnesham, Suffolk, at distances of 173 and 247 statute miles, respectively . . . The transmission path for the X-band system, which used a pulsed magnetron at a frequency of 9.640 Gc/s, also lies between Start Point and Wembley; the pulse length was 2 microsec and the pulse-repetition frequency 500 c/s, the peak power in the pulses being 180 kW. . . .

AN ANALYSIS OF PROPAGATION MEASUREMENTS MADE AT 418 MEGACYCLES PER SECOND WELL BEYOND THE RADIO HORIZON (a Digest)
H. B. Janes, et al., J. Res. Nat. Bur. Stands., vol. 64D, no. 3, May, June 1960, p. 255/257.

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RESULTS FROM A THREE-HOP TROPOSPHERIC SCATTER LINK IN NORWAY WITH PARALLEL OPERATIONS ON 900 MC AND 2200 MC
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CARRIER-FREQUENCY DEPENDENCE OF THE BASIC TRANSMISSION LOSS IN TROPOSPHERIC FORWARD SCATTER PROPAGATION
K. A. Norton, J. of Geophys. Res., vol. 65, no. 7, July 1960, p. 2029/2045.

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C. A. Parry, Commun. and Electronics, no. 47, March 1960, p. 71/80.

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C. A. Parry, IRE Conv. Rec. pt., vol. 8, March 1960, p. 169/178.

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A. V. Prosin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 1/17.

. . . intermodulation distortions . . . owing to multi-path scatter propagation . . . Formulae are produced for determining the power of transient noise. The author establishes the dependence of intermodulation distortions on the length of the path, the beam-width of the aerial, and a number of other factors. . . .

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P. L. Rice, Proc. IRE, vol. 48, June 1960, p. 1021/1029.

AN ANALYSIS OF TIME VARIATIONS IN TROPOSPHERIC REFRACTIVE INDEX AND APPARENT RADIO PATH LENGTH
M. C. Thompson, Jr., et al., J. Geophys. Res., vol. 65, no. 1, Jan. 1960, p. 193/201.

A NOTE REGARDING THE MECHANISM OF UHF PROPAGATION BEYOND THE HORIZON (Correspondence)
A. D. Watt, et al., Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 252.

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F. E. Wilson, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 40/43.

SIMPLE METHODS FOR DESIGNING TROPOSCATTER CIRCUITS
L. P. Yeh, IRE Conv. Rec. Pt. 5, vol. 8, March 1960, p. 180/187.

LONG-RANGE TROPOSPHERIC TRANSMISSION
Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 30/44.

. . . General "State-of-the Art" report.

PACIFIC SCATTER SYSTEM COMPLETED
Electronics, vol. 33, July 1960, p. 39.

GROUND TELECOMMUNICATION PERFORMANCE STANDARDS Part 5 on Tropospheric Systems.
A. F. Barghausen, et al., National Bureau of Standards, Boulder, Colo., 15 June 1961, 377 p., (NBS rept. 6767), AD 266 838.

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PERFORMANCE PREDICTIONS FOR SINGLE TROPOSPHERIC COMMUNICATION LINKS AND FOR SEVERAL LINKS ON TANDEM
A. P. Barsis, et al., National Bureau of Standards, Boulder, Colo., Aug. 1961, 161 p., refs, (NBS-TN-102; PB-161603), N64-17996, AD 288 532.

. . . probability of obtaining a specified grade of service or better for various percentages of time . . . acceptable ratio of hourly median predetection-RMS-signal-to RMS-noise for the type of intelligence to be transmitted. The standard deviation of prediction errors depends upon the percentage of hours the specified grade of service is required . . . The possibility of reducing this standard deviation by making path-loss measurements is discussed . . .

SCADAR
R. G. Beltzer, Bendix Systems Div., Bendix Corp., Ann Arbor, Final rept. Dec. 1961, lv., incl. illus., (Rept. no. BSC-30697; BSR-628), (RADC TDR 62-45), AD 274 282.

. . . new technique of data processing . . . implemented by simulation in the laboratory. . . . A working system was installed on the troposcatter DEW line training link in Illinois. . . .

PROPAGATION CHARACTERISTICS OVER FAR-BEYOND-THE-HORIZON PATHS AT U. H. F. (In Japanese)
K. Kobayashi, et al., J. Inst. Elect. Commun. Engrs. Japan, vol. 44, no. 3, March 1961, p. 317/323.

Measurements of path loss were made at 1300 Mc/s on transhorizon links of length 373 km and 824 km along the southern coast of Japan. Up to 500 km, path loss in terms of distance showed little difference from the values given by Norton's empirical formula, but beyond this distance the loss increased at about 0.18 dB/km, which is greater than has been reported hitherto. The monthly median loss on a 438 km link had a minimum value in July and a maximum in February or March, with a difference of 17 dB. . . .

TROPOSPHERIC SCATTER AS AN ALTERNATIVE TO CERTAIN HF RADIO SYSTEMS
T. H. Moriarity, Page Communications Engineers, Inc., Washington, D. C., 1961, 16 p., AD 419 282.

The present report is a part of the background material being prepared by PEAC (Panel of Experts Advisory Committee) for the United States member of the International Panel of Experts which will meet in Geneva during September of 1961. . . . to prepare recommendations to the International Telecommunications Union on means of reducing congestion in the hf radio band. . . . relates to the use of tropospheric scatter in place of certain hf radio systems. . . . which have a path length of 500 miles or less.

TRANSMISSION BANDWIDTH FOR RECEPTION OF SINGLE AND SCATTERED SIGNALS IN ULTRASHORT-WAVE TROPOSPHERIC PROPAGATION (Translation)
A. S. Nemirovskiy, Telecommunications no. 5, May 1961, p. 17/26.

It is shown that the transmission bandwidth of a tropospheric radio relay link becomes sharply widened when even a small amount of the regular diffracted signal is incident at the receiver in addition to the scattered component. It is also shown that the technique of distributed reception in which the scattered signals are combined linearly before detection permits transmission over a much wider bandwidth, and increases the stability of operation.

WIDTH OF THE PASSBAND IN SINGLE AND SPACED RECEPTION OF THE SIGNALS IN LONG DISTANCE TROPOSPHERIC PROPAGATION OF ULTRA SHORT WAVES
A. S. Nemirovskii, Telecommunications, no. 5, Oct. 1961, p. 501/512.

It is shown that the passband of a tropospheric radio relay line sharply increases in cases

where at the point of reception, in addition to the scattered component, there arrives a regular or a diffraction component, or if the reception of the spaced signals is carried out by the method of linear composition befor the FM detector. . . .

BANDWIDTH LIMITING EFFECTS OF FREQUENCY SELECTIVE FADING OVER TROPOSPHERIC SCATTER PATHS
P. D. Shaft, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Master's thesis, 12 Dec. 1961, 105 p., incl. illus., tables, 28 refs., (Research rept. no. PIBMRI-976-61), AD 281 967.

A set of design curves of intermodulation distortion due to frequency selective fading was derived for tropospheric scatter systems. . . . applicable to systems frequency modulated with frequency division multiplexed telephone and telegraph channels. . . . A two-ray model was selected to derive general results. . . . Equations for intermodulation distortion are evaluated using the parameter normally encountered in tropospheric scatter systems. . . .

INFORMATION BANDWIDTH OF TROPOSPHERIC SCATTER SYSTEMS
P. D. Shaft, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 280/287.

EUR-MED TROPO SYSTEM PATH LOSS TESTS
ITT Communication Systems, Inc., Paramus, N. J., 30 Nov. 1961, 114 p., AD 430 119.

The results are documented of path loss tests conducted in the European-Mediterranean area between the months of February and September 1961. . . . on a frequency of 1965 mc . . . on one path, Reggio-Wheelus, a comparison was also made on a frequency of 872 mc . . . The path loss testing equipment consisted of crystal controlled transmitters, crystal controlled narrow band receivers with recorders, paraboloid antennas, transmission lines and power units.

PERFORMANCE PREDICTIONS FOR SINGLE TROPOSPHERIC COMMUNICATION LINKS AND FOR SEVERAL LINKS IN TANDEM
A. P. Barsis, et al., National Bureau of Standards, Washington, D. C., Oct. 1962, 154 p., incl. illus., refs., (ESD TDR 62-292), AD 291 588.

PROPERTIES OF 400 MCPS LONG-DISTANCE TROPOSPHERIC CIRCUITS
J. H. Chisholm, et al., Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2464/2482.

Measurements are reported on beyond-the-horizon propagation losses at 400 Mcps. Data are from 98 to 830 mi. beyond the horizon. The transmission loss between isotropic antennas varies from about 190 db at 100 mi. to about 300 db at 800 mi. distance. Also described are measurements of frequency-selective fading, space diversity, and variations in the angle of arrival of the signals.

DEWDROP COMMUNICATION SYSTEM PERFORMANCE
W. G. Donaldson, et al., Elect. Commun., vol. 37, no. 3, 1962, p. 222/229.

Dewdrop is a single-sideband suppressed-carrier quadruple-diversity communication system operating between 350 and 450 megacycles per second and employing tropospheric scatter propagation. This 691-mile . . . link, the longest operational single-hop tropospheric scatter system in existence, connects Thule, Greenland, and Cape Dyer, Canada. Many problems and anomalies have been encountered. Some of these were expected but most were not. . . .

AN/FRC-68 ANGLE DIVERSITY COMMUNICATION SYSTEM
I. A. Fantera, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 61/75.

An experimental system for studying tropospheric scatter communications employing multiple angle diversity is described. . . . in the 7125 to 8500 mc range over a 185 mile path . . . facilities for performing simultaneous comparisons of angle diversity combinations with space or frequency diversity . . . instrumentation for automatically computing and recording various signal statistics . . . Data collected to date . . .

DETERMINATION OF PERMITTIVITY VARIATIONS IN THE TROPOSPHERE BY SCATTER-PROPAGATION METHODS
D. T. Gjessing, Proc. Instn. Elect. Engrs., London (Pt. C), vol. 109, no. 16, Sept. 1962, p. 447/455.

An account of an experimental tropospheric scatter-propagation investigation is given. . . . the atmospheric permittivity distribution in a general form is discussed in some detail. . . . experiments . . . to contribute to the general understanding of the conditions in the troposphere which are of importance to long-distance communication. . . .

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF CROSSTALK POWER IN MULTIPATH RECEPTION (Translation)
I. A. Gusiatnskii, et al., Telecommun. Radio Engineering, Part I - Telecommunications, Dec. 1962, p. 1/12, 16 refs., A63-19198.

. . . formulas . . . multipath reception of beyond-horizon UHF communications. The mean value of crosstalk is obtained, as is the probability distribution for the various stages of the propagation medium. . . . experimental measurements . . . in good agreement with theoretical conclusions.

SHAPE'S TROPOSCATTER SYSTEM IN NORWAY (In Norwegian)
N. Knudtzon, Tekn. Ukeblad, vol. 109, no. 48, Dec. 1962, p. 1241/1254.

This is a survey of the telecommunications system of Allied Command Europe, which includes the ACE High troposcatter system extending from Northern Norway to Eastern Turkey. A review of troposcatter theories and characteristics is given. The three-leg "Hot-Line" system between Oslo and Bordø, built in 1956/1958 to obtain experience for the planning of the ACE High system is described . . .

DISCUSSION ON "INFORMATION BANDWIDTH OF TROPOSPHERIC SCATTER SYSTEMS" (Correspondence)

R. G. Medhurst, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 317.

As a footnote to Mr. Shaft's interesting paper, it seems worth recalling an attack on the same problem by this writer a few years ago. . . .

DIGITAL TROPOSPHERIC SCATTER

J. R. Poppe, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 669/674.

. . . Using simple, proven binary detection methods—such as frequency shift keying—substantial range improvement is shown over multichannel FM (frequency-modulated) or SSB (single-side-band) tropospheric scatter schemes, at the sacrifice of analog capability. . . .

MEDIAN SIGNAL LEVEL PREDICTION FOR TROPOSPHERIC SCATTER

G. C. Rider, Marconi Rev., vol. 25, 3rd Qtr., 1962, p. 203/210.

The data from the Bromley-Catterick experimental scatter link have been further analysed to give a regression line of refractive index upon path attenuation. A slope of 0.43 dB per N unit is found, and this is shown to be in agreement with Gray's results for some Caribbean paths. Gray's propagation curves for 900 Mc/s are shown to give good predictions, very simply, for seven paths in widely differing climatic regions. For other frequencies, and for difficult paths, it is suggested that the new regression coefficient be used in Norton's classical prediction formula.

COMPARISON OF CALCULATED AND MEASURED BANDWIDTH OF THE FLORIDA-CUBA TROPOSPHERIC SCATTER SYSTEM (Correspondence)

P. D. Shaft, IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 457.

ETUDE THEORIQUE ET EXPERIMENTALE DES PROBLEMES DE FLUCTUATIONS RAPIDES EN PROPAGATION TROPOSPHERIQUE (Theoretical and Experimental Investigation of Rapid Fluctuations in Tropospheric Propagation) (In French)

R. Tremblay, Ann. Radioelect., vol. 17, no. 70, Oct. 1962, p. 280/296.

TROPOSPHERIC SCATTER AJ EVALUATION. VOLUME II. UNCLASSIFIED APPENDICES

Westinghouse Electric Corp., Baltimore, Md., Technical note no. 1, April-Nov. 1961, 28 May 1962, 1 v. incl. illus., refs., RADC TDR 62-135, vol. 2, AD 276 695.

. . . Tropospheric propagation . . . Duration and rate of fast fades in troposcatter communications . . . Modulation techniques for a tropospheric scatter communications system . . . Diversity reception . . . troposcatter antenna characteristics and receiver techniques . . .

A METHOD FOR PREDICTING INTERCHANNEL MODULATION DUE TO MULTIPATH PROPOGATION IN FM AND PM TROPOSPHERIC RADIO SYSTEMS

C. D. Beach, et al., Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 1/36.

. . . interchannel modulation due to multipath propagation on angle-modulated tropospheric scatter radio systems. Values of signal-to-intermodulation ratio, S/I, are calculated for various pairs of signal reflections in the troposphere, taking into account the base bandwidth and frequency deviation of the system, the antenna patterns, the path geometry, and climatic conditions during the "worst month" of propagation. The lowest value of S/I (worst intermodulation) computed for such pairs of signal reflections is then corrected empirically to account for multiple reflections. The result represents the median value of S/I expected during the worst month of transmission on a specified path.

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING. VOLUME II: POLARIZATION SYSTEMS ANALYSIS

R. S. Berkowitz, et al., Pennsylvania U., Philadelphia Moore School of Electrical Engineering, Moore School Rept. 64-02; RADC-TDR-63-396, vol. 2, AD 430 249, N64-15818.

. . . The troposcatter propagation factors affecting a polarization programming system are presented. . . . polarization programming to an over-the-horizon troposcatter link seems to be feasible . . .

PARAMETERS OF A LONG-RANGE TROPOSPHERIC FORWARD SCATTER LINK

R. R. Burrows, Army Missile Command, Redstone Arsenal, Huntsville, Ala., 5 March 1963, 39 p., Rept. no. RE-TR-63-2, AD 298 939.

A NOMOGRAPH FOR PREDICTING THE PERFORMANCE OF TROPOSPHERIC SCATTER COMMUNICATION CIRCUITS (Correspondence)

H. T. Dougherty, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 138/142.

INFLUENCES CLIMATIQUES EN PROPAGATION TROPOSPHERIQUE (Climatical Influences on Tropospheric Propagation) (In French)

F. Du Castel, Ann. Telecomm., vol. 18, no. 11-12, Nov./Dec. 1963, p. 286/293.

HAUFIGKEIT UND DAUER EINZELNER SCHWUNDEINBRUCHE BEI TROPOSPHARISCHEN SCATTERSTRECKEN
(Frequency and Duration of Individual Fadings at Tropospheric Scatter Intervals)
J. Grosskopf, et al., Emmanuel Coll., Boston, Mass. Research Language Center, Jan. 1963, 34 p., refs., Transl. into English from German an Article from Nachrichtentech Z. (NTZ), no. 2, 1962, p. 71/78, AD 410 793, N64-12278.

. . . to determine the interference fading frequency and the fading duration distribution both for short-term intervals . . . to one hour . . . for long periods of time. The results of the investigations permit the complete calculation of short-term interval statistics when the position of the measuring level relative to the field strength median value and the mean fading frequency of the interval are known . . .

PATH ANTENNA GAIN AND COMMENTS ON "PROPERTIES OF 400 Mcps LONG-DISTANCE TROPOSPHERIC CIRCUITS" (Correspondence)
W. J. Hartman, Proc. IEEE, vol. 51, no. 5, May 1963, p. 847/848.

Although the concept of "path antenna gain" (or the closely related concept "loss in path antenna gain ") . . . for tropospheric scatter paths was introduced some time ago, it is still quite widely misunderstood and misapplied. . . . one specific error . . . the . . . assumption that the loss in path antenna gain may be determined separately for the antennas at each end of the path. . . .

A METHOD OF OBTAINING AND ANALYZING DIGITAL ERROR PATTERNS
D. G. Iram, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., July 1963, 13 p., RADC TDR 63 255, AD 413 474.

. . . experiments were made on a tropospheric scatter channel. . . . indicate the improvement possible on this channel by using a burst-error correction code. . . .

AN INVESTIGATION OF THE TROPOSPHERIC PROPAGATION ON DECIMETRIC WAVES ON A 146-KM LONG MOUNTAIN LINE
N. Kombakov, et al., Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, AD 412 249.

SIMULATION EXPERIMENTS IN TWO-WAY CONTROLLED CARRIER TRANSMISSION
R. J. Massa, Air Force Cambridge Research Labs., Bedford, Mass., May 1963, 45 p., AFCRL 63 159, AD 412 459.

. . . communication performance improvements in tropospheric scatter system . . .

ON THE PREDICTION OF THE INHERENT BANDWIDTH CAPABILITY OF THE TROPOSPHERIC SCATTER LINK
C. A. Parry, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 215/232, 27 refs.

. . . The tropospheric scatter mode . . . exhibits a multipath characteristic that limits the usable bandwidth. . . . bandwidth definitions have little meaning when applied to FM type transmissions since they do not indicate the level of the intermodulation noise introduced into the system by the multipath behaviour, and this may be a significant factor in system performance. . . .

THE STATISTICAL DISTRIBUTION OF INTERMODULATION DISTORTION DUE TO THE PROPAGATION MEDIUM IN THE FM TROPOSPHERIC SCATTER SYSTEM
H. Prescott, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 248/267.

INTERMODULATION DISTORTION ON TROPOSPHERIC SCATTER SYSTEMS (Correspondence)
H. Prescott, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1244.

A METHOD FOR PREDICTING THE STATISTICAL DISTRIBUTION OF BANDWIDTH IN TROPOSPHERIC SCATTER LINKS
H. Prescott, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 281/285.

STUDIES IN DIGITAL COMMUNICATIONS. PART I. FEASIBILITY OF ASYNCHRONOUS MULTIPLEXING. PART II. PERFORMANCE OF HIGH-SPEED DIGITAL COMMUNICATIONS OVER TROPOSCATTER LINKS
M. P. Ristenbatt, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Aug. 1963, 101 p., AD 416 647.

PRODIFFUSION TROPOSPHERIQUE A FREQUENCE OPTIMALE (Tropospheric Transmission at an Optimal Frequency, Using Adaptive Techniques) (In French)
J. Simon, Ann. Telecomm., vol. 18, no. 11-12, Nov./Dec. 1963, p. 301/311, 22 refs.

OSOBENNOSTI OPTIMAL'NOGO PRIEMA IMPUL'SNOGO SIGNALA PRI DAL'NEM TROPOSFERNOM RASPROSTRANENII RADIOVOLN (Peculiarities in the Optimum Reception of a Pulsed Signal During the Distant Tropospheric Propagation of Radio Waves) (In Russian)
I. G. Tratas, Radiotekhnika i Elektronika, vol. 8, April 1963, p. 546/551, A63-19874.

. . . detection of a signal in the case where the transmitter and the receiver are located beyond the direct line of sight. Determined is the receiver structural design that is optimum for the detection of the pulsed signal beyond the horizon. Noted is the increased duration of the signal as compared to a signal that is transmitted within the line of sight.

Related Publications:

PROLONGED SPACE-WAVE FADEOUTS IN TROPOSPHERIC PROPAGATION
A. P. Barsis, et al., J. Res. Nat. Bur. Stand., vol. 66D, no. 6, Nov.-Dec. 1962, p. 681/694.

ON THE STABILITY ANALYSIS OF A TWO-WAY CONTROLLED CARRIER TRANSMISSION SYSTEM
N. J. Bershad, Air Force Cambridge Research Labs., Bedford, Mass., Dec. 1963, 9 p., AFCRL 63 586, AD 428 435.

A mathematical model of a linear controlled-carrier tropospheric communication system is analyzed for tropospheric gain variations with a white-noise power spectral density. The stability of the first moment of the impulse response of the closed loop control system is determined as a function of the linear controllers and the statistical characteristics of the troposphere.

EXPERIMENTS IN FREQUENCY DIVERSITY FOR TROPOSCATTER SYSTEMS
W. S. Patrick, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 217/232.

1.665: Meteoric Scatter Channels

Included: Scattering by meteor trails; Intermittent meteoric communications links; Meteor ionization effects.

Not Included: Adaptive communications techniques (2); Signal processing techniques (3A).

Cross References: Regular ionospheric characteristics (1.632); Irregular ionospheric characteristics (1.633); VHF-UHF propagation characteristics (1.645).

Principal Publications:

WIDE-BAND FACSIMILE TRANSMISSION OVER A 900-MILE PATH UTILIZING METEOR IONIZATION
W. H. Bliss, et al., Rec. Nat. Symp. Ext. Range Space Commun., Washington, D.C., Oct. 1958, p. 42/48.

. . . operating at 40 mc by means of intermittent meteor ionization. Printed matter was scanned at a rate of 2 frames per second, with a resolution of 67 elements per inch. An all-electronic facsimile system recorded a picture when the received signal rose above a preset threshold.

ELECTROMAGNETIC SCATTERING BY LOW-DENSITY METEOR TRAILS
H. Brysk, J. Geophys. Res., vol. 63, Dec. 1958, p. 693/716.

METEOR BURST PROPAGATION
J. T. DeBettencourt, et al., IRE Nat. Conv. Rec., March 1958, p. 121/126.

THE FORWARD-SCATTERED RADIO SIGNAL FROM AN OVERDENSE METEOR TRAIL
P. A. Forsyth, Canad. J. Phys., vol. 36, Aug. 1958, p. 1112/1124.

METRE-WAVE PROPAGATION BY METEORIC IONIZATION (In German)
J. Grosskopf, Nachrichtentech. Z., vol. 11, Sept. 1958, p. 455/460.

STORAGE CAPACITY IN METEOR-BURST COMMUNICATION SYSTEMS
W. S. Helbig, Proc. IRE, vol. 46, Sept. 1958, p. 1649.

A THEORETICAL RATE AMPLITUDE RELATION IN METEORIC FORWARD SCATTERING
C. O. Hines, Canad. J. Phys., vol. 36, May 1958, p. 539/554.

THE INFLUENCE OF METEOR RADIANT DISTRIBUTIONS ON RADIO-ECHO RATES
J. C. James, Georgia Inst. of Tech. Engineering, Experiment Station, Atlanta, May 1958, 105 p., Technical rept. no. 3, AD 162 524.

. . . study. . . to determine how the number of meteor signals received per unit of time varies with the time of day and the month of the year over an arbitrary meteor trail communication link.

. . . Three meteor-scatter links were used to obtain data for comparison with theory. They were the Atlanta-Knoxville, Atlanta-Boston, and Columbia-Boston paths. The link characteristics and the method of reducing the data are described.

A SUGGESTED IMPROVEMENT TO THE C. W. TECHNIQUE FOR MEASUREMENT OF METEOR VELOCITIES
J. S. Mainstone, et al., Austral. J. Phys., vol. 11, June 1958, p. 277/278.

CONCERNING BOOKER'S THEORY OF METEORIC REFLECTIONS
L. A. Manning, et al., J. Geophys. Res., vol. 63, Dec. 1958, p. 737/739.

THE INITIAL RADIUS OF METEORIC IONIZATION TRAILS
L. A. Manning, J. Geophys. Res., vol. 63, March 1958, p. 181/196.

THE DIRECTION AND AMPLITUDE OF REFLECTIONS FROM METEOR TRAILS AND SPORADIC-E IONIZATION ON A 1740 KM NORTH-SOUTH PATH AT VERY HIGH FREQUENCIES
R. W. Meadows, Symp. Long Dist. Prop. Above 30 Mc, Jan. 1958, p. 9.

ON THE CHOICE OF FREQUENCIES FOR METEOR-BURST COMMUNICATION
M. L. Meeks, et al., Proc. IRE, vol. 46, Nov. 1958, p. 1871.

STUDIES OF METEOR-BURST PROPAGATION AT 49 AND 74 MEGACYCLES
M. L. Meeks, Georgia Inst. of Tech., Engineering, Experiment Station, Atlanta, Final rept. 1 Jan. 1956/30 June 1958, 60 p., Rept. no. AFCRC TR-58-178, AD 160 821.

ON THE TRANSMISSION ERROR FUNCTION FOR METEOR-BURST COMMUNICATION
G. F. Montgomery, Proc. IRE, vol. 46, July 1958, p. 1423/1424.

INVESTIGATION OF THE DRIFTS OF THE EFFECTIVE POINT OF RADIO REFLECTION ALONG A METEOR TRAIN
M. S. Rao, et al., Canad. J. Phys., vol. 36, Dec. 1958, p. 1601/1623.

JANET, UBERTRAGUNG MIT METEORISCHER STREUUNG (Janet, a Meteoric Scatter System) (In German)
E. Roessler, Elektronische Rundschau, vol. 12, Dec. 1958, p. 426/432.

VERFAHREN UND ANLAGEN FUR METEORISCHE STREUUBERTRAGUNG (Methods and Equipment for Meteoric Scatter Transmissions) (In German)
E. Roessler, Nachrichtentech. Z. (NTZ), vol. 11, Oct. 1958, p. 497/503.

AIR-TO-GROUND METEOR-BURST COMMUNICATIONS
I. Roth, et al., Nat. Aerospace Navig. Electronics Conf., May 1958, p. 99/101.

MULTIPATH LIMITATIONS IN METEOR BURST COMMUNICATIONS
G. R. Sugar, Rec. Nat. Symp. Ext. Range & Space Commun., Washington, D.C., Oct. 1958, p. 42.

(No Title)
W. R. Vincent, et al., Stanford Res. Inst., Feb. 1958, 25 p., Scientific Rept. no. 6, AD 146 827.

A Meteor-Burst System for Extended Range VHF Communications

Analysis of Oblique Meteor-Propagation Data from the Communications Viewpoint

An Investigation of Storage Capacity Required for a Meteor-Burst Communications System

DISTRIBUTION OF DURATIONS AND DUTY CYCLE FOR METEORIC TRAIL SIGNALS (FOR SHORT PATHS) FOR JUNE 1958
A. E. Ward, Pickard and Burns, Inc., Needham, Mass., Aug. 1958, 22 p., AD 207 663.

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H. J. Wirth, et al., IRE Nat. Conv. Rec., March 1958, p. 127/132.

WIDE-BAND FACSIMILE TRANSMISSION OVER A 900-MILE PATH UTILIZING METEOR IONIZATION
W. H. Bliss, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 4, Dec. 1959, p. 252/256.

HIGH-RESOLUTION PULSE MEASUREMENTS OF OBLIQUE RADIO REFLECTIONS FROM METEOR TRAILS AT 41 MC
R. J. Carpenter, et al., Paper from IRE-URSI Joint Meeting, Oct. 19-21, 1959, San Diego, California.

OBSERVATIONS OF DIRECTION OF ARRIVAL OF LONG-DURATION METEOR ECHOES IN FORWARD SCATTER PROPAGATION
T. Hagfors, et al., J. Geophys. Res., vol. 64, Jan. 1959, p. 19/23.

APPLICABILITY OF MULTIPATH PROTECTION TO METEOR BURST COMMUNICATIONS
T. G. Knight, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 209/210.

This paper investigates past methods of improving the duty cycle of meteor scatter communications links in the presence of multipath distortion and suggests using a technique, for further improvement, which has proved useful at HF frequencies. . . .

THE EFFECT OF TRAIL IRREGULARITIES ON THE INTERPRETATION OF METEOR ECHOES
A. G. McNamara, et al., J. Atmos. Terrest. Phys., vol. 16, Oct. 1959, p. 156/159.

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L. A. Manning, et al., Proc. IRE, vol. 47, Feb. 1959, p. 186/199.

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L. A. Manning, J. Atmos. Terrest. Phys., vol. 14, April 1959, p. 82/93.

PRELIMINARY 106.1-MC METEORIC SCATTER EXPERIMENT: STANFORD, CALIFORNIA TO BOZEMEN, MONTANA
W. R. Vincent, et al., Stanford Research Inst., Menlo Park, Calif., Feb. 1959, Scientific rept. no. 12; AFCRC TN-59-159, AD 212 718.

THE LIMITATIONS OF NARROW-BEAM RADIO EQUIPMENTS IN THE DETECTION OF WEAK METEOR SHOWERS
A. A. Weiss, J. Atmos. Terrest. Phys., vol. 14, April 1959, p. 19/30.

GROUND ILLUMINATION PATTERN OF SIGNALS REFLECTED FROM A METEOR TRAIL
E. M. Young, et al., Stanford Research Inst., Menlo Park, Calif., Dec. 1959, 75 p., Scientific report no. 13, AFCRC TN-59-997, AD 231 122.

Given a transmitter location and arbitrarily oriented meteor trails, the ground-illumination pattern of the reflected signal is calculated. A physical model has been used, consisting of a trail of finite length and a radial distribution of electrons (forming a cylinder) according to Eshleman's theory.

TESTS MADE ON A METEOR-BURST VHF SYSTEM
Brit. Commun. Electronics, vol. 6, Nov. 1959, p. 781.

THE RELATIONSHIP BETWEEN THE NUMBER OF METEORS DETECTED PER HOUR AND THE WAVELENGTH OF THE RADAR
E. I. Fialko, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 11/15.

AIR-TO-GROUND METEORIC SCATTER COMMUNICATION SYSTEM
A. J. Hannum, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 113/133.

. . . designed specifically to operate at fixed frequency (50 mc) through rapidly changing propagation conditions by whatever path exists. Thus, Sporadic E, or other scatter modes, as well as meteoric scatter are effectively utilized to transmit high quantities of data.

EXPERIMENTAL STUDIES OF METEOR ECHOES AT 200 MC
J. L. Heritage, et al., IRE Trans. Antennas Propagation, vol. AP-8, no. 1, Jan. 1960, p. 57/61.

DETERMINATION OF THE OPTIMUM ANTENNA PATTERN FOR A SIGNAL BURST COMMUNICATION SYSTEM
P. A. Lux, et al., IRE WESCON Conv. Rec., vol. 7, Aug. 1960, p. 17/26.

Due to irregularities in the atmosphere, ionosphere, or meteor trails a signal does not arrive at the receiving antenna from one direction only. Therefore the highest possible gain antenna with its narrow beam width is not always optimum for point to point communications.

ELEMENTARY CONSIDERATIONS OF THE EFFECTS OF MULTIPATH PROPAGATION IN METEOR-BURST COMMUNICATION
G. R. Sugar, et al., J. Res. Nat . Bur. Stand., vol. 64D, no. 5, Sept./Oct. 1960, p. 495/500.

Three mechanisms likely to regularly produce multipath propagation are examined. These are: (1) The simultaneous existence of two meteor trails; (2) the existence of a Rayleigh-fading background continuum; and (3) the existence of two first-Fresnel zones along a single meteor trail. . . .

LOSS IN CHANNEL CAPACITY RESULTING FROM STARTING DELAY IN METEOR-BURST COMMUNICATION
G. R. Sugar, J. Res. Nat. Bur. Stand., vol. 64D, no. 5, Sept./Oct. 1960, p. 493/494.

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A. D. Wheelon, J. Res. Nat. Bur. Stand., vol. 64D, no. 5, Sept./Oct. 1960, p. 449/454.

THE RECEIVED-AMPLITUDE DISTRIBUTION PRODUCED BY RADIO SOURCES OF RANDOM OCCURRENCE AND PHASE
W. C. Bain, Proc. Instn. Elect. Engrs., Pt. C (London), vol. 108, no. 13, March 1961, p. 20/24.

A theoretical calculation. . . of the amplitude probability distribution to be expected on an ionospheric v. h. f. forward-scatter circuit due to reflections from meteor trails alone. . . .

RADAR METHODS OF OBSERVATION OF METEORITES (In Russian)
E. I. Fialko, Moscow, Sovetskoye Radio, 1961, 112 p.

. . . presents a systematized treatment of the basic concepts in the observation and investigation of meteorites with the help of radar. . . meteorite radio astronomy . . . communication problems connected with the radar observation of meteorites. Extensive bibliography. . .

POSITIVE AND RANDOM DETECTION OF UNSTABLE METEOR TRACKS
Y. I. Fialko, Radio Engng: Transl. of Radio-Tekhnika, vol. 16, no. 6, 1961, p. 22/32, 16 refs.

Positive and random detection of unstable meteor tracks are examined under the conditions of normal reflection of radio waves from the ionized trails. . . .

THE INITIAL DIAMETER OF METEOR TRAILS
G. S. Hawkins, In Smithsonian Astrophys. Obs. Proc. of the Symp. on the Astronomy and Phys. of Meteors, held at Smithsonian Astrophys. Obs., Cambridge, Mass., Aug. 28-Sept. 1, 1961, 1963, p. 23/26, 9 refs., N63-16630.

THE INITIAL RADIUS OF IONIZED METEOR TRAILS
B. L. Kashcheyev, et al., Obs. Proc. of the Symp. on the Astronomy and Phys. of Meteors, held at Smithsonian Astrophys. Obs., Cambridge, Mass., Aug. 28-Sept. 1, 1961 (See N63-16627) 1963, p. 19/23, 5 refs., N63-16629.

METEOR RADIO COMMUNICATION AT ULTRA-SHORTWAVES (In Russian)
A. N. Kazantsev (editor), Moscow, IL., 1961, 287 p.

Included in the collection are papers published in the foreign periodical press between 1954-1957 on questions of accomplishing a new kind of communication due to radio wave scattering by meteor tracks in the ionosphere. . . .

THE RELATION BETWEEN VISUAL MAGNITUDES OF METEORS AND THE DURATIONS OF RADAR ECHOES

B. A. Lindblad, In Smith Astrophys. Obs. Proc. of the Symp. on the Astronomy and Phys. of Meteors, held at Smithsonian Astrophys. Obs., Cambridge, Mass., Aug. 28-Sept. 1, 1961, 1963, p. 27/39, 15 refs., N63-16631.

RESEARCH ON ADVANCED DATA TRANSMISSION TECHNIQUES FOR AIRBORNE EARLY WARNING COMMUNICATIONS

Jansky and Bailey Div., Atlantic Research Corp., Washington, D.C., 27 April 1961, 19 p., AD 413 982.

Statistical data on certain performance characteristics are needed before design of practical meteor scatter data link systems can be accomplished. These data include the probability distributions for the time intervals between useful meteor bursts, data on meteor burst duration, seasonal and diurnal variations in average duty cycle, and the link. . . .

THE FINE STRUCTURE OF METEOR-BURST SIGNALS

P. J. Bartholome, SHAPE Air Defense Technical Center, The Hague (Netherlands), April 1962, 43 p., incl. illus., 8 refs., Technical memo. no. TM-36, AD 276 512.

. . . The principles of operation in communication systems of the Janet-B type, particularly the gating principle, are not well matched to the characteristics of the medium . . . a pronounced space-diversity effect is present on longer reflections when the signal received fluctuates as a result of trail deformation.

INVESTIGATION OF DIRECTIONAL PROPERTIES OF THE SCATTERING OF MICROWAVE RADIO SIGNALS BY METEOR TRAILS (Translation)

V. P. Chepura, et al., Telecommun. Radio Engineering, Part I - Telecommunications, Nov. 1962, p. 1/9.

THE PROBABILITY OF INTERCEPTING RADIO SIGNALS SCATTERED BY METEOR TRAILS

U. R. Embry, Stanford Electronics Labs., Stanford U., Calif., March 1962, 50 p., incl. illus., table, 17 refs., Technical rept. no. 773-1; SEL-62-012, RADC TDR 62-249, AD 282 334.

. . . detecting communication systems which use signals scattered by meteor trails . . . To obtain the statistical data required on the fraction of meteor trails that scatter energy to an intercept location. . . . a computation program is formulated. . . . data can be used to estimate the performance of a meteor-scatter communications link. Sample computations. . . are carried out. . . .

UBER DIE HAUFIGKEIT VON METEOR-ECHOS (On the Frequency of Meteor Echos) (In German)

R. Eyfrig, et al., Arch. elekt. Uebertragung, vol. 16, Dec. 1962, p. 609/610.

. . . Back-scatter echoes from meteors have been recorded on a radio frequency of 51.3 Mc/s. The values are analyzed in four groups according to the signal level. For each group the average time coverage, echo duration, and probability are indicated. . . .

METEOR-BURST SIGNAL DISTRIBUTIONS

G. R. Sugar, National Bureau of Standards, Boulder, Colo, 30 Jan. 1962, lv. incl. illus., tables, refs., NBS rept. no. 7224, AD 273 461.

Measurements of meteor-burst duty cycle and waiting time between bursts at transmission frequencies of 30, 50, and 73 mc over paths from Long Branch, Illinois to Boulder, Colorado; Norman, Oklahoma to Fargo, North Dakota; and. . . a general survey of meteor propagation is also presented.

SOME APPLICATION OF THE METEOR BURST PROPAGATION MODE

D. L. Albright, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 241/247.

. . . The experimental meteor-burst link between Seattle, Washington and Bozeman, Montana is described and the results to date are presented. . . . several specific system applications of this propagation mode are explored. . . include an instantaneous time synchronization system, an automatic weather station complex, private or clandestine communication systems, and an emergency communication system. . . .

PROGRESS IN METEOR ASTRONOMY IN 1958-1961

I. S. Astapovich, et al., Joint Publications Research Service, Washington, D. C., 3 Feb. 1964, 18 p., Transl. into English of an article from Meteoritika (Moscow), No. 23, 1963, JPRS-23047; OTS-63-21470, N64-14528.

. . . includes. . . the use of radar to study meteors and the use of meteor phenomena (ionization for example) for long-range radio communication. . .

APPARATUS FOR EXPERIMENTAL INVESTIGATION OF THE SCATTERING OF RADIO WAVES BY METEOR TRAILS

I. V. Bayrachenko, et al., Joint Publications Research Service, Washington, D.C., In its Sov. Rept. on Meteor Observations by Radar, 30 April 1963, p. 18/22, refs., Transl. into ENGLISH from Sb. Rabot po Mezhdunarodnomu Geofiz. Godu (Kiev), no. 1, 1961, p. 49/51, N64-10811.

The circuitry and component functions of the radar indicating-recording device used for investigating the dispersion of radio waves by meteor trails are presented.

RESEARCH ON THE DIRECTIONAL SCATTERING OF UHF RADIO SIGNALS BY METEOR TRAILS

V. F. Chepura, et al., Joint Publications Research Service, Washington, D. C., Feb. 11, 1963, 13 p., refs., Transl. into English of an article from Elektrosvyaz (Moscow), v. 16, no. 11, Nov. 1962, p. 3/10, JPRS-17555, OTS-63-21089, N64-10563.

. . . experimental study of UHF scattering by meteor trails. Data have been obtained on the variation in the correlation factor of two signals of nearly the same frequency received simultaneously at the same location. During the experiment one of the transmitters was fixed, while the other was moved various sites. . .

MESSAGE GENERATION AND RECEPTION EQUIPMENT FOR A METEOR-BURST COMMUNICATION SYSTEM

D. C. Coll, et al., Defence Research Telecommunications Establishment (Canada), April 1963, 13 p., Rept. no. 1108, AD 407 686.

. . . This system was operated at 100 mc on a circuit between Ottawa, Ontario and Goose Bay, Labrador. Thirty-digit messages were transmitted at rates of up to 25,000 digits per second.

VREMENNOI KHOD SIGNALA, OTRAZHENNOGO OT SLEDA METEORA (Time Dependence of a Signal Reflected From a Meteor Wake) (In Russian)

I. K. Kalinin, Geomagnetizm i Aeronomiia, vol. 4, no. 1, 1964, p. 124/130, 12 refs., A64-17007.

. . . distribution of electron concentration in a meteor wake, using the equations of ambipolar diffusion. The time dependence of a signal reflected from a meteor is determined by means of the perturbation method. . . The signal dependence on time is expressed in the form of Fresnel integral of a complex argument.

METHOD OF PREVENTING SIGNAL DISTORTIONS CAUSED BY MULTIPATH DISTRIBUTION DURING METEORIC COMMUNICATION

V. V. Sidorov, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 25 July 1963, 3 p., AD 414 686

POLARISATIONS-DIVERSITY BEI METEOR-VERBINDUNGEN (Polarisation Diversity in Meteoric Radio Communications) (In German)

L. Triskova, Astronomical Institutes of Czechoslovakia, Bulletin, vol. 15, no. 2, 1964, p. 67/74, 13 refs., A64-17867.

. . . possibility of increasing the duty cycle in polarization-diversity reception, for meteoric radio communications. . . . The 24-hour variation in the probability of the appearance of a signal at a vertical receiver antenna is defined for a horizontal polarization of the emitting antenna. Measurements indicate a 25% maximum increase in duty cycle.

AN EQUIPMENT FOR COMBINED GEOPHYSICAL AND ASTRONOMICAL MEASUREMENT OF METEORS

A. A. Weiss, et al., Proc. Instn. Radio Engrs. Australia, Sp. Issue on Radio Astronomy, vol. 24, no. 2, Feb. 1963, p. 197/203.

A 27 Mc/s radio equipment for comprehensive measurements on individual meteor trails is described. The two key features of the instrument are continuous-wave operation, which provides a reference phase at the receivers; and an outstation network whose main purpose is the triangulation of the flight paths of individual meteors. . . . some preliminary results of the observing program are given. . . .

Related Publications:

METEOR ACTIVITY AS A FACTOR IN IONOSPHERIC SCATTER PROPAGATION

G. A. Isted, Marconi Rev., 4th quarter, 1958, p. 161/172.

DOPPLER INVESTIGATIONS OF THE RADAR AURORA AT 400 MC/S

R. L. Leadabrand, et al., J. Geophys. Res. vol. 64, Sept. 1959, p. 1197/1203.

AS ESTIMATION OF THE MEAN TELEGRAPHY SPEED FOR AN INTERMITTENT RADIO LINK WITH FREQUENCY KEYING

V. S. Mel'nikov, Radio Engrg., vol. 14, no. 4, 1959, p. 26/36.

Using the theory of potential interference suppression developed by Kotel'nikov an estimation is made of the mean telegraphy speed for an intermittent radio link using frequency keying. An estimation is made of the advantages of intermittent radio communication. . . . The most typical radio link of this type is that which uses meteor ionization.

PROCEDURAL EFFICIENCY FOR INTERMITTENT COMMUNICATIONS SYSTEMS

B. M. Sifford, Stanford Research Inst., Menlo Park, Calif., Dec. 1959, 20 p., Scientific report no. 14, AFCRC TN-59-998, AD 231 123.

DOPLOC SYSTEM STUDIES

W. E. Scharfman, et al., Stanford Research Inst., Menlo Park, California, Final rept., pt. B., July 1960, 70 p., Rept. no. 10, AD 419 771.

. . . the report also estimates the number of meteor echoes that will be detected by the DOPLOC system and how they will affect system performance. . . .

THE EFFECT OF HIGH-ALTITUDE NUCLEAR EXPLOSIONS ON RADIO COMMUNICATION

H. P. Williams, IRE Trans. Mil. Electronics, vol. MIL-6, no. 4, Oct. 1962, p. 326/338.

1.666: Needles Channels

Included: Orbital dipole channels; Chaff communications; Dispersive communications channels; Artificial scatterer channels; Project West Ford Channels.

Not Included: Launching of chaff scatterers.

Cross References: Analysis of time-variant dispersive channels (1.612).

Principal Publications:

SOME THOUGHTS ON MODULATION AND DEMODULATION FOR THE NEEDLES CHANNEL, PART I
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, 15 April 1959, 18 p. (Group rept. no. 34-86), AD 262 922.

A highly random model for the Needles channel is adopted, and the application of detection theory yields a cross-correlator-radiometer receiver that is near-optimal at low S/N in the channel. Relationships to the Rake system are discussed. It is concluded that under certain conditions desirable waveforms for the Needles channel are sinusoids employed in a manner that circumvents intersymbol interference. . . .

COMMUNICATIONS BY RE-RADIATION FROM CHAFF
B. V. Blom, Conf. Proc. Nat. Conf. Mil. Electronics, vol 4, June 1960, p. 542/546.

. . . The scattering pattern of an ensemble of chaff dipoles was analyzed by Dr. R. A. Hessemer, Jr. of the Applied Research Laboratory . . .

THE DICON SYSTEM
R.S. Berg, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 31 Oct. 1961, 28 p. (Technical rept. no. 251), AD 267 536.

Built to demonstrate the applicability of the project West Ford channel as a high capacity digital data link, the DICON system comprises a transmitter which provides a variety of modulation signals to the West Ford RF transmitter and a receiver designed to recover the modulation signal from the output of the West Ford X-band receiving system and to measure and record the perturbations introduced by the West Ford channel. These perturbations are expected to be due principally to Doppler shift, Doppler spread and multipath delay. Since the fluctuation and multipath times may be of the same order, a noncoherent detection scheme is used.

COMMUNICATION VIA ARTIFICIAL SCATTERER
H. Raabe, et al., General Mills, Inc., Minneapolis, Minn., Electronics Div., Dec. 1, 1961, 112 p., 11 refs., Rept. 2245, N63-22442.

. . . possibility of creating a stable, efficient scatter-propagation communication path below the ionosphere . . .

EXPERIMENTAL INVESTIGATION OF CHAFF TRANSMISSION IN THE 1300 TO 1800 MC FREQUENCY RANGE
L. H. Bauer, Radiation, Inc., Melbourne, Fla., Quarterly progress rept. no. 3, 1 Jan. - 31 March 1962, 31 March 1962, lv. incl. illus., AD 275 622.

. . . Data are presented on the behavior of bistatic cross section of the chaff clouds, the effects of polarization, the probability distribution of received signal power and the spectra of fading frequencies. The bistatic cross section for 3.75 (10 to the 6th power) dipoles was 1500 to 2500 square meters with an average value of approximately 2000 square meters. . . . The probability distribution of received power was essentially Rayleigh. The spectrum of fading frequencies for six samples was 0 to 5 c.

FEASIBILITY STUDY OF CHAFF COMMUNICATION
L. H. Bauer, et al., IRE Internat. Conv. Rec., Part 8, vol. 10, March 1962, p. 131/139.

. . . use of re-radiation from chaff as a means of communication over non-line-of-sight paths at UHF. . . . Tests were made using military radio relay equipment. In addition, radar equipments were utilized to determine chaff cloud position and size. The chaff was dispensed at an altitude of 10,000 feet by aircraft. . . .

PERFORMANCE OF A RAKE SYSTEM OVER THE ORBITAL DIPOLE CHANNEL
P. Bello, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 46/53.

. . . Rake . . . has been used effectively . . . due to the ability of the . . . receiver . . . isolate the various paths, measure the (time-varying) path gains and phases, and coherently add the contributions of the various paths. . . . here, we determine the signal-to-noise ratio of a Rake-like system as a function of the spread factor of the channel. The channel model chosen is that of the Orbital Dipole Channel, for which a tapped delay line representation with independent complex value Gaussian processes for tap functions seems to be applicable. The system analyzed . . . differs from the previous Rake system in two notable ways. First, two independent noise carriers, of which only one is modulated, are

transmitted simultaneously. Second, not only digital but analog signal modulation methods (such as PM, FM, SSB) can be used. . . .

DISTRIBUTED SATELLITE CIRCUMGLOBAL COMMUNICATION TECHNIQUE STUDY
R.A. Cushman, et al., Bell Telephone Labs., Inc., Whippany, N.J., Rept. for 11 Jan. 1961 - 11 Jan. 1962, 11 Jan. 1962, 167 p., incl. illus. tables, 30 refs., (RADC TDR 62-120), AD 274 911.

. . . first year results of a continuing study of the use of orbiting dipole belts to meet Air Force communication requirements . . . cross section . . . statistical characterization of the scattering medium. . . . weight of dipoles, operating frequency, transmitter power, and antenna size, and calculations of the required power for a basic channel using a quaternary frequency-shift code. . . . interference problems . . . survivability and cost, and choice of operating frequency within the 2- and 8-Gc region.

ORBITAL SCATTER CHANNEL PROPAGATION EXPERIMENT
P.R. Drouilhet, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 21 Dec. 1962, 24 p., 7 refs., Tech. rept. no. 292, ESD TDR 62-280, AD 401 311.

. . . essential characteristics for channels of this type may be expressed in terms of the channel 'scattering function', which exhibits the average character of the time and Doppler smearing of the medium. . . . can be measured by observing the channel with a coherent bistatic pulsed radar.

STATISTICAL PROPERTIES OF THE DICON RECEIVER
J.A. Dumanian, Lincoln Lab., Mass. Inst. of Tech., Lexington, 2 March 1962, 11 p., illus., 3 refs., (Rept. no. 52 G-2), AFESD TDR 62-85, AD 275 278.

. . . frequency-shift keying and energy detection. . . . The final bit decision is performed by subtracting the outputs to two channel receivers tuned to the two information frequencies and determining the sign of the result. Results were obtained for a variety of parameters representative of the range of experimental conditions expected in West Ford communications.

PARAMETRIC ANALYSIS OF AIR GROUND COMMUNICATIONS VIA ORBITING DIPOLES
C.C. Gauder, Electromagnetic Warfare and Communications Lab., Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio, Rept. on Applied Communication Research for Air Force Vehicles, Sept. 1962, 38 p., incl. illus. tables, 8 refs., (ASD TDR 62-579), AD 289 879.

. . . analysis shows that for communication ranges of up to 4000 miles, air/ground communications at a 50-bit per second information rate is feasible for a dipole payload weight of 1500 pounds in a 2000-mile polar orbit. A sophisticated modulation and demodulation technique is envolved to overcome the effects of channel adversities such as multipath spread and Doppler smear. System analysis of an experimental airborne complex is used to predict the degree of performance of an experiment entitled Leap Frog to determine feasibility of an air/ground communication link.

COMMUNICATION VIA ARTIFICAL SCATTERS PHASE II
W. Grosz, et al., General Mills, Inc., Minneapolis, Minn., 15 Dec. 1962, lv. incl. illus. tables, 12 refs, Rept. no. 2353, AD 401 672 and AD 406 835 and N63-22443.

. . . feasibility of establishing an effective scatter propagation communication path below the ionosphere has been further examined. . . . would be free from interuption due to ionospheric storms. . . . limited to a frequency range of 1 mc/s to 20 gc/s and an altitude of the artifical scatters which is below the ionosphere . . . (1) scattering by coherent grating arrays deployed in the atmosphere; (2) active repeaters placed on the ocean surface; and (3) scattering by a cloud of randomly oriented artificial scatters in the atmosphere.

INVESTIGATION OF CHAFF COMMUNICATIONS AT 5,000 MCPS
L.H. Bauer, et al., Radiation Inc., Melbourne, Fla., Final rept. 1 Dec. - 31 May 1963, 31 May 1963, 157 p., AD 420 192.

An experimental and theoretical program was carried out to investigate the use of chaff for communication beyond the line-of-sight. . . . The theoretical program included investigations of bistatic scattering cross section for chaff clouds, bandwidth and modulation effects, diversity performance, acquisition and tracking requirements and optimum antenna sizes. In the experimental program, field tests were conducted at 5 gigacycles. . . . A 10 lb. chaff unit was dispensed over the receiver site by an aircraft. The measured values of cross section agreed with the predicted values to within the experimental error. . . .

CORRELATION FUNCTIONS IN A TAPPED DELAY LINE MODEL OF THE ORBITAL DIPOLE CHANNELS
P. Bello, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 2/11.

. . . considers the properties of the tap gain functions . . . Specifically, auto-correlation and cross-correlation functions are computed for these tap functions in terms of assumed statistics for the motion of illuminated dipoles. . . .

SIGNAL DESIGN FOR DISPERSIVE CHANNELS
R.S. Kennedy, et al., IEEE Spectrum, Convention Issue, March 1964, p. 231/237, 9 refs., A64-16463.

. . . channels in which extended moving media are used as reflectors, as in the case of a belt of orbiting microwave dipoles. . . .

MODULATION TECHNIQUES FOR ORBITING DIPOLE SCATTER COMMUNICATION
W. E. Morrow, Jr., Institute of the Aerospace Sciences, Annual Meeting, 31st, New York, N.Y., Jan. 21-23, 1963, Paper 63-66, 8 p., A63-11617.

Discussion of modulation techniques for reliable long-range radio communication involving the scattering of microwave radio signals from belts of thin microwave dipoles placed in orbit about the Earth. Multiplicative disturbances of the scattering medium, which complicate the design of modem (modulation-demodulation) techniques for this type of propagation, are discussed in detail. Tables are included which present (1) the maximum multipath time delay as a function of antenna size, and (2) the incoherent detection multiplicative loss factors.

OPTIMUM PULSE TRANSMISSIONS FOR MULTIPATH CHANNELS
J. G. Proakis, et al., Lincoln Lab., Mass. Inst. of Tech., Lexinton, 16 Aug. 1963, 38 p., Rept. no. 64G3, AFESD TDR63 101, AD 416 639.

. . . Probability of error expressions are . . . generalizations of results obtained earlier by Turin, Hahn, and Pierce. From these expressions the optimum time duration for pulse transmissions is computed for two channels — the orbital dipole channel and the moon.

COLLISIONS BETWEEN WEST FORD NEEDLES AND MICROMETEORITES
A. Sauval, Liege U., Inst. d'Astrophysique (Belgium), Technical Note No. 2, 10 May 1963, 11 p., 37 refs., (AFCRL-63-649), N63-17588.

Over a period of eight years, there are enough collisions of micrometeorites with needles of Project West Ford to break most of them.

Related Publications:

DISTRIBUTED SATELLITE CIRCUM-GLOBAL COMMUNICATION TECHNIQUE STUDY
R. E. Graham, et al., Bell Telephone Labs., Inc., New York, Rept. for 11 Jan. 1962 - 11 March 1963, 11 March 1963, 96 p., RADC TDR 63 216, AD 408 269.

. . . (6) studies to determine the approximate cost of the ground equipment for a complete system utilizing belts of orbiting dipoles.

ANTI-JAM TROPOSPHERIC SCATTER THEORETICAL ANALYSIS
ITT Communication Systems, Inc., Paramus, N. J., Final rept. 15 June 1963, 133 p., ESD TDR 64 218, AD 431 197.

. . . effect of radar chaff on the communication perfomrnace of tropospheric scatter communication systems using FDM-FM . . .

1.667: Point-to-Point Space Channels

Included: Channel characteristics of Moon relays; Lunar reflection channels.

Not Included: Equipment descriptions of Moon relays (4A); Systems design of Moon relays (4A).

Cross References: Beyond line-of-sight satellite channels (1.675); General references to space communications channels (1.602).

Principal Publications:

A LUNAR AND PLANETARY ECHO THEORY
W. E. Brown, Jr., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, 30 April 1960, 32 p., incl. illus., (Technical release no. 34-54), AD 240 772.

A relatively simple statistical approach is used to derive a theoretical impulse response of the lunar reflection . . . The same value appears to be consistent with data from Goldstone and Millstone experiments. The echo was assumed to consist of two components, specular and scatter . . . ratio of total scatter power and toal specular power reflected (cpr) is found to fall between 0.1 and 1.0. The depth of the surface layer could be a great as 10 km.

COMPUTATION AND MEASUREMENT OF THE FADING RATE OF MOON-REFLECTED UHF SIGNALS
S. J. Fricker, et al., J. Res. Nat. Bur. of Stand., vol 64D, no. 5, Sept. - Oct. 1960, p. 455/465.

EFFECTIVE BANDWIDTH MEASUREMENTS USING THE MOON AND ECHO SATELLITE
R. E. Anderson, et al., Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 509.

The constantly changing multipath structures of the lunar propagation path creates distortions of several types on signals reflected from the moon. . . .

BANDWIDTH OF A MOON COMMUNICATION CIRCUIT
J. V. Evans, Brit. J. Appl. Phys., vol 12, no. 8, Aug. 1961, p. 406/409.

Radar studies of the moon by a number of workers have shown that the principal reflections occur from a region at the center of the visible disk having a radius of about one-tenth of that of the moon. Thus it is possible to use the moon as a reflector in a communication system, and several successful systems of this type have been demonstrated. This paper describes measurements made at Jodrell Bank to determine the single-channel bandwidth of the system using double-sideband amplitude-modulated transmissions. It is found that the demodulation of the signals caused by the multiple scattering at the moon's surface restricts the bandwidth to about $\pm$ 1 kc/s, although the demodulation does not appear to increase rapidly at higher modulation frequencies.

LUNAR REFLECTION STUDY
B. Claxton, et al., General Electric Co., Schenectady, N.Y., Final rept., pt. 1, 20 March 1962, 96 p., incl. illus. tables, 25 refs., (ARCRL 62-300, vol. 1), AD 276 233.

. . . A step-by-step approach is presented to the design of a lunar reflection communication system. . . . Limitations of the moon path

. . . distortion present on the reflected signals. Methods for the calculation of signal strength, moon availability, moon position, and libration are given, as well as antenna formulas and system noise temperature calculations.

LUNAR REFLECTION STUDY
B. H. Claxton, et al., General Electric Co., Schenectady, N.Y., Final rept., pt. 2, 31 Aug. 1962, 48 p., incl. illus. tables, 21 refs., (AFCRL 62-300, vol. 2) AD 286 277.

The effective bandwidth of the lunar reflection path was determined. Doppler shift, signal strength, and amplitude fading of CW signals were measured, and the results analyzed and compared to theoretical predictions. Double sideband suppressed carrier transmissions centered at 915 Mc, with audio frequency modulation to produce two signals separated in frequency by a small amount, were reflected from the moon and received. The amplitudes of the two sidebands were separately recorded, and their correlation coefficient computed to give a measure of the quality of the circuit. Forty-five determinations of the correlation gave a value of .26 $\neq$ .07, showing that the coherent bandwidth of the moon reflection path is extremely narrow. A standard word list was expected . . . 74% of the moon-reflected words, whereas 95% of the words on a similar list presented without distortion but in the same signal/white noise environment, were correctly judged. . . .

A LUNAR ECHO STUDY AT 425 MCS
R. G. Mathis, Texas U., Austin, June 1963, 81 p., AD 415 812.

Since the first radar returns were received from the moon in 1946, many investigators have been studying the moon with radio signals . . . These studies have utilized pulse lengths ranging from a few microsecond to c.w. and radar wavelength extending from a few centimeters to several meters. One of the primary needs has been to determine accurately the nature of the reflection of electromagnetic energy from the lunar surface. This means that (1) the type of return must be determined . . . (2) the area of the moon from which the echo comes must be found and (3) a mathematical model of the moon must be derived . . . Finding solutions to these three key problems is the main purpose of this study . . .

WIDE BAND LUNAR RELAY COMMUNICATIONS
W. M. Waters, et al., Electronic Communications, Inc., Timonium, Md. Final rept. 16 May 1963, 39 p., AFCRL 63 332, AD 422 223.

. . . problem of increasing Lunar relay bandwidth. An adaptive receiving array is described which makes possible the use of exceptionally large apertures capable of being focused on a small spot on the Lunar surface. However, an analysis shows that sidelobe effects considerably reduce expected bandwidth gains. A bandwidth of 25 kc is calculated for a 1000 ft. square X-band array which employs a "maximum energy" taper. Between 256 and 1024 array elements are required.

Related Publications:

THE USE OF AN HF LUNAR REFLECTION CIRCUIT IN THE STUDY OF IONOSPHERIC ELECTRON DENSITY
J. R. Davis, et al., Naval Research Lab., Washington, D.C., 19 July 1963, 15 p., refs., (NRL-5968; AD 414 850), N64-15130.

A high-power HF transmitter has been used to illuminate the moon at moonrise. The returned signals that have been observed display both the smooth-sphere scattering components and the rough-scatter components reported previously by observers utilizing the VHF and UHF bands . . .

BIBLIOGRAPHY OF BACKSCATTER AND RELATED SUBJECTS
D. H. Lenhert, et al., New Mexico U., Albuquerque, Engineering Experiment Station, June 1963, 43 p., 549 refs., N63-20249.

. . . (2) lunar surface properties . . .

Section 1.67
Characteristics of Omnidirectional and Mobile Channels

Space communications systems incorporate links with the fastest moving terminals imaginable. Therefore, space communications engineers are interested in the progress of all other mobile communications systems.

Omnidirectional systems may be systems with fixed or with mobile stations. They are usually designed as broadcasting systems where many dispersed receiving stations listen in to one or more transmitting stations. The problems of such channels are presented in subdivision 1.672.

The other three subdivisions of this section deal with mobile systems on Earth, in the air and in space. The latter subdivision concentrates on satellite communications links reaching beyond the line-of-sight limit.

1.672: Omnidirectional Communications Channels

Included: Broadcasting mode of communications; Television signal propagation characteristics.

Not Included: RADAS-type of communications systems (2); Radio central stations.

Cross References: Medium wave propagation characteristics (1.643); Terrain influence on propagation (1.635).

Principal Publications:

THE USE OF VERTICAL POLARIZATION TO SOLVE UHF TELEVISION "GHOSTING" PROBLEMS IN A SHADOWED VALLEY
D. W. Peterson, RCA Rev., vol. 19, no. 2, June 1958, p. 208/215.

UHF Television broadcasting in hilly or mountainous terrain suffers from "ghosting" or multi-path reception in shadowed valleys. An experimental study of the ghosting problem has led to the conclusion that vertically polarized co-channel amplifier boosters and passive boosters will solve the problem of serving shadowed valleys. New service can be rendered without denying any existing service resulting from creation of a "mush" area. . . .

REDUCTION OF CO-CHANNEL INTERFERENCE BY PRECISE FREQUENCY CONTROL OF TELEVISION PICTURE CARRIERS. PART II.
W. L. Behrend, RCA Rev., vol. 20, no. 2, June 1959, p. 349/364.

The visibility of co-channel television interference has maxima and minima at carrier offset frequencies which are multiples of frame frequency. Earlier subjective tests determined the reduction in visibility of co-channel interference which might be achieved by precise carrier frequency control for the condition of one station, at a 10- or 20-kilocycle offset, interfering with the desired station.

Additional subjective tests have been made for the following conditions: two offset stations simultaneously interfering with a desired station; an on-frequency station interfering with a desired on-frequency station; and a series of tests with moving pictures as the desired picture and as the source of visual interference from a co-channel station offset 10 or 20 kilocycles. . . .

ERSTE ERGEBNISSE VON FARBFERNSEH-AUSBREITUNGSVERSUCHEN IN DER SCHWEIZ (First Results of Color Television Propagation Tests in Switzerland) (In German)
K. Bernath, Nachrichtentech. Z. (NTZ), vol. 12, June 1959, p. 281/285.

EXPERIENCE WITH LONG-DISTANCE TELEVISION FIELDS USED FOR RETRANSMISSION
W. L. Braun, Commun. Electronics, no. 45, Nov. 1959, p. 594/595.

. . . long-distance (100-150 miles) very-high frequency propagation. . . of wide-band performances. . . . ultimate use as signal sources for a community antenna system. . . .

V. H. F. SOUND BROADCASTING. SUBJECTIVE APPRAISAL OF DISTORTION DUE TO MULTI-PATH PROPAGATION IN F. M. RECEPTION
R. V. Harvey, Proc. Instn. Elect. Engrs., Pt. B (London), vol. 107, no. 35, Sept. 1960, p. 412/422.

In f. m. reception the delayed signals caused by multi-path propagation result in unwanted amplitude and phase modulation of the primary signal, and consequent distortion of the programme output of the receiver. The paper describes the results of tests which were carried out in simulated multi-path conditions to determine the importance of the parameters of both the received signal and the receiver in influencing the subjective annoyance caused by the distortion. . . . The use of pre- and de-emphasis appreciably reduces the distortion, being equivalent to a reduction of about 8 dB in the amplitude of the delayed signal when the path difference is about 16 km. . . . The mechanism of multi-path distortion is discussed, and the harmonic spectra of the distortion shown for particular conditions. . . .

PROBABILITIES OF INTERFERENCE WITH MOBILE FIELD RADIO DERIVED FROM A FIELD-STRENGTH SURVEY AT 59 Mc/s
D. R. Thomas, Proc. Instn. Electr. Engrs. Pt. B (London), vol. 108, no. 39, May 1961, p. 264/272, 25 refs.

. . . experimental investigation of common- and immediately-adjacent-channel interference areas for mobile radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. . . . Particular attention has been paid to investigating the distribution of field strength at each distance, which is shown to approximate closely to log-normal. It is also established that the variance of these log-normal distributions may be considered to have a single value for each type of country, irrespective of range. Protection ratios acceptable for satisfactory operation are determined from experimental observation of common- and adjacent-channel interference. . . .

TELEVISION BROADCAST TRANSMITTER SERVICE AREA PREDICTION
M. W. Davies, Proc. Instn. Radio Engrs., Australia, vol. 23, no. 10, Oct. 1962, p. 555/575.

. . . service area of a television broadcast transmitter. . . Iso-service diagrams for adjacent channel and co-channel interference conditions are described. . . . typified by considering conditions for VHF transmitters in the Newcastle-Sydney-Illawarra area of New South Wales. . . .

SOME CONSIDERATIONS OF TELEVISION CHANNEL ALLOCATION
K. G. Dean, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 3, March 1963, p. 304/313.

. . . some aspects of the problem of positioning a number of mutually interfering television stations under certain idealized situations. . . . Although the results of the analysis cannot be used directly in planning a TV service, they draw attention to some underlying factors, the significance of which should not be ignored at the detailed planning stage. . . .

CROSS-POLARIZATION WITH REFERENCE TO TELEVISION PLANNING
D. E. MacDonald, et al., Proc. Instn. Radio Engrs., Australia, vol. 24, no. 7, July 1963, p. 570/582.

. . . describes measurements taken of the horizontally polarized component (E_H) and the vertically polarized component (E_V) of the emissions of existing TV stations. In the analysis, it is shown that the statistical distribution with location of the parameter E_H/E_V from one station, although currently used, does not provide a valid means of estimating the improvement to be expected when using cross-polarized transmitters as a means of reducing interference. . . . Cross-polarization should be of greatest use. . . where the receiving location lies between the wanted and unwanted stations. The analysis relates to the effects of propagation and does not take into account the problems of domestic receiving aerial installations. . . .

COMPARATIVE STUDY OF LOW-VHF, HIGH-VHF, AND UHF TELEVISION BROADCASTING IN THE NEW YORK CITY AREA
D. W. Peterson, RCA Rev., vol. 24, no. 1, March 1963, p. 57/93.

. . . In 1961, the Federal Communications Commission placed a UHF system in operation in New York City for an extensive study aimed at providing a quantitative measure of the comparative merit of VHF and UHF television transmission in large cities. A comparison between the FCC UHF (channel 31) transmission from the Empire State Building and existing VHF transmissions has also been made by RCA. A comparative evaluation of picture degradation from multipath propagation and of the availability of useful levels of signal strength in highly built-up parts of Manhattan were the principal objects of study. . . .

ZUR AUSBREITUNG HORIZONTAL UND VERTIKAL POLARISIERTER ULTRA-KURZWELLEN IN VERSCHIEDENEN GELANDEFORMEN BEI NIEDRIGEN ANTENNENHOHEN (On the Propagation of Horizontally and Vertically Polarized VHF waves When Originating at Low Antenna Height in Various Kinds of Terrain) (In German)
H. Widdel, Arch. Elekt. Uebertragung, vol. 17, March 1963, p. 145/150.

. . . in level and hilly, open and timbered terrain. . .

1.673: Mobile Communications Channels on Earth

Included: Special propagation problems in mobile communications.

Not Included: Personal communications for astronauts (4D); Intercommunications in space craft (4D); RADAS-type of systems (2).

Cross References: Doppler distortions (1.613).

Principal Publications:

PROBABILITIES OF INTERFERENCE WITH MOBILE FIELD RADIO DERIVED FROM A FIELD-STRENGTH SURVEY AT 59 Mc/s.
Proc. Instn. Elect. Engrs. (GB), vol. 108B, May 1961, p. 264/272, Paper 3472 E.

. . . experimental investigation of common- and immediately-adjacent-channel interference areas for mobile radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. . . .

MAJOR SYSTEM TRADEOFFS AMONG FIXED, TRANSPORTABLE, AND MOBILE STATIONS IN SATELLITE COMMUNICATION SYSTEMS
A. Alma, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 193.

Abstract only . . .

USE OF RADIO LINKS AND UHF RADIO COMMUNICATION IN POWER SYSTEMS (In Russian)
N. T. Babayev and V. V. Kulikov, Moscow-Leningrad, Gosenergoizdat, 1963, 176 p.

. . . presents concise information on UHF propagation, the organization of communication via UHF, and the principles of multiplexing of radio communication lines . . . descriptive data, technical characteristics and basic circuits of radio-link equipment and mobile UHF radio stations in Soviet production. . . .

AN ANALYSIS OF PCM TRANSMISSION VIA SINGLE SIDEBAND
R. Gardner, et al., RCA Defense Electronic Products, New York, 1 May 1963, 191 p., AD 406 700.

. . . to determine the relative merits of single-sideband transmission as against FM transmission of multichannel (e.g. 12-channel) PCM signals, for tactical radio relay equipment in the lower portion of the UHF range and to recommend immediate and long-range development plans . . .

GROUNDWAVE PROPAGATION EFFECTS ON MICROSECOND PULSES AT 141 MCS
R. W. Heffner, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 182/196.

. . . A test program was performed to investigate the propagation effects around 141 mcs using microsecond pulses of different carrier frequencies. These investigations used omnidirectional antennas at the transmitter and receiver locations. Antenna height at both locations was twelve feet. The results to be discussed are: a) propagation attenuation contour; b) pulse stretching; c) selective fading and enhancement of pulses within the time-frequency matrix frame; d) backscatter pulse stretching, and; e) polarization dependence. . . . only limited information was applicable to the special wide band multiple pulse system requirements of RACEP. . . .

DEVELOPMENT OF RADIO SET AN/GRC-103
D. F. Lee, et al., Canadian Marconi Co. Semi-annual progress report no. 1, vol. 1, 31 March 1963, 1 v., Rept. no. 1, AD 406 891.

. . . a transportable, medium-power radio set capable of carrying 12 pulse-code-modulated voice channels, operating on 0.5-mc spaced channels in the UHF band. . . .

THE COLLECTION, DIGITAL PROCESSING, AND SPECTRAL ANALYSIS OF MOBILE RADIO-FADING SIGNALS, AND A THEORETICAL MODEL FOR FADING DUE TO BUILDING REFLECTIONS
J. F. Osanna, Jr., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, no. 8, March 1963, p. 3.

. . . Knowledge of the statistical behavior of mobile radio-fading signals can permit more meaningful system study and design effort. For example, the choice and design of automatic gain control systems and systems involving data transmission can be aided. This paper describes the results of an analysis of the fading during simultaneous transmission of two channels near 870 Mc. The collection, digitization, calibration, and digital processing to obtain signal level and level-crossing statistics, power spectra, and cross spectra are discussed. A theoretical model for the fading due to reflections from buildings near the mobile station is described. . . .

PARAMETER STUDY OF PULSED RADIO FREQUENCY TRANSMISSION
Westinghouse Electric Corp., Baltimore, Md., Final rept., 15 Oct. 1963, 42 p., AD 424 390.

. . . for maintaining communications between individual members of tactical fighting unit in a limited war situation . . . considering the signalling or communication problem associated with the dense jungle environment . . . merits of wide-band versus narrow-band FR pulses are investigated so that an optimum choice of signal structure (with respect to transmitted energy) can be established. The system problem is studied in light of the adverse jungle propagation losses that exist. A jungle range equation is derived . . .

Related Publications:

FORWARD ACTING AUTOMATIC GAIN CONTROL
A. L. Hopper, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 358/370.

. . . good suppression of rapid fading in mobile radio transmission when delays within the FAAGC circuit are properly matched . . .

1.674: Airborne Communications Channels

Included: Air-to-air channels; Air-to-ground channels; Ground-to-air channels; Air-to-space channels.

Not Included: Equipment design; Multiple access problems (2).

Cross References: Propagation in the lower atmosphere (1.634); Ground reflections (1.635).

Principal Publications:

REFRACTION ANOMALIES IN AIRBORNE PROPAGATION
M.S. Wong, Proc. IRE, vol. 46, Sept. 1958, p. 1628/1638

DIGITAL COMMUNICATIONS BETWEEN AEROSPACE VEHICLES AND STATIONS ON THE GROUND
K.W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 58/66, 23 refs.

A survey of the principal methods of improving the reliability of long-range digital communication systems . . . Special modulation techniques as well as redundant transmission of pulses, redundant in time and in carrier frequency, are described as methods to counteract the effects of multipath distortion in connection with the proper special demodulation and diversity reception techniques. . . . for an air-to-ground communication system, in which Doppler shift has to be considered in addition to the multipath distortion, high reliability can be obtained if quantized frequency modulation (QFM) and time redundancy are properly applied. . . .

DESIGN OF RELIABLE LONG-DISTANCE AIR-TO-GROUND COMMUNICATION SYSTEMS INTENDED FOR OPERATION UNDER SEVERE MULTIPATH PROPAGATION DISTURBANCES
K.W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 67/78.

. . . tutorial paper presents an introduction to the problems of communications between aerospace vehicles and stations on the ground. The possible types of aerospace-to-ground communication links are described and classified according to the mode of signal propagation and according to obtainable range. The suitability of carrier frequencies throughout the electromagnetic radiation spectrum from very-low radio frequencies to light frequencies is discussed for the various types of links. . . . selection of modulation and demodulation techniques . . . practical value of digital coding . . . transmitter power requirement

MESSAGE STANDARDS FOR G/A/G DIGITAL COMMUNICATIONS
ITT Communication Systems, Inc., Paramus, N.J., 24 Sept. 1962, 10 p., Rept. no. ICS62TR104, ESD TDR 64 228, AD 431 639.

. . . including digitally initiated voice communications. It presents those message characteristics for which common or compatible standards between commercial and military data systems are necessary.

PRELIMINARY RESULTS OF UHF AIR-TO-GROUND PROPAGATION MEASUREMENTS
A.P. Barsis, National Bureau of Standards, Boulder, Colo., Bedford, Mass., Electronics Systems Div., July 1963, 36 p., refs., (ESD-TDR-63-422) AD 417 196, N64-15701.

. . . in the UHF band . . . originate from airborne transmitters at a nominal altitude of 23,000 ft. above east central Indiana . . . The character of short-term fading at the various receiving site depends quite markedly on the direction of the flight pattern axis.

LONG RANGE V.H.F. AIR/GROUND COMMUNICATIONS
D.B. Clemow, et al., J. Brit. Instn. Radio Engrs., vol. 25, no. 1, Jan. 1963, p. 17/32.

In recent years among airlines and civil aviation administrations interest has developed in the use of v.h.f. radiotelephony for air ground communications at ranges much in excess of those conventionally regarded as the maximum obtainable. . . . tests conducted from an experimental station in the Persian Gulf . . .

AUTOMATISCHE DATENUBERMITTLUNG BODEN-BORD-BODEN (Automatic Ground-Air-Ground Data Transmission) (In German)
J. Emser, Luftfahrttechnik Raumfahrtte chnik, vol. 10, Feb. 1964, p. 53/55, A64-16047.

Delineation of the important considerations which must be taken into account in the planning and construction of an automatic ground-air-ground communications system using digital computers. Requirements are briefly considered for: communications channel, modulation techniques, transmission velocities, problems of error control . . . interrogation networks, and data presentation.

GROUND-AIR-GROUND DATA TRANSMISSION SYSTEMS TESTS
A. J. Uryniak, RADC, Griffiss Air Force Base, N.Y., July 1963, 21 p., RADC RAU TM 63 2, AD 414 629, N63-20749.

. . . to check the feasibility of Air/Ground/Air Narrow Band FSK Data System utilizing frequency diversity and doppler correcting techniques. . . . These tests were conducted between RADC's Ava Test Annex and a KC-135 flying to California and Alaska. . . . It can be concluded . . . transmission is feasible, resulting in reliability and error rates equivalent to ground point-to-point systems operating within similar effective power ranges and antenna gains.

OPERATIONAL TEST AND EVALUATION FAA SINGLE CHANNEL RADIO, TV-20/U TRANSMITTER, RV-7/U RECEIVER, COAXIAL AND CIRCULARLY POLARIZED ANTENNAS
Air Force Communications Services, Scott Air Force Base, Ill., Final rept., Aug. 1963, 16 p., AD 417 930.

. . . equipment capable of operating with 50 KC channel spacing . . . consideration of "off-shelf" items . . . provided improved communications over existing equipment . . . Anticipated improvements in circuit design, channel spacing, and state of the art over existing VHF equipments . . . were not evident.

AIRBORNE COMMUNICATION SYSTEM. MARCOM RELAY, PHASE I.
Bell Telephone Labs, Inc., Whippany, N. J., Quarterly progress rept. no. 5, 15 June-15 Sept. 1963, 15 Oct. 1963, 83 p., AD-424 617.

. . . to gather and analyze information on air-to-air and ground-to-air microwave propagation and transmission. The findings will aid in predicting the capabilities of multichannel microwave communication systems using airborne radio relay stations. . . .

Related Publications:

FAA DEVELOPMENT IN AIRCRAFT DATA COMMUNICATIONS
W. R. Deal, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 79/84.

. . . During the past four years active development and evaluation programs have been conducted . . . major effort was spent on the development and evaluation of an experimental "Automatic Ground-Air Communication System" referred to as AGACS. This two-way time division multiplex system was designed primarily for operation at 750 bits per second, and provided both frequency-shift keyed carrier (FSK) and tone-shifted amplitude-modulation (FSK-AM) options. . . .

ANALYSIS OF AFSK-QFM TEST DATA
ITT Communication Systems, Inc., Paramus, N.J., 24 Sept. 1962, 5 p., Rept. no. 62 TR103, ESD TDR 63 695, AD 430 584.

Ground-to-air transmissions are superior to air-to-ground transmissions for both quenching frequency modulation (QFM) and automatic frequency shift keyers (AFSK) and for both equipments AN/ARC-65 and AN/ARC-58. . . .

1.675: Special Channel Characteristics of Satellite Links

Included: Beyond line-of-sight satellite links.

Not Included: Re-entry links; Telemetry links (4B); Optical space links (3B).

Cross References: General references to space communications chanels (1.602).

Principal Publications:

MULTIPATH IN THE HIGH IONOSPHERE
L. C. Humphrey, et al., Proc. Nat. Aeron, Electronics Conf., vol. 8, May 1960, p. 387/395.

. . . the need will coon arise for communication between space vehicles. . . communication between high orbiting vehicles may be carried on at frequencies below a megacycle. One reason for such a procedure occurs when non-directional antennas are used since the basic transmission loss is less at lower frequencies.

EXPERIMENTS FOR FEASIBILITY STUDY OF TROPOSPHERIC SCATTER PROPAGATION BETWEEN THE EARTH AND SATELLITES
W. J. Hartman, et al., National Bureau of Standards, Boulder, Colo., 1 Dec. 1962, 15 p., NBS rept. 7625, AD 414 771.

Proposed experiments are described. . .

THE SCREENING EFFECT OF THE IONOSPHERE (Correspondence)
B. C. Potts, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1980.

. . . reflection of CW signals from the vicinity of an artificial earth satellite . . . usually carried out at frequencies just above the critical frequency of the ionosphere where the largest effects are expected. . . . ionospheric screening is important. . . . the inclusion of ionospheric screening in statistical studies of CW reflection is essential in order to obtain good correlation. . . .

OPTIMUM FREQUENCY PREDICTION TECHNIQUES FOR SATELLITE COMMUNICATION BEYOND LINE-OF-SIGHT PATHS
A. W. Biggs, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 139/145.

. . . Orbital paths are above and below the F2 region of the ionosphere. Requirements for propagation beyond and within line-of-sight paths are established as functions of the critical frequency. Results for a representative orbit include effects of diurnal, seasonal, geographical, and sunspot activity from 1965 through 1970. . . .

FARADAY ROTATION NEAR THE TRANSVERSE REGION OF THE IONOSPHERE

G. A. Dulk, Ballistic Research Labs., Aberdeen Proving Ground Md., April 1963, 32 p., AD 406 222.

Some of the equations usually used to describe Faraday rotation are incorrect for the case of propagation through an anistropic magnetic field when the cosine of the angle between the magnetic field and the wave normal changes sign along the ray path. Such a case is common when transmissions are from a high altitude satellite in the region of the ionosphere where the direction of propagation is nearly perpendicular to the earth's magnetic field. Use of the uncorrected equations can result in a misinterpretation of the data. The corrected equations are given and are shown to be consistent with measured Faraday rotation. . .

FEASIBILITY OF COMMUNICATION WITH SATELLITES BY MEANS OF TROPOSPHERIC SCATTER

W. J. Hartman, National Bureau of Standards, Boulder, Colo., 1963, 1v., AD 405 801.

Theoretical methods are developed for predicting the transmission loss over a tropospheric scatter path from a point on the earth to a satellite. The results indicate that presently available equipment allows reliable communication to only very slightly beyond the radio horizon. Some of the difficulties encountered in designing experiments to test the theoretical predictions are investigated.

FACTORS AFFECTING EARTH-SATELLITE MILLIMETER WAVE-LENGTH COMMUNICATIONS

A. W. Straiton, et al., (IEEE Millimeter and Submillimeter Conference, Orlando, Fla., Jan. 7-10, 1963.), IEEE Trans. Microwave Theory Techniques, vol. MTT-11, Sept. 1963, p. 296/301, 10 refs., A64-11516.

Discussion of the possible use of millimeter wavelengths for satellite transmissions, by employing the large bandwidths and high gain with small antennas possible at these wavelengths . . . The attenuation through the entire atmosphere over the millimeter spectrum is given as a function of elevation angle of the antenna beam. . . . Refraction by the atmosphere is less than one milliradian. . . Fluctuations due to refraction may, however, be quite severe. . . antenna temperatures from the atmosphere, the Earth, the Sun and Moon are given for Earth-based antennas and antennas in space.

Section 1.68

1.680: Various Other Communications Channels

Included: Surface communications on other celestial objects; Special still unexplored propagation effects.

Cross References: General references to space communications channels (1.602).

Principal Publications:

RADIO AND RADAR EXPERIMENTS

Commun. Electronics, vol. 7, no. 4, April 1960, p. 286.

Our American Correspondent discusses a newly-discovered radio propagating channel in the lower atmosphere which may provide a reliable means of intercontinental communications. Details are also given of Man's first radar contact with the Sun.

PRELIMINARY INVESTIGATION OF LUNAR SURFACE COMMUNICATIONS

J. P. Ferrara, et al., (American Astronautical Society, Symposium on Manned Lunar Flight: American Association for the Advancement of Science, Annual Meeting, 128th, Proceedings, Denver, Colo., Dec. 29, 1961.), IN: Advances in the Astronautical Sciences, Vol. X-Manned Lunar Flight, North Hollywood, Calif., Western Periodicals Co., 1963, p. 251/264, A63-17902.

. . . utilization of medium radio frequencies for beyond-line-of-sight transmission on the surface of the Moon. Ground-wave field intensity is calculated as a function of distance and frequency. The effects of cosmic noise, receiver parameters, and the field intensities are combined in a plot of maximum range vs frequency for a given transmitter power.

DIVISION 1.7:
NOISE AND DISTURBANCES IN TRANSMISSION CHANNELS

Division 1.7 contains references to publications on all kinds of distrubances which enter communications channels somewhere in the transmission medium. These disturbances are in general independent of the transmission signals. They will be present even in the absence of useful signals.

Two large classes of noise are not included in the references of this division. One class is extra-terrestrial noises, such as radiations from the Sun, the planets, the galaxy and other celestial sources. These radiations are the subject of a special branch of space research (radio astronomy) and the large number of publications makes it impractical to list them as a subdivision of channel disturbances. The other class of noise to be excluded is so-called circuit noise. This is closely linked to components, circuits and equipment design, which are not included in this bibliography. Circuit noise has been the subject of intensive investigations during the last three decades and there appears no need to assemble a detailed bibliography at this time. There is, however, a subdivision (1.702) within the general section, which lists a number of books and surveys on the subject of circuit noise. These references may guide the reader to older publications in this area.

Two other closely related subjects are not considered in this division. They are the subject of equipment interference (electromagnetic compatibility) and the subject of noise sensitivity of the various modulation systems (noise immunity). The reason for the first omission is its close association with equipment design, The exclusion of the second subject is based on the fact that most problems in this area are referenced in other divisions in connection with the various modulation methods.

All other kinds of channel disturbances and related problems are arranged in five sections. The first is again the analytical section dealing with Gaussian and non-Gaussian noise. This is followed by sections about natural noise, man-made disturbances, communications noise and jamming.

Section 1.70:
General Information on Noise

1.701: Noise and Disturbances in General

Included: Books and surveys on noise.

Not Included: Electromagnetic compatibility problems; Extra-terrestrial noise sources; Noise measurements.

Cross References: Fundamentals of statistical mathematics (Sect. 1.11); Noise characteristics of various analog modulation methods (Div. 1.2); Noise characteristics of various digital modulation methods (Div. 1.3); Noise characteristics of pulse communications methods (Div. 1.4); Noise characteristics of pulse code modulation (Div. 1.5); Surveys of thermal agitation noise (1.702).

Principal Publications:

METHODS OF SOLVING NOISE PROBLEMS
W. R. Bennett, Proc. IRE, vol. 44, May 1956, p. 609/638.

THE SYNTHESIS OF ATMOSPHERIC FORMS AND THE EFFECTIVE PARAMETERS OF THE LOWER PART OF THE IONOSPHERE AT LOW FREQUENCIES
L. Al'pert, et al., Radio Engrg. & Electronics, vol. 4, no. 2, 1959, p. 65/77.

THE VERY LOW-FREQUENCY EMISSIONS GENERATED IN THE EARTH'S EXOSPHERE
R. M. Gallet, Proc. IRE, vol. 47, Feb. 1959, p. 211/231.

LE BROUILLAGE DES IMAGES DE TELEVISION PAR LES SIGNAUX PARASITES (The Disturbances of Television Pictures by Noise and Interference) (In French)
L. Goussot, L'Onde Electrique, vol. 39, May 1959, p. 352/361.

CIRCUIT THEORY OF LINEAR NOISY NETWORKS
H. A. Haus and R. B. Adler, New York: John Wiley and Sons, Inc., 1959, 79 p.

EFFECTS OF NOISE IN TELEVISION TRANSMISSION
T. Kilvington, J. Televis. Soc., vol. 9, Jan.-March 1959, p. 26/31.

CCITT RECOMMENDATIONS FOR MULTICHANNEL RADIO RELAYS AND WHITE NOISE
C. A. Parry, Commun. and Electronics, May 1959, p. 107/117.

INFORMATION TRANSMISSION, MODULATION, AND NOISE: A UNIFIED APPROACH TO COMMUNICATION SYSTEMS
M. Schwartz, New York, McGraw-Hill Book Co., Inc., 1959, 461 p.

OBSERVATIONS OF ATMOSPHERIC RADIO NOISE
G. R. A. Ellis, Nature, vol. 186, no. 4720, April 1960, p. 229.

Recent observations of radio noise at a frequency of 5 kc/s appears frequently to come from sources of limited geographical size.

SOME PROBLEMS CONCERNING NOISE IN WIDE-BAND CARRIER SYSTEMS
S. Janson, et al., Ericsson Tech., vol. 16, no. 1, 1960, p. 3/42.

TRANSMISSION PERFORMANCE IN PRESENCE OF CIRCUIT NOISE
F. Markman, Ericsson Tech., vol. 16, no. 2, 1960, p. 165/206.

Comprehensive work on transmission performance in the presence of circuit noise of different types has been done during the last decade by telephone administrations . . . and the CCITT Laboratory in Geneva. . . . tests. . . were made using the AEN technique; as this method suffers from many serious artificialities a new method, based on the opinions of ordinary telephone users, has been adopted by the . . . CCIT. . . . Results obtained from both methods are given. . . .

NOISE IN A PCM TRANSMISSION SYSTEM
H. Scheftelowitz, Ericsson Tech., vol. 16, no. 2, 1960, p. 207/244.

The different noise sources in a p. c. m. transmission system have been evaluated and their impact on the overall signal-to-noise ratio calculated. Formulae are given which show the signal-to-noise ratio in relation to repeater spacing. . . .

INTERFERENCE SUPPRESSION IN HOUSEHOLD APPLIANCES
F. A. Thebridge, Proc. Instn. Radio Engrs., Australia, vol. 21, no. 9, Sept. 1960, p. 577/580.

VYDELENIE SIGNALOV NA FONE SLUCHAINYKH POMEKH (The Isolation of Signals in a Background of Random Noise) (In Russian)
L. A. Vainshtein and V. D. Subakov, Moscow, Izd. Sov. Radio , 1960, 448 p.

. . . deals with the use of statistical methods for determining and evaluating the optimum means of isolating signals in different backgrounds of statistical-type interference. . . . Part I . . . optimum linear filters . . . Part II . . . general theory of optimum receivers, . . . problem of checking statistical hypotheses. . . . different cases of detecting useful signals and the evaluation of their unknown parameters. . . . Part III . . . problems in interference theory . . . statistical description of certain types of interference . . . intended for scientific workers, engineers, students and instructors . . .

PROPRIETES STATISTIQUES DU BRUIT DE FOND (Statistical Characteristics of Noise), (In French)
A. Blanc-Lapierre, B. Picinbono, Paris, Masson, 1961, 104 p.

NOISE AND RANDOM PROCESSES
J. R. Ragazzini, et al., New York U. Coll. of Engineering, N. Y., Oct. 1961, 35 p., (Tech. rept. 400-40), AD 269 567.

. . . theory of noise and random processes in electronic devices was developed in two states . . . first stage . . . nature and effects of noise in vacuum tubes and circuits. The second stage, initiated by Wiener . . . established the theoretical basis for synthesizing systems which optimized the transmission and detection of signals in the presence of noise . . . Only highlights and significant stepping stones in the development of the theory are described.

BRUIT RADIOELECTRIQUE D'ORIGINE TERRESTRE (Radio Noise of Terrestrial Origin) (In English)
F. Horner, Amsterdam, Elsevier Publishing Co., 1962, 203 p.

NOISE AND FLUCTUATIONS: AN INTRODUCTION
D. K. C. MacDonald, New York, John Wiley and Sons, Inc., 1962, 100 p.

. . . emphasis is on basic physical principles. . . . Arguments are based on experiments and physical intuition . . .

NOISE AND RANDOM PROCESSES
J. R. Ragazzini, et al., Proc. IRE, vol. 50, May 1962, p. 1146/1151.

COMMUNICATION IN RANDOM OR UNKNOWN CHANNELS
C. K. Rushforth, Stanford Electronics Lab., Stanford U., Calif., July 1962, 62 p. incl. illus., 19 refs., (Rept. no. SEL-62-086; Technical rept. no. 2004-6), AD 283 083.

. . . problem of communicating in the presence of random or unknown multiplicative disturbances . . . signal selection . . . design and evaluation of the associated receiver. . . . optimum signals for a known channel can be the worst possible

signals for the unknown or random channel. . . . Evaluation of the error probability for the transmitted-reference system for various situations indicates that, for a fixed signal-to-noise ratio, the error probability increases as the time-bandwidth product increases.

ROCKET OBSERVATIONS OF VERY LOW FREQUENCY RADIO NOISE AT NIGHT
D. G. Cartwright, Planetary and Space Science, vol. 12, Jan. 1964, p. 11/16, 10 refs., A64-15082.

Observation of diffuse whistlers, with sometimes a single echo, during a nighttime rocket flight; none were observed on the ground at the same time . . . A band of hiss, centered at about 2.8 kc, 2 kc wide, and deeply modulated by spin, was also observed at the rocket but not on the ground. It is suggested that, even at night, many more VLF phenomena can be observed above the ionosphere than on the ground.

EFFECTIVE ANTENNA TEMPERATURE FROM TERRESTRIAL AND COSMIC NOISE IN THE 0.1- TO 40.0-Gc BAND
A. Naparstek, Institute of Science and Tech., U. of Michigan, Ann Arbor, March 1963, 41 p., AD 406 215.

. . . for an antenna viewing a multitude of discrete and distributed radio-frequency noise sources . . . comprehensive review and analysis of current knowledge of and available data on radio frequency noise of terrestrial and extraterrestrial origin in the 0.1- to 40.0-Gc frequency band . . . The report also shows how to determine realistic bounds for the effective antenna temperature of antennas located in aerospace.

A NOTE ON "VERY NOISY" CHANNELS
B. Refifen, Lincoln Lab., Mass. Inst. of Tech., Lexington, June 1963, 5 p., AD 416 195.

. . . a 'very noisy' channel is defined. This definition corresponds to many physical channels operating at low signal-to-noise ratio. . . . the computation cutoff rate for sequential decoding, R (comp), is shown to be one-half the capability, C . . .

CONTRIBUTIONS TO SIGNAL AND NOISE THEORY
D. Slepian, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 229/233, 115 refs.

DIVERSITY RECEPTION OF NONFADING FREQUENCY SHIFT KEYING
J. K. Wolf, Rome Air Development Center, Griffiss AFB, N. Y., Jan. 1964, 23 p., refs., RADC-TDR-63-475; AD 431 870, N64-17302.

. . . Both a noncoherent receiver system and a coherent receiver system are considered . . . compared for both manmade and natural interference . . .

A STUDY OF "PROPAGATION MEDIUM RF NOISE"
Smyth Research Associates, San Diego, Calif., Interim engineering rept. no. 3, Jan.-March 1964, March 1964, 29 p., Rept. no. 384, AD 433 630.

The effects of the propagation medium noise upon long distance, line-of-sight, tropospheric microwave circuits are examined. . . . modulates the phase, amplitude, and angle of arrival of the signal. . . . phase noise (time frequency noise) will not be serious in the case of transmission between fixed terminals if the video bandwidth is properly chosen. In particular, frequency components of less than 0.1 cps should be excluded by the video filter. The angle of arrival noise (space frequency noise) may become serious if fixed antennas with beamwidths of less than one degree are used. The amplitude modulation, which is apparently due to some sort of atmospherically modified multipath situation, lead to 25 db fades for a period of time which will be important for high reliability circuits. When one or both of the terminals are moving, the effects of the propagation medium noise should be considerably more serious. . . .

1.702: Reviews of Thermal Agitation Noise

Included: Books, surveys, reviews on circuit noise; Reviews of transistor noise.

Not Included: Physics and theory of noise in electronic devices; Low noise components; Low noise amplifiers; Noise in parametric amplifiers; Masers; Lasers (3B); Noise in millimeter wave components (3B).

Cross References: Fundamentals of statistical mathematics (Sect. 1.11); Noise characteristics of various analog modulation methods (Div. 1.2); Noise characteristics of various digital modulation methods (Div. 1.3); Noise characteristics of pulse communications methods (Div. 1.4); Noise characteristics of pulse code modulation (Div. 1.5); Surveys of thermal agitation noise (1.702).

Principal Publications:

NOISE IN ELECTRON DEVICES
L. D. Smullin and H. A. Haus (editors), London, W.C. 2, Chapman & Hall Ltd., 1958, 413 p.

THE AUTOCORRELATION AND THE POWER SPECTRUM OF NONSTATIONARY SHOT NOISE
L. P. Hyvärinen, Acta Polytech. Scandinavica, 1958, p. 23.

THE SPECTRAL DENSITY OF THE A.M. NOISE IN REFLEX KLYSTRONS
H. Haggblom, Proc. Inst. Elect. Engrs., London, pt. B, 106, no. 30, Nov. 1959, p. 497/500.

THE SECOND-ORDER DISTRIBUTION OF INTEGRATED SHOT NOISE
J. Keilson, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 75/77.

THE SPECTRUM OF FLICKER NOISE
A. N. Malakhov, Radio Engrg. & Electronics, vol. 4, no. 1, 1959, p. 86/100.

NOISE THEORY FOR HOT ELECTRONS
P. J. Price, IBM J. Res. Developm., vol. 3, no. 2, April 1959, p. 191/193.

FLUCTUATION PHENOMENA IN SEMICONDUCTORS
A. van der Ziel, Bethesda, Maryland, Butterworth, Inc., 35S, 1959, 168 p.

AMPLITUDE DISTRIBUTION OF SHOT NOISE
E. N. Gilbert, et al., Bell Syst. Tech. J., vol. 39, no. 2, March 1960, p. 333/350.

A NOTE OF THE LOCAL STRUCTURE OF SHOT NOISE
R. A. Silverman, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 548/550.

It is shown how to construct shot noise which, like the turbulent velocity field, is quite accurately univariate normal, but exhibits marked departures from bivariate normality at close ranges . . .

NOISE AND INTERMODULATION PROBLEMS IN MULTICHANNEL CLOSED-CIRCUIT TELEVISION SYSTEMS
C. A. Collins, et al., Commun. Electronics, vol. 80, no. 57, Nov. 1961, p. 486/491.

In the past decade there has been a rapid growth in communication facilities designed to transmit television (TV) signals relatively short distances over coaxial cables. These systems handle six or more video signals which amplitude-modulate (AM) r-f (radio-frequency) carriers in the 8- to 220-mc (megacycle) range. The associated audio signals frequency-modulate (FM) r-f sound carriers whose rest frequencies are 4.5 mc away from their associated picture carriers. . . . This paper will discuss two problems . . . thermal noise and intermodulation products created by amplifier nonlinearity. . . .

VARIATION OF L.F. NOISE FIGURE OF A JUNCTION TRANSISTOR
S. Deb, et al., J. Brit. Instn. Radio Engrs., vol. 21, no. 1, Jan. 1961, p. 49/56.

UBER DAS RAUSCHEN VON STROMLOSEN WIDERSTANDEN UND HALLELEMENTEN (Noise in Current-free Resistors and in Hall Elements) (In German)
C. B. Burckhardt, et al., Arch. Elekt. Uebertragung, vol. 16, Dec. 1962, p. 597/599.

. . . It is pointed out that the formula for thermal noise of a resistor, which is often called H. Nyquist's formula, was derived about 16 years earlier by G. L. de Haas-Lorentz and H. A. Lorentz. This deviation, which is based on a thermodynamic treatment, is given because of its lucidness and because it seems to be little-known. The result of course is the same as H. Nyquist's. Furthermore a treatment of thermal noise of Hall-elements is given. . . .

ON THE TWO-GENERATOR METHOD (e_n, i_n) OF NOISE CHARACTERIZATION (Correspondence)
H. F. Cooke, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2520/2521.

A system of noise measurement first proposed by Rothe has been gaining popularity recently as a method for noise characterization of transistors at low frequencies. . . .

A COMPARISON BETWEEN THERMAL AND QUANTUM NOISE IN RADIO RECEPTION
C. Ducot, Philips Res. Rep., vol. 17, no. 4, Aug. 1962, p. 382/392.

. . . comparison between disturbances due to thermal agitation and signal-energy quantization in radio reception, extended up to optical frequency ranges . . . disturbing effect of photon quantization in the received signal . . .

INCOHERENCE, QUANTUM FLUCTUATIONS, AND NOISE
I. R. Senitzky, Phys. Rev., vol. 128, no. 6, Dec. 1962, p. 2864/2870.

An examination is made of the relationship between the uncertainty principle and minimum amplifier noise. First, the concept of coherence is discussed, and an incoherence parameter is defined in terms of the uncertainty that enters into the uncertainty principle. Harmonic oscillator states are examined for coherence. The concept of noise is then discussed and contrasted with incoherence, noise referring to behaviour in time of a single system while incoherence involving comparison among members of an ensemble. It is shown, with illustrations, that the two concepts are different, and that an incoherent field of a cavity need not exhibit noise.

THE FUNDAMENTAL NOISE LIMIT OF LINEAR AMPLIFIERS (Correspondence)
R. M. Bevensee, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 245.

The question of the noise limit of a linear amplifier is far more subtle than Heffner's quick article suggests. In this note . . . three facets of the question; 1) the noise limit as given by Heisenberg's Uncertainty Principle is usually unrealistically low, 2) noise must generally be regarded as a time-varying, nonstationary phenomena, and 3) a complete analysis must include the noise introduced by the source of energy as well as by the dissipation mechanism.

NOISE MEASUREMENTS IN FIELD-EFFECT TRANSISTORS (Correspondence)
W. C. Bruncke, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 378/379.

Van der Ziel has given a theory of noise in field-effect transistors. It is the aim of this note to compare some predictions of this theory with experiment. . . .

NOISE BEHAVIOR IN SEMICONDUCTOR DEVICES
E. G. Fonda, Electronic Industries, vol. 23, April 1964, p. 72/78, 12 refs., A64-16939.

. . . a key transistor device design. Briefly considered are the different types of noise and their origin, and it is shown how minimum noise figure (NF) can be secured for transistor circuit design. . . .

HIGH-FREQUENCY NOISE IN PROBES IMMERSED IN GAS DISCHARGES
A. R. Galbraith, et al., Physica, vol. 29, Nov. 1963, p. 1165/1173, A64-13470.

. . . The noise below 30 Mc was measured with a preamplifier followed by a radio receiver and a quadratic detector. . . .

RESEARCH ON SOLID STATE NOISE DEVICES
Annual Scientific Report (June 13, 1962-July 31, 1963)
R. H. Haitz, Clevite Corp, Palo Alto, Calif., Shockley Lab., Aug. 1963, 99 p., 28 refs., N63-23376.

. . . This report is concerned with two problems: (1) the investigation of the basic mechanisms of avalanch breakdown and (2) their application to the generation of high-amplitude white noise with considerable temperature independence . . .

A METHOD FOR SUPPRESSING PHOTO-MULTIPLIER NOISE
R. W. Hill, et al., California U., Livermore, Lawrence Radiation Lab., Jan. 1, 1963, 10 p., 7 refs., N63-17537.

. . . Since noise pulses occur at random and the individual signal pulses are correlated by the decay time of the scintillator, it is possible to separate the signal pulses due to two or more photoelectrons from the noise by making use of this time correlation.

INTERNAL NOISE
R. B. Muchmore, IN: SPACE COMMUNICATIONS, Edited by A. V. Balakrishnan, New York, McGraw-Hill Book Co., Inc., 1963, p. 71/84, 18 refs., A64-11234.

. . . definitions of noise figure and noise temperature . . . characteristics of thermal noise, shot noise, and spontaneous-emission noise. . . .

ETUDE DU BRUIT DE FOND DANS LES JONCTIONS p-n DE GERMANIUM A COURANT DE GENERATION (Study of the Noise in Germanium Functions) (In French)
M. Savelli, et al., Ann. Telecomm., vol. 18, no. 7-8, July/Aug. 1963, p. 163/172.

GATE NOISE IN FIELD EFFECT TRANSISTORS AT MODERATELY HIGH FREQUENCIES
A. van der Ziel, Proc. IEEE, vol. 51, no. 3, March 1963, p. 461/467.

NOISE IN MULTI-DIMENSIONAL ELECTRON STREAMS
C. P. Wen, Electron Physics Lab., U. of Michigan, Ann Arbor, March 1963, 202 p., AD 406 863.

STUDY OF NOISE IN SEMICONDUCTOR DEVICES
Minnesota U., Minneapolis, Quarterly rept. no. 1, 1 Aug.-30 Nov. 1963, 30 Nov. 1963, 1 v., AD 436 874.

Equipment for stabilizing the operating point of FET's and for pulsing GaAs lasers has been built noise measurements on Crystalonics FET's at low temperature revealed an excess noise that is not of the generalization-recombination types. . . .

Related Publications:

TECHNIQUES OF MICROWAVE NOISE MEASUREMENT
B. G. Bosch, et al., J. Brit. Instn. Radio Engrs., vol. 21, no. 6, June 1961, p. 503/515, 30 refs.

. . . some aspects of microwave oscillator noise . . . various techniques of noise measurement. The latter include a.m. and f.m. direct detection and superheterodyne methods as well as systems for the measurement of correlation.

Section 1.71
Analysis of Noise and Disturbances

Reviews of publications in statistical mathematics are in section 1.11. In particular, there are references to recent publications on Gaussian processes and on special distributions of other random processes. Subdivision 1.119, on the experimental evaluation of statistical populations, may be of special interest.

This section deals with applications of statistical mathematics in the analytical treatment of Gaussian and non-Gaussian noise processes. Subdivision 1.716 has examples of the analytical treatment of problems concerning the passage of signal plus noise through various circuits. The collection of references in this area is not complete. Only some references have been selected for demonstrating the application of noise analysis; there is no intention to cover the wide field of circuit analysis with random input excitation. Similar restrictions have been applied in the selection of references for the subdivision 1.714 and 1.715.

The subdivision 1.717 on pulsive noise analysis is to be considered in conjunction with subdivision 1.743 on pulsive noise in telephone circuits. Most publications in this area report on experimental observations, but they usually also contain an analytical section. To save space, we avoided duplicate entries of references.

1.711: Assessment Measures for Noise and Distrubances

Included: Scale of measurement for noise; Physical attributes of noise; Numerical magnitudes to assess the influence of disturbances; Definition of signal-to-noise ratio; Signal contrast; Units for noise.

Not Included: Equipment for noise measurement.

Cross References: Experimental evaluation of statistical populations (1.119); Computer simulation of noise and disturbances (1.719).

Principal Publications:

CARRIER-TO-NOISE STATISTICS FOR VARIOUS CARRIER AND INTERFERENCE CHARACTERISTICS
K. K. Clark, et al., Proc. IRE, vol. 46, May 1958, p. 889/895.

EQUIVALENT CIRCUITS OF NOISY NETWORKS
L. Young, Electrical Engrg., vol. 30, April 1958, p. 205/207.

SOME RESULTS ON NOISE THROUGH CIRCUITS
W. M. Brown, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 217/227.

NOISE PARAMETERS IN VHF-UHF CIRCUIT DESIGN
C. Metelmann, Electronic Industr., vol. 18, July 1959, p. 90/93.

DIE STÖRWIRKUNG BEI UNGLEICHMASSIGER SPEKTRALVERTEILUNG DER STÖRSCHWANLUNGEN (The Effect For Uneven Spectral Distribution of Disturbances) (In German)
E. Sennhenn, Elektronische Rundschau, vol. 13, Jan. 1959, p. 9/12.

EVALUATION OF MESSAGE CIRCUIT NOISE
A. J. Aikens, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 879/909, 16 refs.

. . . measuring some physical attribute of the electrical noise such that two noises that are judged to be equally interfering are assigned approximately equal numerical magnitudes. To give meaning to such magnitudes, the scale of measurement is related by way of subjective assessment into terms useful to telephone engineering. . . . characterization of the relative interfering effect of single-frequency noise components and the way the ear combines these components to indicate the total effect. The correlation between a noise measurement and its associated over-all end-effect may be made by finding the transmission-loss equivalent of the noise being measured or by the direct application of telephone-user opinions expressing degree of transmission satisfaction. . . .

UNITS FOR CURRENT NOISE
P. L. Kirby, et al., Electronic Engrg., vol. 32, no. 389, July 1960, p. 412/413.

REPRESENTATION OF NOISE IN LINEAR TWOPORTS
Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 69/74.

PARASITIC MODULATION CAUSED BY SMALL ADDITIVE NOISE
E. L. Blokh, et al., Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 11, Nov. 1962, p. 3/13.

General relations are derived for the signal/noise ratio when a carrier is acted on by small additive noise. A geometric interpretation of the problem is given. As an example, a carrier in the form of a sequence of trapezoidal pulses is examined. The possibility of compensating the parasitic modulation by variation of unmodulated parameters of the carrier is discussed. . . .

NOISE FIGURES, NOISE TEMPERATURES, AND SYSTEM SENSITIVITY
P. H. Enslow, Jr., Stanford Electronics Lab., Stanford U., Calif., 10 July 1961, 111 p., (Tech. rept. 516-2), AD 265 552.

. . . definitions of terms used in systems noise work. . . a unified development of 7 noise temperatures encountered in this field, with tables showing the relationships among them and their uses. A general technique for calculating the sensitivity of a receiver is presented and 3 examples are treated in detail: the simple crystal-video system, the crystal-video receiver with RF pre-amplification, and the superheterodyne system. All systems are divided into 2 classes for which the calculations are similar: receivers having only a simple detector, and those having some form of linear amplification preceding the detector. The final analysis of the noise performance of the system requires a comparison of the pre-detection excess noise.

A COMPLETELY CONSISTENT DEFINITION OF TEMPERATURE SENSITIVITY INCLUDING NEGATIVE CONDUCTANCE DEVICES (Correspondence)
S. T. Fisher, Proc. IRE, vol. 50, Feb. 1962, p. 204.

. . . the most widely-used criterion of receiver sensitivity is the noise figure. . . . Another criterion, which the author believes to be far more useful than noise figure, is the temperature sensitivity or system noise-temperature of the receiver. This quantity refers the total noise in the system to the receiver input and expresses it in dimensions of degrees Kelvin.

CONFIDENCE INTERVALS AND SAMPLE SIZES IN THE MEASUREMENT OF SIGNAL AND NOISE POWERS, SIGNAL-TO-NOISE RATIOS AND PROBABILITY OF ERROR
J. Holsinger, Lincoln Lab., Mass. Inst. of Technology, Lexington, 3 Jan. 1963, 42 p. incl. illus, 9 refs., (Rept. no. 34G-9), AD 295 133.

The estimation errors involved in both discrete and continuous estimates of certain parameters of a Gaussian random process is considered. . . .

PEGELANGABEN IN DER UBERTRAGUNGS-TECHNIK (Level Indication in Transmission Techniques) (In German)
W. Zaiser, Nachrichtentech. Z., vol. 16, Sept. 1963, p. 461/463, 11 refs., A63-24422.

Description of the new "C-message weighting curve" for signal noise. Reference is made to a nomogram with 14 scales which covers white noise in the low frequency range from 0.3 to 3.4 kc.

Related Publications:

A NEW MEASURING SET FOR MESSAGE CIRCUIT NOISE
W. T. Cochran, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 911/931.

. . . The sensitivity of the set is such that it can detect—90 dbm. This value is chosen as the new reference for measurement and is defined as "zero dbrn" . . .

FLUCTUATIONS FROM THE NONEQUILIBRIUM STEADY STATE
M. Lax, Rev. Mod. Phys., vol. 32, no. 1, Jan. 1960, p. 25/64.

Method of Solving Markoffian Noise Problems
Connections with Onsager, Einstein, Langevin, and Thevenin
Generalizations of Our Method to Continuous Parameters and Nonlinear Systems

SITE NOISE AND ITS CORRELATION WITH VEHICULAR TRAFFIC DENSITY
A. G. Ellis, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 1, Jan. 1963, p. 45/52.

In the VHF and UHF ranges, one of the major parameters associated with the prediction of radiotelephone system performance is the effective noise factor. This factor is a combination of the receiver's internal noise factor, a relatively small and constant component, and another noise factor, called the site noise factor, which assesses the intensity of the noise fields enveloping the receiver's antenna. Although this latter component has long been known to vary from site to site, its magnitude for planning purposes has hitherto been arbitrarily set at one of several discrete levels, the one chosen being determined solely by the size of the city in the vicinity of the site. This paper shows that predictions of greater accuracy are obtained when the site noise is related to the nearby traffic density, and as a result of measurements taken at various sites in Victoria and New South Wales, suggests the law between them. . . .

1.712: White Gaussian Noise

Included: Duration of noise peaks; Number of overshoots in normal noise; Zero-crossing problem for normal noise; One-sided barrier problem.

Not Included: Physics of noise sources; Circuit noise analysis.

Cross References: Zero-crossing problem of Gaussian processes (1.112).

Principal Publications:

MATHEMATICAL ANALYSIS OF RANDOM NOISE
S. O. Rice, Bell Syst. Tech. J., vol. 23, July 1944, p. 282/332; vol. 24, Jan. 1945, p. 46/158.

TIME STATISTICS OF NOISE
W. M. Brown, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 137/144.

. . . measurements on noise are usually time averages. . . called time statistics.

SIMULTANEOUS VARIATION OF AMPLITUDE AND PHASE OF GAUSSIAN NOISE, WITH APPLICATIONS TO IONOSPHERIC FORWARD-SCATTER SIGNALS
T. Hagfors, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 105, Nov. 1958, p. 555/559.

FLUCTUATIONS OF RANDOM NOISE POWER
D. Slepian, Bell Syst. Tech. J., vol. 37, no. 1, Jan. 1958, p. 163.

The probability distribution of the power, y, of a sample of Gaussian noise of time duration T is considered. Some general theory is presented along with curves for the cumulative distribution and probability density of y for several different power spectra and values of T.

ZEROS OF GAUSSIAN NOISE
G. M. White, J. Appl. Phys., vol. 29, April 1958, p. 722/729.

GENERATION OF A SAMPLED GAUSSIAN TIME SERIES HAVING A SPECIFIED CORRELATION FUNCTION
M. J. Levin, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 545/548.

A computationally convenient method is presented for simulating a sequence of sampled values of a stationary Gaussian process having a specified correlation function or power spectrum. Z-transform theory is applied to provide a simple recursive formula for generating the values from a set of independent Gaussian random variables.

PROBABILITY DENSITY FOR THE DURATION OF FLUCTUATIONS
V. I. Tikhonov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 9, 1960, p. 10/24, 15 refs.

. . . study. . . of three approximate methods of calculating the probability density for the duration of the peaks of normal stationary fluctuations and certain experimental results are given. The field of application of the various methods is shown by comparing the theoretical probability densities with the experimental results.

EXPERIMENTAL INVESTIGATION OF THE DURATION OF NOISE PEAKS
A. I. Velichkin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 28/35.

The probability density of the duration of peak periods and intervals between peaks is experimentally determined at different levels of Gaussian noise and Rayleigh noise. . . .

THE AXIS CROSSINGS OF A STATIONARY GAUSSIAN MARKOV PROCESS
J. A. McFadden, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 150/153.

. . . In a stationary Gaussian Markov process (or Ornstein-Uhlenbeck process) the expected number of axis crossings per unit time, the probability density of the lengths of axis-crossing intervals, and the probability of recurrence at zero level do not exist as ordinarily defined . . . In This paper new definitions are presented and some asymptotic formulas are derived.

SOME COMBINATIONS OF NOISE SIGNALS (Correspondence)
K. Abend, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2518/2519.

. . . two independent Gaussian noise signals . . . The cumulative distribution function of N_i . . . The density function of a full-wave rectified noise signal. . .

ZERO-CROSSING INTERVALS OF GAUSSIAN PROCESSES
A. J. Rainal, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 372/278.

. . . Probabilities and probability densities defined by the zero-crossing points of Gaussian processes having various power spectral densities are presented. At present none of the probabilities or probability densities can be derived explicitly by analytical methods. The results are compared with theoretical approximations. . . .

THE ONE-SIDED BARRIER PROBLEM FOR GAUSSIAN NOISE
D. Slepian, Bell Syst. Tech. J., vol. 4, no. 2, March 1962, p. 463/501.

PREFACE TO NORTH PAPER
L. Blake, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1015/1027.

This classic report, written in 1943 by Dwight O. North, appears here for the first time in a publication readily available to the engineering profession, although it was issued as a military-security-classified report during World War II (RCA Laboratories Report PTR-6C, dated June 25, 1943). It is reprinted here because of its historical importance and because it is still a basic but otherwise unavailable reference of great value in current research. . . .

A GENERALIZATION OF A MARKOFF ENVELOPE PROCESS (Correspondence)
R. Esposito, Proc. IEEE, vol. 51, no. 12, Dec. 1963, p. 1792.

It is well known that the envelope of the output of a high-Q single tuned RLC filter is a first-order Markoff process when the filter input is white Gaussian noise. The purpose of this communication is to show that the same result holds true for the perturbation of the envelope of a steady oscillation supported by a nonlinear element in parallel with the single tuned circuit driven by a white noise current. . . .

THE ZERO-CROSSING PROBLEM
H. Levenbach, Queen's U., Kingston (Canada), Sept. 1963, 116 p., refs., (Res. Rept. 63-4), N64-16943.

. . . expository survey of the zero-crossing problem is presented. . . concerned with the probabilities and probability densities defined by the zero-crossing points of a stationary random process. At present none of the probabilities or probability densities can be derived explicitly by analytical means. . . applied to the case of the gaussian processes. . . comparing the empirical and theoretical results. Finally, a complete list of the mathematical, physical, and engineering references is compiled, including those of closely related topics.

PERIODOGRAM FOR COMPLEX GAUSSIAN RANDOM PROCESSES (Correspondence)
C. L. Mehta, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 165.

Much interest has recently been shown in the complex Gaussian processes (1)-(5). A well known property of a real Gaussian process is that only the second-order moments are sufficient to describe the process completely, since all the higher-order moments are expressible in terms of second-order ones (6). . . .

ZERO-CROSSING INTERVALS OF RANDOM PROCESSES
A. J. Rainal, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., April 1963, 41 refs., Technical rept. no. AF-102, AD 401 148.

A digital system for studying the zero-crossing intervals of random processes is described. Probabilities and probability densities defined by the zero-crossing points of various Gaussian processes are presented. . . . sine wave plus a Gaussian process. . . . . At present none of the probabilities or probability densities can be derived explicitly by analytical methods. . . . correlation coefficients for two successive intervals are presented. The first moments associated with the probability densities are compared with the exact theoretical values.

ERROR OF THE GAUSSIAN APPROXIMATION (Correspondence)
D. Silber, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1259.

By the Central Limit Theorem, the probability density function of the sum of a number of independent random variables having arbitrary (within the validity of the Central Limit Theorem) probability densities approaches a Gaussian density as the number of added random variables becomes large. An assumed Gaussian density for the sum of a finite number of random variables will have an error that decreases (assuming the same probability density for each added random variable) as the number of added variables increases. . . there is little information in the literature on evaluation of the error. In particular, information concerning the error of the "tails" (of interest in finding the probability of false alarm) is lacking. Following is an evaluation of this error for rectangular individual densities, carried out with the aid of a digital computer. . . .

DISPERSIIA CHISLA VYBROSOV V REALIZATSIIAKH NORMAL'NOGO SHUMA KONECHNOIDLITEL'NOSTI (Dispersion of the Number of Overshoots in a Normal Noise of Finite Duration) (In Russian)
V. I. Tikhonov, Radiotekhnika i Elektronika, vol. 9, Jan. 1964, p. 45/52, 10 refs., A64-15779.

. . . formulas for the dispersion number of "positive" zeros in a normal stationary noise with the Gaussian spectral density. . . .

Related Publications:

THE AXIS-CROSSING INTERVALS OF RANDOM FUNCTIONS—II
J. A. McFadden, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 14/24.

CORRELATION FUNCTION AND POWER SPECTRA OF RADIO LINKS AFFECTED BY RANDOM DIELECTRIC NOISE
D. S. Bugnolo, IRE Trans. Antennas Propagation, vol. AP-7, April 1959, p. 137/141.

. . . of an electromagnetic wave by an extension of the notions of time-variable linear networks. . . .

STATISTICAL ANALYSIS OF NOISE-SIGNAL AMPLITUDES
D. Hoffman, et al., Electronics, vol. 32, no. 24, July 1959, p. 48/50.

DETECTABILITY OF SMALL IRREGULARITIES IN A BROADBAND NOISE SPECTRUM
C.I. Malme, MIT, Res. Lab., no. 52, Jan. 1959, p. 139/142.

ON THE USE OF LAGUERRE POLYNOMIALS IN TREATING THE ENVELOPE AND PHASE COMPONENTS OF NARROW-BAND GAUSSIAN NOISE
I.S. Reed, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959.

The joint probability density of the envelope of a Gaussian process at two different times is expanded by the use of Hardy's identity into a series involving Laguere polynomials. It is shown how this result may be used to estimate the cross-correlation function of the output of two quite general envelope-distorting filters.

ON THE CHARACTERISTIC FUNCTION OF A STATIONARY RANDOM PROCESS WITH GAUSSIAN ENVELOPE (Correspondence)
R. Esposito, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1997.

. . . two recent letters to the editor by Bunkin and Gudzenko . . .

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J.M. Kirshner, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

The concept of signal space allows one to apply geometric principles to waveforms used in communication. Its use enables a number of interesting conclusions to be drawn. . . . 2. Orthogonality of Functions . . . 3. Modulation, Demodulation, and the Sampling Theorem . . . 4. The Sampling Theorem and Separation of Channels . . . 5. Noise and Channel Capacity . . . 7. Rotation of Coordinates and the Number of Independent Channels . . . 8. Orthogonality of Gaussian Noise Signals. . . .

ON THE LENGTHS OF INTERVALS IN A STATIONARY POINT PROCESS
J.A. McFadden, J. Royal Statistical Society, Series B (Methodological), 24:2, p. 364/382, 1962, AD-403 555.

Relations are given between the various probability functions and moments are considered. Two different random variables are introduced for the lengths of intervals, according to whether the measurement is made from an arbitrary event or beginning at an arbitrary time, and their properties are compared. In particular, new properties are derived for the correlation coefficients between the lengths of successive intervals. Examples are given. . . . application to the theory of binary random processes and to the zeros of a Gaussian process.

THE NORMAL BIVARIATE DENSITY FUNCTION AND ITS APPLICATIONS TO WEAPON SYSTEMS ANALYSIS, A REVIEW
H.C. Sebring, General Electric Co., Philadelphia, Pa., 10 April 1962, 27 p., AD 412 332.

. . . It is discussed in terms of probability area in a plane, and as a correlation surface. Several numerical methods of solving the normal bivariate distribution double integral are presented, and a curve is included for converting elliptical error distributions to circular probable errors. Regression and correlation coefficients are discussed. . . .

ON THE BINARY DATA TRANSMISSION ERROR RATES DUE TO COMBINATIONS OF GAUSSIAN AND IMPULSE NOISE
L.R. Halsted, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Dec. 1963, p. 428/435.

Error rates are computed for a binary data transmission system subject to both Gaussian and impulse noise. The rates are displayed as a function of λT where T is the signal duration and λ^{-1} is the average time between noise pulses. Poisson-distributed impulse noise and periodically recurring noise pulse clusters are considered. . . .

The computed error rates illustrate, for data transmission systems subject to impulsive interference, the reduction in error rate that can be realized by increasing the signal duration. The simultaneous transmission of orthogonal signals is discussed. This makes it possible to use signals having a long duration without reducing the data rate or causing inter-signal interference; this can be done without requiring additional bandwidth. . . .

1.713: Stationary Noise in General

Included: Wide band non-Gaussian noise; Colored noise; Non-white noise; Frequency dependent noise.

Cross References: Band limited gaussian noise; (1.714); Markov processes (1.113); Non-gaussian processes (1.114); Special distributions of random processes (1.117); Pulsive noise analysis (1.717); Pulsive noise analysis (1.717); Pulsive noise in communications facilities (1.743).

Principal Publications:

SOME SPECTRAL PROPERTIES OF WEIGHTED RANDOM PROCESSES
H. S. Shapiro, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 123/128.

THE PASSAGE OF WHITE AND FREQUENCY-DEPENDENT NOISE THROUGH AN AMPLIFIER WITH A LOW Q-FACTOR
G. V. Voishvillo, et al., Radio Engng: Transl. of Radiotekhnikda, vol. 15, no. 12, 1960, p. 29/34.

. . . results are given of calculating the mean square noise voltage at the output of an amplifier with a low Q-factor consisting of one to three stages, in the presence of noise with a constant spectral density, or noise which varies according to the law 1/f, at the output.
The results are used to determine the ratio of the maximum instantaneous value of the pulse signal to the mean square noise voltage in the output circuit of the amplifier. . . .

ON THE APPROACH OF A FILTERED PULSE TRAIN TO A STATIONARY GAUSSIAN PROCESS
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 144/149.

. . . output of a narrow-band filter when the input is wide-band non-Gaussian noise of a certain class, and the bandwidth of the narrow-band filter approaches zero. The non-Gaussian input consists of a train of pulses having identical waveshapes, but random amplitudes and phases.

DATA TRANSMISSION OVER A NOISY GAUSSIAN CHANNEL
L. H. Zetterberg, K. Tekn. Hogsk. Handle, no. 184, 1961, 87 p., 46 refs.

. . . assumed . . . only . . . one-way transmission . . . phase distortion does not occur. The Gaussian noise present consists of one part of white noise and one-part of coloured or narrow-band noise of fixed power but arbitrary spectral density. The transmitter is fed with data which have a fixed information rate, and generates signals of finite duration and limited power, with certain restrictions on spectral content. . . . A binary coded 2-signal system is compared with a system using error-correcting codes, and also with a multi-signal system, the systems being rates according to the tolerated noise level.

EXPERIMENTAL INVESTIGATIONS OF THE PEAKS OF THE SMOOTHED ENVELOPE OF QUASI-SINUSODIDAL NOISE (Translation)
V. T. Goriainov, Telecommunications and Radio Engineering, Part II - Radio Engineering, March 1963, p. 1/8, A63-21031.

Description of a method for obtaining oscillograms of the smoothed envelope of quasi-sinusoidal noise. A method of processing the oscillograms to determine the statistical characteristics of the peaks of the smoothed envelope is given. . . .

DETECTION OF SIGNALS IN COLORED NOISE
B. Harris, New York U., Col. of Engineering, N.Y. May 1, 1962, 39 p., (NASA CR-50348; Tech. Memo. 25), N63-17231.

The basic concepts . . . are extended to include the case of additive non-white gaussian interference, i.e., that interference where the noise power per unit bandwidth is not the same at all frequencies. It is found that with nonwhite as with white noise, the correlation techniques are optimum, but the received signal is not correlated with the possible message signals, but with modified signals obtained from the characteristics of the message signals and the noise power spectrum. . . .

1.714: Bandlimited Gaussian Noise

Included: Two channel systems; Noise in partially correlated channels; Interchannel correlation in filter banks; Narrow band Gaussian noise; Generalized envelope.

Not Included: Bandfilter theory and design.

Cross References: Noise through nonlinear devices (1.715); Signal plus noise in circuits (1.716).

Principal Publications:

AN EXPERIMENTAL INVESTIGATION OF SOME PROPERTIES OF BAND-PASS LIMITED GAUSSIAN NOISE
K. Blotekjaer, IRE Trans. Inform. Th., vol. IT-4, no. 3, Sept. 1958, p. 100/102.

The probability distribution of time intervals between successive zero crossings of band-pass limited Gaussian noise is determined experimentally for a number of different filters having nearly rectangular frequency characteristics. For one particular filter the distribution of time intervals between crossings of levels different from zero is also found.

ENVELOPES AND PRE-ENVELOPES OF REAL WAVEFORMS
J. Dugundji, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 53/57.

. . . Rice's formula is very cumbersome . . . different formula . . . easier to handle analytically.

SUBJEKTIVE MESSUNGEN ÜBER DEN EINFLUSS DER SPITZENHALTIGKEIT VON BANDPASSRAUSCHEN AUF DIE EMPFIDNDUNG DER LAUTSTARKE (Subjective Measurements of the Influence of the Density of Noise Peaks in Band-Limited Noise on the Sensation of Loudness) (In German)
H. Niese, et al., Hochfrequenztech. u. ElektAkust, vol. 66, March 1958, p. 150/160.

A MARKOFF ENVELOPE PROCESS
J.N. Pierce, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 163/166.

It is shown that the envelope of a narrow-band Gaussian noise constitutes a first-order Markoff process if the power spectrum of the noise is the same as would be obtained from a singly tuned RLC filter with white noise at the input.

DISTRIBUTION OF THE DURATION OF FADES IN RADIO TRANSMISSION: GAUSSIAN NOISE MODEL
S.O. Rice, Bell Syst. Tech. J., vol. 37, no. 3, May 1958, p. 581/635.

The fluctuations of a received radio signal due to fading are assumed to behave like the envelope of narrow-band Gaussian noise. Estimates of the distribution of the fade lengths for various depths of fades are given, and relations which may be useful in analyzing fading data are derived. A similar problem involving the separation of the intercepts of noise current itself, instead of its envelope, is also discussed.

DENSITY OF DISTRIBUTION OF INTERVALS BETWEEN ZERO OF A NARROW-BAND NORMAL STATIONARY RANDOM PROCESS
L.I. Bialyi, Radio Engrg. & Electronics, vol. 4, 1959, p. 266/269.

A PROPERTY OF THE GENERALIZED ENVELOPE
J. L. Brown, Jr., IRE Trans. Circuit Theory, vol. CT-6, no. 3, Sept. 1959, p. 325.

. . . envelope of a narrow-band signal has a mean-square value which is twice the mean-square value of the original signal.

INTERCHANNEL CORRELATION IN A BANK OF PARALLEL FILTERS
J. Galejs, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 106/117.

The first-order effects of interchannel noise correlation on the false alarm and incorrect dismissal probabilities are computed for a bank of parallel RLC filters by expanding the envelope distribution of the n filter outputs in a power series.

A THEOREM ON CROSS CORRELATION BETWEEN NOISY CHANNELS
J. Keilson, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 77/79.

ON THE USE OF LAGUERRE POLYNOMIALS IN TREATING THE ENVELOPE AND PHASE COMPONENTS OF NARROW-BAND GAUSSIAN NOISE
I.S. Reed, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959.

The joint probability density of the envelope of a Gaussian process at two different times is expanded by the use of Hardy's identity into a series involving Laguerre polynomials. It is shown how this result may be used to estimate the cross-correlation function of the output of two quite general envelope-distorting filters.

PROPAGATION OF BAND LIMITED NOISE (Correspondence)
M.W. Smith, et al., J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 512/514.

FREQUENCY DIFFERENCES BETWEEN TWO PARTIALLY CORRELATED NOISE CHANNELS
J. Galejs, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 72/81.

. . . which contain dissimilar Gaussian, rectangular or triple-tuned RLC band-pass filters are calculated. For noise channels that differ only in time delay, a proportionality between rate of change of instantaneous frequency and the difference frequency is assumed. For dissimilar filters, an approximately equivalent single filter-time delay process is defined . . .

AN ESTIMATE OF THE VARIATION OF A BAND-LIMITED PROCESS
A. Papoulis, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 72/74.

Upper and lower bounds are established for the mean-square variation of a stationary process X(t) whose power spectrum is bounded by w_c, in terms of its average power P_0 and the average P_1 of its derivative. . . .

Related Publications:

TWO NOTES ON A MARKOFF ENVELOPE PROCESS (Correspondence)
C.W. Helstrom, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 139/140.

. . . envelope of the output of a high-Q singly tuned RLC filter is a first-order Markoff process when the filter input is white Gaussian noise. . . . proof of this . . .

MATCHED FILTERS FOR MULTIPLE PROCESSES (Correspondence)
A.V. Balakrishnan, IRE Trans. Inform. Th., vol. IT-7, no 1, Jan. 1961, p. 52.

By a multiple process is meant a q-dimensional (real-valued) vector stochastic process. As is well-known, a matched filter is defined for one-dimensional processes as one that minimizes the noise-to-signal ratio. Now, in the multiple process case we can define noise-to-signal ratio in several ways and it is the purpose of this note to examine the corresponding matched filters.

1.715: Gaussian Noise Through Nonlinear Devices

Included: Amplitude distorted Gaussian noise; Noise after coherent detection; Band pass limiter output; Infinitely clipped noise; Post detection statistics of noise; Integrated white noise; Rectified narrow band noise; Limited Gaussian noise.

Not Included: Theory of coherent detectors (2); Post detection statistics of signals and noise (2); Detection and decision theory (2).

Cross References: Special distributions of random processes (1.117).

Principal Publications:

THE EFFECT OF INSTANTANEOUS NON-LINEAR DEVICES ON CROSS-CORRELATION
R. Leipnik, IRE Trans. Inform. Th., vol. IT-4, 1958, p. 73/76.

If X(t), $X_2(t)$ are two noises (stochastic processes), f and g are functions describing the action of two instantaneous nonlinear devices, we say that the (m, n) cross-correlation property-holds. . . . whenever f and g are polynomials of degrees not exceeding m and n, respectively.

THE FOURTH PRODUCT MOMENT OF INFINITELY CLIPPED NOISE
J.A. McFadden, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 159/162.

A USEFUL THEOREM FOR NONLINEAR DEVICES HAVING GAUSSIAN INPUTS
R. Price, IRE Trans. Inform. Th., vol. IT-4, p. 69/72.

NOISE OUTPUT OF BALANCED FREQUENCY DISCRIMINATOR
D. Slepian, Proc. IRE., vol. 46, March 1958, p. 614.

THE SPECTRUM OF LIMITED GAUSSIAN NOISE
F. L. H. Stumpers, Philips Res. Report, vol. 13, Dec. 1958, p. 509/514.

INTEGRATED WHITE NOISE
R. Leipnik, Naval Ordnance Test Station, China Lake, Calif., July 1959, 11 p., (NAVORD rept. no. 7013), AD 230 442.

The autocovariance of n-times finite-integrated band-limited white noise is calculated in terms of exponential-integral functions. Asymptotic results are obtained for large and small band-width limits, and error-bounds are given, with a view toward error-analysis of integrated accelerometers.

RECTIFICATION OF NARROW-BAND NOISE
K.S. Stull, Jr., Electronic Industr., vol. 19, May 1960, p. 103.

APPROXIMATE CALCULATION OF THE DISTRIBUTION FUNCTION OF A NORMAL PROCESS AT THE OUTPUT OF A TYPICAL RADIO SECTION
V.S. Borodin, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 1/6.

The author determines an approximate expression for the differential distribution function of instantaneous values of a normal random process with unlimited spectrum (white noise) at the output of a typical radio section. A typical section consists of the first RC filter, the square-law detector and the second RC filter. A comparison of two methods of calculating the cumulants of distribution is given. A preferred method of determining cumulants is cited. . . .

THE AMPLITUDE DISTRIBUTION AND FALSE ALARM RATE OF NOISE AFTER POST-DETECTION FILTERING
S. Thaler, et al., Proc. IRE, vol. 49, Feb. 1961, p. 479/485.

THE EVALUATION OF THE RESPONSE OF SINGLE-VALUED NON-LINEARITIES TO SEVERAL INPUTS
D. P. Atherton, Proc. Instn. Elect. Engrs. London, Part C), vol. 109, no. 15, March 1962, p. 146/157.

The transform method for evaluating the coefficients of the various terms in the output autocorrelation function of a non-linearity with an input consisting of a sinusoidal signal and Gaussian noise is considered. Solutions, all of which involve cofluent hypergeometric functions, are given for a few analytically defined non-linear characteristics. A short table of these functions is also given to facilitate computation. A new expression for evaluating the coefficients, a double integral involving the non-linear characteristic and the moments of the sinusoidal and Gaussian input signals, is derived. . . .

PROBABILITY DENSITY FOR CORRELATORS (Correspondence)
M. C. Grignetti, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 383/384.

In a recent paper, probability densities for the output of short-time cross-correlators were derived, yielding rather unwieldy expressions involving infinite series of higher transcendental functions. . . . As a consequence, the authors of the above-mentioned paper worked out a saddle-point approximation which gives numerical results that, the s - s case, have not been checked against the exact expressions. We shall show, however, that one of these expressions can be considerably simplified. . . .

THE EFFECTS OF NOISE THROUGH AN ANALOG INTEGRATOR WHICH INTEGRATES WITH RESPECT TO AN ARBITRARY VARIABLE
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 151/158.

. . . to consider the effects of noise, both internal and external, on any possible computation control process. The external noises would arise in communication links, the drifts of gyros, possible variations in external conditions, variations in amounts and rates of rocket burning, and other causes. The internal noises could be those electronically generated (such as short and Johnson noises) and those generated by digital computation processes. . . . In the event that an incremental digit or analog computer is part of a control loop, a typical problem would be signal plus noise into an analog or digital integrator.

FM RECEPTION AND THE ZEROS OF NARROW-BAND GAUSSIAN NOISE
N. M. Blachman, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 235/241.

. . . the low-frequency output spectral density of an FM receiver is obtained. Below the threshold the output signal-to-noise ratio is found . . . By the addition of well known "triangular" noise, this expression is made valid through and above the threshold, thus unifying various results of Rice. The quieting of a wide-band FM receiver by a signal is also considered. . . .

APPROXIMATE BAND-PASS LIMITER ENVELOPE DISTRIBUTIONS
W. Doyle, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 180/185, 20 refs.

An approximate distribution is computed for the envelope of sine wave plus noise after passage through a wide-band filter, limiter, and narrow-band filter. It is shown that the input bandwidth to the limiter increases, the output envelope distribution converges to the usual sine wave in noise envelope distribution, without limiting, but with a definite 1.04 db loss. . . .

CORRELATION FUNCTION AT THE OUTPUT OF AN ERROR FUNCTION LIMITER
H. Kaufman, et al., J. Electronics and Control, Aug. 1963, p. 165/170, A63-20431

Analysis of a half-wave limiter with a Gaussian input. . . . A series expression is obtained for the output correlation function.

THE MEAN VALUE OF THE ENVELOPE OF A SINE AND COHERENT WAVE SUPERIMPOSED ON THE NARROW-BAND GAUSSIAN NOISE
B. Leskovar, J. Electronics and Control, vol. 14, no. 1, Jan. 1963, p. 113/120.

. . . The mean value is calculated and plotted as a function of both the sine wave-to-noise and coherent wave-to-noise ratios of the coherent detector input wave. Attention is paid to the mean value of the envelope for various phase angles between the coherent wave and the sine wave plus narrow-band Gaussian noise. The normalized form of the mean value's computed curves suitable for direct application on an additive type of coherent detector is given.

COMMENT ON: "A USEFUL THEOREM FOR NONLINEAR DEVICES HAVING GAUSSIAN INPUTS" (Correspondence)
R. Price, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 171.

The theorem in question deals with zero-memory nonlinear devices driven by Gaussian processes, and it relates derivatives of output correlation functions with respect to those of the inputs to derivatives of the nonlinear characteristics. . . .

GENERAL RESULTS IN THE MATHEMATICAL THEORY OF RANDOM SIGNALS AND NOISE IN NONLINEAR DEVICES
H. B. Shutterly, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 74/84.

An analysis is made of the output resulting from passing signals and noise through general zero memory nonlinear devices. New expressions are derived for the output time function and autocorrelation function in terms of weighted averages of the nonlinear characteristic and its derivatives. These expressions are not restricted to Gaussian noise and apply to any nonlinearity having no more than a finite number of discontinuities. The method of analysis used is heuristic. . . .

Related Publications:

STATISTICAL ERRORS IN MEASUREMENTS ON AMPLITUDE-DISTORTED GAUSSIAN SIGNALS
D. L. Haas, Quarterly Progress Report. Res. Lab., MIT, April 1958, p. 81/89.

PHASE MODULATION THROUGH A LIMITER
JPS Res. Summary, vol. 1, no. 367, Dec. - Jan. 1960, p. 54/60.

The performance of an ideal limiter followed by a synchronous detector and a low-pass filter has been studied. . . . The signal suppression resulting from the presence of noise controls the effective noise bandwidth of the loop. . . .

EFFECT OF HARD LIMITING ON THE PROBABILITIES OF INCORRECT DISMISSAL AND FALSE ALARM AT THE OUTPUT OF AN ENVELOPE DETECTOR
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 60/66.

. . . The input to the system is a pulsed IF signal immersed in noise whose power spectrum is uniform over a band of width W cycles . . .

RECONSTRUCTION ERROR AND DELAY FOR AMPLITUDE-SAMPLED WHITE NOISE (Correspondence)
D. S. Ruchkin, Proc. IRE, vol. 49, Sept. 1961, p. 1436.

ON OPTIMAL DIVERSITY RECEPTION
G. L. Turin, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 154/166.

. . . The ideal probability-computing M-ary receiver is derived for a fading, noisy, multidiversity channel. . .

STATISTICAL PROPERTIES OF M-ARY FREQUENCY-SHIFT-KEYED MODULATED CARRIERS
H. Zabronsky, RCA Rev., vol. 22, no. 3, Sept. 1961, p. 431/460.

. . . statistical properties of frequency-shift-keyed and phase-shift-keyed modulated carriers through a limiter plus other devices, in the presence of white Gaussian noise.

COMPARISON OF SIGNAL AND NOISE IN FULL-WAVE AND HALF-WAVE RECTIFIERS (Correspondence)
M. D. Rubin, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 379/381.

The literature contains analyses of the signal-to-noise performance of half-wave linear rectifiers and of full-wave square-law rectifiers. In the following, we compare directly the half-wave linear rectifier with the full-wave linear rectifier, when used as detectors. . . .

1.716: Noise Plus Signals in Various Circuits

Included: Output probabilities of correlation detectors; Signal plus quasi-sinusoidal noise; Gaussian signals in Gaussian noise.

Not Included: Circuit theory; Detection and decision theory (2).

Cross References: Signal and noise in analog modulation methods (Div. 1.2); Signal and noise in digital modulation methods (Div. 1.3); Signal and noise in semi-analog (pulse) modulation methods (Div. 1.4); Signal and noise in pulse code modulation methods (Div. 1.5).

Principal Publications:

A NOTE ON THE EVALUATION OF THE RESPONSE OF A NON-LINEAR ELEMENT TO SINUSOIDAL AND RANDOM SIGNALS.
J. L. Douce, Proc. Instn. Elect. Engrs. pt. C, vol. 105, March 1958, p. 88/92.

THE PREDICTION OF DERIVATIVES OF POLYNOMIAL SIGNALS IN ADDITIVE STATIONARY NOISE
I. Kanter, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 131/146.

. . . unifying theory for a problem which arrises in a now classical paper on predication theory.

A PHYSICAL INTERPRETATION OF SHANNON'S AMBIGUITY
J. Loeb, Ann. Telecommun., vol. 13, March - April 1958, p. 78/82.

. . . for the case of Gaussian noise superposed on an AM signal, by a transitional probabilities matrix ("grille"). . . . can also be applied to problems involving non-Gaussian noise or nonlinear circuit elements.

ON THE DISTRIBUTION CURVES OF THE AMPLITUDE ENVELOPE OF THE OUTPUT OF A SELECTIVE SYSTEM IN THE PRESENCE OF RANDOM FREQUENCY FLUCTUATIONS OF THE E.M.F.
A. V. Prosin, Telecommunications, no. 1, 1958, p. 9/16.

The passage of a frequency-modulated oscillation through selective systems with non-linear phase characteristics and non-regular frequency characteristics.

THE FLUCTUATION RATE OF THE CHI PROCESS
R. A. Silverman, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 34/38.

. . . results from ideal symmetric limiting of a very narrow-band signal in narrow-band Gaussian noise. At small input snr this loss can be expressed in terms of the degradation of the effective signal energy-to-noise power per cycle ratio.

STATISTICAL ANALYSIS OF NOISE-SIGNAL AMPLITUDES
D. Hoffman, et al., Electronics, vol. 32, no. 24, July 1959, p. 48/50.

CUMULATIVE DISTRIBUTION FUNCTIONS FOR A SINUSOID PLUS GAUSSIAN NOISE (Correspondence)
A. Levine, et al., IRE Trans. Inform Th., vol. IT-5, no. 2, June 1959, p. 90/91.

THE EFFECT OF MIXING TWO NOISY SIGNALS
N. A. Huttly, Marconi Rev. (GB), 4th Qtr., vol. 23, 1960, p. 153/169.

. . . Approximate solutions are given for the output signal-to-noise ratio when certain assumptions can be made about the bandwidths and the beat note frequency. . . .

ON THE POSTDETECTION CORRELATION BETWEEN TWO SINUSOIDAL SIGNALS WITH SUPERIMPOSED CORRELATED NOISE (Correspondence)
K. Blotekjaer, IRE Trans. on Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 271/272.

The problem of measuring autocorrelation and cross-correlation is frequently encountered in experimental analysis. . . . The results of the present paper have also been successfully applied to the analysis of signals from earth satellites. Since most of the signals used in transmission techniques are high-frequency signals with relatively narrow bandwidths, the correlation measurements are most easily performed on the detected signals, whereas for theoretical calculations the correlation between the undetected signals is required. It is therefore of great importance to know the relationship between the correlation before and after detection. It is the purpose of this paper to establish this relationship for a special class of signals, namely signals consisting of a sinusoidal component with superimposed narrow-band Gaussian noise. . . .

ENVELOPE PROBABILITY AS A FUNCTION OF E/N_0 (Correspondence)
L. E. Davies, Proc. IRE, vol. 49, May 1961, p. 971/972.

SELECTIVITY CONCENTRATION AND INTEGRATION EFFICIENCY
W. Gersch, et al., IRE Trans. Circuit Theory, vol. CT-8, no. 3, Sept. 1961, p. 296/301.

. . . The relationship between the maximum achievable peakedness of the selectivity characteristic and the signal detection performance of a spectrum analyzer whose input is a finite duration sinusoid immersed in white noise is considered.

THE PROBABILITY DENSITY OF THE PHASE DIFFERENCE OF A NARROW-BAND GAUSSIAN NOISE WITH SINUSOIDAL SIGNAL (Correspondence)
H. R. Raemer, et al., IRE Trans. on Inform. Th., IT-7, no. 4, Oct. 1961, p. 265/267.

The first-order amplitude and phase probability densities for a stationary narrow-band Gaussian noise both with and without a sinusoidal signal have been reported by several people. The second-order probability density function of phase for noise alone was evaluated by MacDonald. We have calculated the second-order probability function for phase with sinusoidal signal by approximation techniques and have numerically evaluated the probability density function for a phase difference between two instants of time for various parameter values. Values used are those applicable to a specific signal processing problem for which the work was done. . . .

RAPID EVALUATION OF THE AUTOCORRELATION FUNCTION OF THE OUTPUT OF SIGNAL-VALUED NON-LINEARITIES IN RESPONSE TO SINUSOIDAL AND GAUSSIAN SIGNALS
D. P. Atherton, Proc. Instn. Elect. Engrs., London, (Pt. C), vol. 109, no. 16, Sept. 1962, p. 656/664.

. . . can be used for the rapid evaluation of the response of a signal-valued non-linear element to a sinusoidal signal and Gaussian noise, applied separately or together. The technique used is to approximate the non-linear characteristic by a stepped or 'digitized' waveform; exact evaluation of the response of the digitized characteristic can easily be obtained. . . .

PARASITIC MODULATION CAUSED BY SMALL ADDITIVE NOISE (Translation)
E. L. Blokh, et al., Telecommun. Radio Engineering, Part II—Radio Engineering, vol. 17, Nov. 1962, p. 3/13, A63-16482.

. . . geometric interpretation . . . A carrier in the form of a sequence of trapezoidal pulses is examined. . . .

APPROXIMATE BAND-PASS LIMITER ENVELOPE DISTRIBUTIONS
W. Doyle, et al., Rand Corp., Sanda Monica, Calif., Feb. 1962, 21 p., incl. illus., 20 refs., (Memo. no. RM-2987-PR), AD 274 684.

. . . An approximate distribution is computed for the envelope of sine wave plus noise after passage through a wide-band filter, limiter and narrow-band filter. . . .

AN APPROXIMATE METHOD IN SIGNAL DETECTION
W. F. Freiberger, Brown U. Div. of Applied Mathematics, Providence, R.I., Jan. 1962, 10 p., incl. illus., 3 refs., (Technical rept. no. 12), AD 274 202.

. . . theorem from the theory of Toeplitz norma . . . estimating the best test statistic for the detection of Gaussian signals in Gaussian noise.

THE OUTPUT PROBABILITY DISTRIBUTION OF A CORRELATION DETECTOR WITH SIGNAL PLUS NOISE INPUTS
M. J. Jacobson, Rensselaer Polytechnic Inst., Troy, N.Y., 1 June 1962, 28 p., incl. illus., refs., (RPI Math Rep. no. 55), AD 276 364.

CORRELATION FUNCTION AT THE OUTPUT OF A NONLINEAR DEVICE (Correspondence)
G. E. Roberts, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 322/323.

. . . output of a power-law device when the input consists of an AM signal plus Gaussian noise. . . .

THE EFFECTS OF NOISE THROUGH A RECTANGULAR-INTEGRATION PROCESS AND SOME SAMPLED SPECTRAL-DENSITY METHODS
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 159/175.

. . . the effect of signal plus noise on the rectangular integration process that . . . a digital integrator might use. The arguments are cased in the form taken by a digital differential analyzer (DDA) integrator. . . .

EXPERIMENTAL INVESTIGATIONS OF THE PEAKS OF THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE
V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 3, March 1963, p. 1/8.

An experimental setup is described for obtaining samples (oscillograms) of the smoothed envelope of quasi-sinusoidal noise. A method of processing the oscillograms to determine the statistical characteristics of the peaks of the smoothed envelope is given. Experimental results are presented, showing the distribution of the highest maxima, of the lowest minima and of the vertical distance between a minimum and the following maximum in samples of the smoothed envelope of the sum of a sinusoidal signal and Gaussian noise. . . .

DISTRIBUTION OF OVERSHOOT PERIODS FOR THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE
V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 1/7.

Experimental results are presented showing the average number of overshoots and the distribution of positive or negative overshoot periods in a smoothed envelope comprising the sum of a sinusoidal signal and quasi-sinusoidal noise. The experimental data obtained are compared with results of analytical investigations.

HARD-LIMITING OF TWO SIGNALS IN RANDOM NOISE
J. J. Jones, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 34/42.

. . . Two sinusoidal signals and Gaussian noise lying in a narrow band are passed through an ideal band-pass limiter that confines the output spectrum to the vicinity of the input frequencies. The output spectrum, consisting of both discrete and continuous components, is studied in terms of its corresponding autocorrelation function. . . .

THE MEAN VALUE OF THE ENVELOPE OF A SINE AND COHERENT WAVE SUPERIMPOSED ON THE NARROW-BAND GAUSSIAN NOISE
B. Leskovar, J. Electronics and Control, vol. 14, no. 1, Jan. 1963, p. 113/120.

. . . The mean value is calculated and plotted as a function of both the sine wave-to-noise and coherent wave-to-noise ratios of the coherent detector input wave. Attention is paid to the mean value of the envelope for various phase angles between the coherent wave and the sine wave plus narrow-band Gaussian noise. The normalized form of the mean value's computed curves suitable for direct application on an additive type of coherent detector is given.

APPROXIMATE DETERMINATION OF THE DISTRIBUTION FUNCTION OF FADE LENGTHS BELOW THRESHOLD LEVEL FOR THE SUM OF A DETERMINISTIC SIGNAL AND GAUSSIAN STATIONARY NOISE
B. R. Levin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 20/26.

The distribution function of the axis-crossing intervals for the envelope of the sum of a sinusoidal signal and Gaussian noise by the first-approximation curve for noise alone when the intervals are small and by an exponential curve when the intervals are too large is approximated. . . . compared with known experimental data as well as with Rice's approximation method. . . .

AN ANALYSIS OF THE FACTORS WHICH DETERMINE SIGNAL/NOISE DISCRIMINATION IN PULSED-CARRIER SYSTEMS
D. O. North, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1016/1027.

K RASCHETU KHARAKTERISTIK OBNARUZHENIIA FLUKTUIRUIUSHCHIKH SIGNALOV (On the Calculation of Detection Characteristics of Fluctuating Signals) (In Russian)
R. L. Stratonovich, et al., Moskovskii Universitet, Vestnik, Seriia III-Fizika, Astronomiia, vol. 19, Jan.-Feb. 1964, p. 43/49, 5 refs., A64-17118.

. . . of correlated Gaussian radio signals in a correlated Gaussian noise. Exact expressions are derived for determining the errors of optimal and nonoptimal detectors of fluctuating radio signals. These expressions can also be used as a basis for tabulating the detection characteristics using a high-speed computer.

ESTIMATION OF THE CONSTANT COMPONENT OF A DETECTED PERIODIC SIGNAL MIXED WITH ADDITIVE GAUSSIAN NOISE USING A SEGMENT OF A SINGLE SAMPLE OF FINITE DURATION
A. B. Tatarinov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 5/14.

Using a single sample of finite duration, the problem of estimation of the mean value of a detected harmonic signal on a background of additive Gaussian noise, mixing with the signal before the detection process, is considered. For linear and square-law detectors, equations are derived for the relative bias of the estimate . . .

VYBROSY SUMMY SIGNALA I SHUMA (Horns on a Signal-Noise Wave) (In Russian)
V. I. Tikhonov, Radiotekhnika i Elektronika, vol. 8, Nov. 1963, p. 1803/1811, 10 refs., A64-12028.

. . . formulas for the mean number of "horns" per unit time of a wave composed of normal steady noise and a signal . . . considers two types of signals: a signal in the form of normal quasi-harmonic (narrow-band) noise, and a harmonic signal. . . . several numerical examples. . . .

Related Publications:

A NOTE ON POWER-LAW DEVICES AND THEIR EFFECT ON SIGNAL-TO-NOISE RATIO
C. N. Berglund, Queen's U., Belfast (Gt. Brit.), Aug. 1962, 21 p., incl. illus., 5 refs., (Research rept. no. 62-3), AD 291 427.

. . . used as either band-pass non-linear amplifiers or enveloped detectors . . . determined for both limiting cases of very large and very small input signal-to-noise ratios. . . . The results are general, applying to Gaussian and non-Gaussian noises and modulated and unmodulated signals, and allow important conclusions to be reached concerning the value of power-law devices in communication systems in various signal and noise environments. . . .

A COMPUTER-AUGMENTED TECHNIQUE FOR THE DESIGN OF LIKELIHOOD-RADIO RECEIVERS
T. B. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor., Oct. 1962, 36 p., incl. illus., tables, 9 refs., (Technical rept. no. 130; 3674-3-T), AD 292 161.

Standard approximation methods of design of detection receivers are reviewed, and a method based on fitting curves calculated on a high-speed computer is presented. This computer-augmented technique is applied to the design problem of a signal distorted by a sign-preserving, rapidly varying transmission gain.

ON THE DETECTION OF A RANDOMLY DISTORTED SIGNAL IN GAUSSIAN NOISE
L. Halsted, et al., Michigan U., Ann Arbor, Oct. 1962, 38 p., incl. illus., 8 refs., (Technical rept. no. 129; Rept. no. 3674-2-T), AD 291 982.

. . . designing a likelihood ratio receiver for detection of a signal that has been distorted by a randomly varying transmission loss and subsequently masked by an additive Gaussian noise. . . . The optimum receiver was evaluated for the two-input-samples case using a digital computer. . . . Various facets of the performance of two nonoptimum receivers, the crosscorrelator and the clipper crosscorrelator, were also evaluated using the computer.

LIMITING ACCURACY OF THE SIMULTANEOUS ESTIMATION OF TWO SIGNAL PARAMETERS IN THE PRESENCE OF NORMAL NOISE (Translation)
E. I. Kulikov, Telecommun. Radio Engineering, Part II—Radio Engineering, Jan. 1963, p. 531/61, A63-21045.

Derivation, using the maximum value of the probability functions, of formulas for the calculation of the variance and correlation coefficient for the simultaneous estimation of two radio signal parameters with a random initial phase in the presence of additive correlated normal noise. On the basis of these formulas, the characteristics of the simultaneous evaluation of the delay time and frequency shift for the reception of a bell-shaped radio signal in the presence of white noise are calculated, for the cases of no internal frequency modulation and linear frequency modulation.

1.717: Pulsive Noise Analysis

Included: Quasi-stationary noise processes; Nonstationary noise processes; Non-Gaussian processes in non-Gaussian noise.

Not Included: Error correction codes for error bursts (2).

Cross References: Observations and evaluation of pulsive noise (Sect 1.74); Special random processes (1.114); Stationary noise in general (1.713); Statistics of error distributions due to pulsive noise (1.743); Computer simulation of pulsive noise (1.719).

Principal Publications:

NONSTATIONARY VELOCITY ESTIMATION
T. M. Burford, Bell Syst. Tech. J., vol. 37, no. 4, July 1958, p. 1009/1021.

A nonstationary noise may frequently be approximated by the product of a stationary noise and a deterministic function of time.

THE ACTION OF NON-STATIONARY FLUCTUATIONS ON LINEAR SYSTEMS
I. I. Samoilenko, Radio Engrg., vol. 14, no. 7, 1959, p. 20/22.

THE PROBABILITY DISTRIBUTIONS OF THE OUTPUTS OF FIRST ORDER AND TUNED SECOND ORDER FILTERS WITH COIN-TOSS SQUARE WAVE INPUTS
A. R. Cohen, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 371/377.

. . .A method is presented for constructing the probability distribution functions of the outputs of an RC low-pass filter and a tuned second-order filter for coin-toss square wave inputs. The input is a binary process in which axis crossings can occur only on a set of equally spaced sample points . . .

SHORT TERM AMPLITUDE PROBABILITY DISTRIBUTION OF IMPULSIVE ATMOSPHERIC RADIO NOISE
M. Satyam, J. Sci. Industr. Res., vol. 21D, no. 7, July 1962, p. 221/227.

SOME ANALYTICAL TECHNIQUES FOR A CLASS OF NON-GAUSSIAN PROCESSES
B. A. Bowen, Queen's U., Kingston (Canada), June 1963, 61 p., Rept. no. RR63 3, AD 428 431.

. . . a study of impulse noise interference in a simple communications receiver model. A review of the cumulant concept is presented, then an impulse model postulated. . . . the cumulants are defined in terms of integrals of functions of the wave shape of the impulse events. . . . A unique presentation is derived to compare the moments of a gaussian process to a nongaussian one. It is shown that as the ratio of the equivalent order moments is different from unity, correction terms are generated which change the probability distribution to a nongaussian form. The cumulants are used in conjunction with a transform technique to derive the correlation function of impulse noise or of signal plus noise when a linear filter is followed by a nonlinear device. The results reduce to the known gaussian results as the impulse rate is increased.

RELATION BETWEEN OUTPUTS OF A FULL-WAVE AND HALF-WAVE LINEAR RECTIFIER FOR A CLASS OF NON-GUASSIAN INPUTS (Correspondence)
J. L. Brown, Jr., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 288/289.

CERTAIN PROPERTIES OF RANDOM PULSE PROCESSES
Y. I. Khurgin, Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div., 8 Oct. 1963, 10 p., refs., Transl. into ENGLISH from Tr. Vses. Soveshch, po Teorii Veroyatnosti i Mat. Statist. (Yerevan), 1960, p. 72/28, (FTD-TT-62-1147/1+2+4), AD 423 603, N64-12625.

. . . sequence of spikes above a certain defined level of random noise. In general, attention was directed toward a single class of such processes which is reasonably descriptive of many practical interesting cases . . . the simplest class of random pulse processes in which the sequence interval between the moments of pulse appearances is a sequence of positive, independent, identically distributed random variables having probability density.

CALCULATED STATISTICAL CHARACTERISTICS OF ATMOSPHERIC RADIO NOISE
T. Nakai, Proc. of the Res. Inst. of Atmospherics, Nagoya U., Vol. 10, Jan. 1963, p. 13/24, 2 refs., N63-18222.

The Poisson noise process is considered in which the pulses of rectangular form with a constant duration are arriving at the times determined by Poisson's distribution law . . .

ON THE RESPONSE OF LINEAR SYSTEMS TO CERTAIN NON-GAUSSIAN RANDOM INPUTS (Correspondence)
G. M. Northrop, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 169/170.

The problem of calculating the probability density at the output of a linear device with non-gaussian input is largely unsolved. This communication considers the special class of non-Gaussian inputs that can be generated by passing a Gaussian Markov process through a nonlinear device without energy storage whose input and output stand in 1 to 1 relation. The result is . . . a partial differential equation . . . the fact that such an equation can be written down readily for a general 1 to 1 nonlinearity is thought to be of some interest. . . .

DETECTION OF NON-GAUSSIAN PROCESSES IN NON-GAUSSIAN NOISE
F. G. Ogg, Jr., Johns Hopkins U., Carlyle Barton Lab., Baltimore, Md., June 1963, 37 p., 4 refs., N63-18647.

. . . detection of stochastic processes in noise. . . under the assumption that neither the signal nor the noise need be gaussian. The detector structure is found in terms of the semi-invariants of the signal and noise processes. The general detector structure is extremely complicated, but a threshold form may be obtained . . . It is shown that large degradations in sensitivity occur if the noise is highly impulsive in character, but the nongaussian character of the signal process is found to have very little effect on the detector sensitivity.

A NONLINEAR FILTER FOR NON-GAUSSIAN INTERFERENCE
R. H. Richard, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Dec 1963, p. 436/443.

A nonlinear filter is investigated and its effectiveness in improving signal detectability in the presence of certain types of non-Gaussian noise is determined. The filter consists of a zero-memory nonlinear device followed by a low-pass filter, the nonlinear device being designed on the basis of only the first-order statistics of the interfering noise and of the sum of signal and noise. . . . The results of the study indicate that, when the noise probability density function is sufficiently different from Gaussian, a considerable improvement in detection reliability can be obtained. When the noise is Gaussian the filter reduces to a linear one. . . .

A STUDY OF CORRELATOR BEHAVIOR USING "NON-STATIONARY" SIGNALS. PART II
Dewey, G. C. and Co., Inc., New York, 17 June 1963, 38 p., AD 412 534.

. . . cross-correlation gains of an analog and clipper correlator . . . The signals and noise used in this study we have characterized as being non-stationary. An attempt has been made to compare experimentally determined gains for the case of small signals buried in noise with those predicted theoretically.

Related Publications:

A NEW APPROACH TO THE SPECTRUM ANALYSIS OF NONSTATIONARY SIGNALS
W. W. Wierwille, IEEE Paper no. 63-63, Feb. 1963, 18 p.

1.719: Computer Simulation of Noise and Disturbances

Included: Computer generation of noise; Simulation of radar clutter; Simulation of pulsive noise.

Not Included: Simulation programs in general (3A); Design of noise generators.

Cross References: Experimental evaluation of statistical populations (1.119); Special statistical dixtributions (1.117); Jamming of communications transmissions (Sect. 1.75).

Principal Publications:

RECHENMETHODEN BEI RAUSCHVORGANGEN (Computation Methods for Noise Processes) (In German)
K. Lunze, Nachrichtentechnik, vol. 8, Dec. 1958, p. 530/537.

REALISTIC SIMULATION OF RADAR CLUTTER
J. Atkin, Electronics, vol. 32, no. 39, Sept. 1959, p. 78/81.

DIGITAL COMPUTER SIMULATION OF IMPULSE NOISE
R. V. D'Aiello, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 31 Oct. 1961, 81 p., incl. illus., tables, 17 refs., (Research rept. no. PIBMRI-967-61), AD 283 104.

A method of using a digital computer to generate probability distributions is described. . . . can . . . be used to simulate the effects of impulse noise on the transmission of digital data. The statistics of impulse noise is discussed, and two probability distributions are proposed in order to describe these phenomena.

COMPUTER SIMULATION ROUTINE FOR RADIO FREQUENCY BACKSCATTER: ANALYSIS FOR COMPUTER GENERATION OF NOISE
G. W. Evans II, et al., Stanford Research Inst., Menlo Park, Calif., May 1962, 12 p., incl. illus., 4 refs., (Technical rept. no. 2), AD 277 582.

. . . simulation . . . amplitude of noise signals which are bounded and are either time dependent or time independent . . . it is assumed that there exists a cumulative distribution function for the amplitudes of the noise signal.

SIMULATION USING THE MONTE CARLO METHOD
R. F. Iuorno, Rome Air Development Center, Griffiss Air Force Base, N. Y., May 1963, 25 p., RADC RAW TM 63 5, AD 410 290.

. . . problem of communications in a jamming environment is used to illustrate the use of the Monte Carlo method. Two mathematical models, each representing a different jamming communication configuration, are constructed and solved using the Monte Carlo method . . .

Related Publications:

THE PROBABILITY DISTRIBUTIONS OF THE OUTPUTS OF FIRST ORDER AND TUNED SECOND ORDER FILTERS WITH COIN-TOSS SQUARE WAVE INPUTS
A. R. Cohen, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 371/377.

. . . A method is presented for constructing the probability distribution functions of the outputs of an RC low-pass filter and a tuned second-order filter for coin-toss square wave inputs. The input is a binary process in which axis crossings can occur only on a set of equally spaced sample points . . .

THE EFFECTS OF NOISE THROUGH AN ANALOG INTEGRATOR WHICH INTEGRATES WITH RESPECT TO AN ARBITRARY VARIABLE

P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 151/158.

. . . to consider the effects of noise, both internal and external, on any possible computation control process. The external noises would arise in communication links, the drifts of gyros, possible variations in external conditions, variations in amounts and rates of rocket burning, and other causes. The internal noises could be those electronically generated (such as short and Johnson noises) and those generated by digital computation processes. . . . In the event that an incremental digit or analog computer is part of a control loop, a typical problem would be signal plus noise into an analog or digital integrator.

SIMULATION OF A FADING MEDIUM

R. Krulee, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 233/240.

. . . a model that is consistent with observed experimental data is developed for a fading circuit. The instrumentation necessary to allow laboratory simulation and testing under exactly those conditions which are most critical for satisfactory system design is discussed. . . .

ANALYSIS OF THE PARETO MODEL FOR ERROR STATISTICS ON TELEPHONE CIRCUITS

S. M. Sussman, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 213/221.

A statistical model for the occurrence of errors in data transmission over telephone circuits was recently proposed by Berger and Mandelbrot. In their model the intervals between successive errors are distributed independently according to the Pareto distribution $t^{-\alpha}$. This paper presents an analysis based on the Pareto model and compares the results with published measurements on telephone networks. . . . Comparison with experiments indicates that the Pareto distribution provides an excellent representation of the error statistics. . . .

Section 1.72
Noise of Natural Origin

This section discusses the characteristics of noise contributions from natural sources, which produce spectral components within the frequency band and within the beam of radio transmissions. Such contributions cannot be eliminated by careful antenna design or by particular beam orientation.

Noise from celestial sources is excluded from this discussion, as are special geophysical problems and propagation characteristics of atmospheric noise.

1.722: Atmospheric Noise

Included: Statistical characteristics of atmospheric radio noise; VLF radio noise; Lightning transients; Atmospheric electricity; Impulsive atmospheric noise; Spheric pulses; Radio noise of terrestrial origin; Radio emission from clouds; Musical atmospheres; Atmospheric angles.

Not Included: Lightning protection; Noise suppression devices; Geophysics of atmospheric noise.

Cross References: Analysis of pulsive noise (1.717); Computer simulation of noise and disturbances (1.719); Precipitation static (1.723).

Principal Publications:

ATMOSPHERIC NOISE INTERFERENCE TO SHORT-WAVE BROADCASTING
S. V. Chandrashekhar Aiya, Proc. IRE, vol. 46, March 1958, p. 580/589.

ATMOSPHERIC NOISE INTERFERENCE TO MEDIUM WAVE BROADCASTING
S. V. Chandrashekhar Aiya, Proc. IRE, vol. 46, Aug. 1958, p. 1502/1509.

A PRELIMINARY REPORT "ON THE NATURE AND ORIGIN OF ATMOSPHERICS" (Work for the I. G. Y. 57/58)
M. W. Chiplonkar, et al., J. Sci. Indust. Res., vol. 17A, Dec. 1958, p. 3/23.

REPORT ON URSI COMMISSION IV - RADIO NOISE OF TERRESTRIAL ORIGIN
H. E. Dinger, Proc. IRE, vol. 46, July 1958, p. 1366/1373.

ATMOSPHERIC RADIO NOISE
J. Harwood, et al., Elect. & Radio Engrg., vol. 35, May 1958, p. 183/190.

(Equipment for the Measurement of Amplitude Distributions)

ATMOSPHERIC RADIO NOISE AT FREQUENCIES BETWEEN 10 KC/S AND 30 KC/S
J. Harwood, Proc. Instn. Elect. Engrs. pt. B, vol. 105, May 1958, p. 293/300.

SOME PROPERTIES OF LIGHTNING IMPULSES WHICH PRODUCE WHISTLERS
R. A. Helliwell, et al., Proc. IRE, vol. 46, Oct. 1958, p. 1760/1762.

THE RELATIONSHIP BETWEEN ATMOSPHERIC RADIO NOISE & LIGHTNING
F. Horner, J. Atmos. & Terrest. Phys., Dec. 1958, p. 140/154.

ATMOSPHERIC ANGELS MIMIC RADAR ECHOES
V. G. Plank, Electronics, vol. 31, no. 14, March 1958, p. 140/145.

BETWEEN THE ATMOSPHERICS
G. Reber, J. Geophys. Res., vol. 63, March 1958, p. 109/123.

Examination is made of the residual intensity of energy received between the atmospherics at a frequency of 520 kc.

RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY
L. G. Smith, (editor), London, England, Pergamon Press Ltd., 1958, 631 p., 59 papers.

. . . describes current experimental and theoretical investigations into the many natural electrical phenomena in the atmosphere. . . . text of the Proceedings of the Second Conference on Atmospheric Electricity held at Portsmouth, New Hampshire, May 20-23, 1958 . . .

POLARIZATION OF ATMOSPHERIC PULSES DUE TO SUCCESSIVE REFLECTIONS FROM THE IONOSPHERE
A. P. Tantry, et al., J. of Geophys. Res., vol. 63, Sept. 1958, p. 527/538.

LEHRBUCH DER LUFTELEKRIZITÄT (Textbook of Atmospheric Electricity) (In German)
E. Von Kilinski, Leipzig: Akademische Verlagagesellschaft, Geese & Portig - K-G, 1958, p. 141.

SFERICS RANGING TECHNIQUES
J. W. Wood, Army Signal Research and Development Lab., Fort Monmouth, N. J., Dec. 1958, 20 p., (ARSDL Technical rept. no. 1998), AD 213 767.

AVERAGE POWER OF IMPULSIVE ATMOSPHERIC RADIO NOISE
S. V. Chandrashekhar Aiya, Proc. IRE, vol. 47, Jan. 1959, p. 92.

THE SYNTHESIS OF ATMOSPHERIC FORMS AND THE EFFECTIVE PARAMETERS OF THE LOWER PART OF THE IONOSPHERE AT LOW FREQUENCIES
L. Al'pert, et al., Radio Engrg. & Electronics, vol. 4, no. 2, 1959, p. 65/77.

DIRECTIONAL OBSERVATIONS OF RADIO NOISE FROM THE OUTER ATMOSPHERE (Suppl. No. 17)
G. R. Ellis, et al., Nature, vol. 184, Oct. 1959, p. 1307/1308.

SPACED OBSERVATIONS OF RADIO NOISE FROM THE OUTER ATMOSPHERE (Suppl. No. 18)
G. R. A. Ellis, et al., Nature, vol. 184, Oct. 1959, p. 1391/1392.

INTERPRETATION OF SMOOTH-TYPE ATMOSPHERIC WAVEFORMS
F. Hepburn, J. Atmos. Terrest. Phys., vol. 14, June 1959, p. 262/272.

COMPARISON OF SFERICS PROPAGATED ALONG THE FAIRBANKS-THULE GREAT CIRCLE
J. H. Priedigkeit, Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

SFERIC MEASUREMENTS AT THREE ARCTIC STATIONS - SEPT. 1958 THROUGH MARCH, 1959
A. L. Whitson, Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

HF NOISE RADIATORS IN GROUND FLASHES OF TROPICAL LIGHTNING (Correspondence)
S. V. Chandrashekhar Aiya, Proc. IRE, vol. 48, May 1960, p. 955/956.

MEASUREMENTS OF THE SPECTRUM OF RADIO NOISE FROM 50 TO 100 CYCLES PER SECOND
M. Balser, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 4, July, Aug. 1960, p. 415/418.

THE TRANSMISSION OF SIGNALS DURING THUNDERSTORMS (Letter to the Editor)
V. A. Baranul'ko, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 6, 1960, p. 25/26.

. . . there has as yet been no fundamental study of radio interference due to distant thunderstorms. To do this, use has been made of radio direction finders spread out over 800 to 1000 km. These have made it possible to determine distant sources of interference in the South. Experiments have also been carried out in recent years to observe radio echo from lightning during local thunderstorms . . .

DETERMINATION OF THE AMPLITUDE-PROBABILITY DISTRIBUTION AT ATMOSPHERIC RADIO NOISE FROM STATISTICAL MOMENTS
W. Q. Crichlow, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 1, Jan., Feb. 1960, p. 49/56.

A STUDY OF ATMOSPHERIC RADIO NOISE RECEIVED IN A NARROW BANDWIDTH AT 11 MC/S
C. Clarke, Proc. Instn. Elect. Engrs., Pt. B, vol. 107, no. 33, May 1960, p. 311/319.

OBSERVATIONS OF ATMOSPHERIC RADIO NOISE
G. R. Ellis, Nature, vol. 186, no. 4720, April 1960, p. 229.

Recent observations of radio noise at a frequency of 5 kc /s appears frequently to come from sources of limited geographical size.

ATMOSPHERICS ON 20 KC /S AT THE TIME OF LOCAL AURORAE
E. Gherzi, Nature, vo. 187, no. 4733, July 1960, p. 225/226.

THE MEASUREMENT OF ATMOSPHERIC RADIO NOISE BY AN AURAL COMPARISON METHOD IN THE RANGE 15-500 KC/S
J. Harwood, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 107, no. 31, Jan. 1960, p. 53/59.

Atmospheric noise . . . is compared with a locally-generated . . . signal to estimate the level at which the signal is 95% intelligible. . . . range 15-500 kc/s. apparatus . . . results . . . discussed . . . noise powers . . . predictions . . .

RADAR STUDIES OF SOURCES OF NOISE IN LIGHTNING (A SURVEY OF EXSISTING KNOWLEDGE)
F. J. Hewitt, IN: RADIO NOISE OF TERRESTRIAL ORIGIN. International Scientific Radio Union, General Assembly, 13th, Commission 4 on Radio Noise of Terrestrial Origin, Proceedings, London, England, Sept. 1960, New York, Elsevier Publishing Co., 1962, p. 72/84, 15 refs., A63-22891.

. . . characteristics of radio noise from lightning discharges, as reported by various investigators, emphasizing the intensity, the waveform, and the location of the source, and the rate of occurrence. . . .

PROPERTIES OF NATURAL NOISE - RESULTS OF THE I.G.Y. ATMOSPHERIC NOISE PROGRAMME
F. Horner, IN: RADIO NOISE OF TERRESTRIAL ORIGIN. International Scientific Radio Union, General Assembly, 13th, Commission 4 on Radio Noise of Terrestrial Origin, Proceedings, London, England, Sept. 1960, New York, Elsevier Publishing Co., 1962, p. 100/108, 17 refs., A63-22893.

Review of measurements designed to establish the world distribution and properties of noise. An assessment is made of the amount and value of the available data, and the requirements for the study of these data are discussed. . . .

VLF PHASE CHARACTERISTICS DEDUCED FROM ATMOSPHERIC WAVE FORMS
A. G. Jean, et al., J. Geophys. Res., vol. 65, no. 3, March 1960, p. 907/912.

SOME MEASUREMENTS OF ATMOSPHERIC NOISE LEVELS AT LOW & VERY LOW FREQUENCIES IN CANADA
C. A. McKerrow, J. Geophys. Res., vol. 65, no. 7, July 1960, p. 1911/1926.

TROPOSPHERIC SCATTER PROPAGATION & ATMOSPHERIC CIRCULATIONS
W. F. Moler, et al., J. Res. Nat. Bur. Stand., vol. 64D, no. 1, Jan., Feb. 1960, p. 81/93.

MEASURED FREQUENCY SPECTRA OF VERY-LOW-FREQUENCY ATMOSPHERICS
T. Obayashi, J. Res. Nat. Bur. Stand., vol. 64D, no. 1, Jan., Feb. 1960, p. 41/48.

ATMOSPHERICS FROM LIGHTNING FLASHES WITH MULTIPLE STROKES
E. T. Pierce, J. Geophys. Res., vol. 65, no. 7, July 1960, p. 1867/1871.

VLF ATTENUATION FOR EAST-WEST AND WEST-EAST DAYTIME PROPAGATION USING ATMOSPHERICS
W. L. Taylor, J. Geophys. Res., vol. 65, no. 7, July 1960, p. 1933/1938.

ELECTROMAGNETIC STANDING WAVES AND BALL LIGHTNING
L. Tonks, Nature, vol. 187, no. 4742, Sept. 1960, p. 1013/1014.

A THEORYOF BALL LIGHTNING FORMATION
W. K. R. Watson, Nature, vol. 185, no. 4711, Feb. 1960, p. 449/450.

ELF ELECTRIC FIELDS FROM THUNDER-STORMS
A. D. Watt, J. Res. Nat. Bur. Stand., vol. 64D, no. 5, Sept., Oct. 1960, p. 425/433.

SFERIC DATA MAY IMPROVE NAVIAGATION
Electronics, vol. 33, no. 14, April 1960, p. 78.

STRUCTURE OF AN ATMOSPHERIC RADIO NOISE
S. V. Chandrashekhar Aiya, J. Sci. Industr. Res., vol. 21D, no. 7, July 1962, p. 203/220.

. . . improving the existing noise data. Available information is examined. The results of lightning discharge investigated and the characteristics of the different modes of propagation are analyzed . . . studies of both short-term and long-term amplitude and time characteristics of the noise . . . Conclusions (a) the distribution of any physical parameter associated with a lightning flash is log-normal; and (b) for all the effects arising directly from the same physical parameter, the standard deviation is also the same.

ATMOSPHERIC RADIO-NOISE STUDIES BASED ON AMPLITUDE-PROBABILITY MEASUREMENTS AT SLOUGH, ENGLAND, DURING THE INTERNATIONAL GEOPHYSICAL YEAR
C. Clarke, Proc. Instn. Elect. Engrs, London (Pt. B), vol. 109, no. 47, Sept. 1962, p. 393/404, 13 refs.

. . . presented are frequencies of 24 kc/s, 135 kc/s, 11 Mc/s and 20 Mc/s. The diurnal and seasonal variations of the noise power and average value of the noise envelope are derived, and a comparison is made between the measured noise power and predictions prepared under the auspices of the International Radio Consultative Committee. (C. C. I. R.) . . .

LIGHTNING—FACTS AND FANCIES
W. A. Gambling, J. Brit. Instn. Radio Engrs., vol. 23, no. 3, March 1962, p. 163/170.

. . . considerable amount of mythology on the subject, . . . After a discussion of these "fancies" the paper turns to the work of Benjamin Franklin who made the first serious study of lightning, . . . famous controversy concerning sharp and blunt conductors. . . . outline of current theories of the lightning discharge . . . of interest to the radio engineer. . . .

DIFFERENT TYPES OF MUSICAL ATMOSPHERES AND THEIR RELATIONS TO LIGHTNING DISCHARGES
E. Knudsen, et al., Uppsala U., Sweden, 1962, 19 p, AFCRL 63 228, AD 404 953.

The recording method at a whistler observation station allowed of a correlation between lightning discharges and musical atmospheres produced by them. About 700 musical whistlers collected in 1958-1961 have been analyzed. It was found that about 70% of the records were correlated to lightning discharges and about 30% were not.

SHORT TERM "TIME" CHARACTERISTICS OF IMPULSIVE ATMOSPHERIC NOISE
K. N. Lakshminarayan, J. Sci. Industr. Res., vol. 21D, no. 7, July 1962, p. 228/232.

DURATION AND SPACING OF SFERIC PULSES
R. F. Linfield, et al., Proc. IRE, vol. 50, no. 8, Aug. 1962, p. 1841/1842.

. . . obtained from a limited sample of sferics recorded simultaneously at two stations. About 9000 sferic waveforms from the 35/mm film records were analyzed . . .

SHORT TERM AMPLITUDE PROBABILITY DISTRIBUTION OF IMPULSIVE ATMOSPHERIC RADIO NOISE
M. Satyam, J. Sci. Industr. Res., vol. 21D, no. 7, July 1962, p. 221/227.

LONG TERM AMPLITUDE PROBABILITY DISTRIBUTION OF ATMOSPHERIC NOISE
M. Satyam, J. Sci. Industr. Res., vol. 21D, no. 8, Aug. 1962, p. 251/260.

CONVERSION OF THE AMPLITUDE-PROBABILITY PROBABILITY DISTRIBUTION FUNCTION FOR ATMOSPHERIC RADIO NOISE FROM ONE ONE BANDWIDTH TO ANOTHER

A. D. Spaulding, et al., J. Res. Nat. Bur. Stand., vol. 66D, no. 6, Nov., Dec. 1962, p. 715/720.

The amplitude-probability distribution function of atmospheric radio noise can be predicted with reasonable accuracy for a given bandwidth using only the first two moments of the noise measured at that bandwidth. This paper presents a method for predicting this distribution function for any specified bandwidth from the moments of the noise measured at a particular bandwidth.

OBSERVATIONS OF VLF RADIO NOISE AT GODHAVN, GREENLAND

E. Ungstrup, Technical U., Copenhagen (Denmark), Final technical rept., (Rept. no. 12), Sept. 1962, 108 p., incl. illus., tables, 27 refs., AD 293 834.

Audio frequency radio noise in the band from 0.5 to 15 Kc has been recorded at Godhavn, Greenland since July 19, 1947. The equipment used was designed according to the IGY specifications. . . . the occurrence of whistlers and the type of ionospheric noise named chorus has been studied.

RADIO NOISE OF TERRESTRIAL ORIGIN

International Scientific Radio Union, General Assembly, 13th Commission 4 on Radio Noise of Terrestrial Origin, Proceedings, London, England, Sept. 1960, Edited by F. Norner, New York, Elsevier Publishing Co., 1962, 210 p., A63-22889.

SPRING TUNDERSTORMS OVER BANGALORE

S. V. C. Aiya, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1493/1501.

. . . utilizing the now known experimental result that all types of flashes are equally effective in radiation HF noise. . . . for investigating the flashing characteristics of thunderstorms and deducing therefrom values of flash densities and thunderstorm parameters such as storm life, number of cells developed during the lifetime of a storm, cell life, rates of flashing, etc. The results of such studies of spring thunderstorms over Bangalore are discussed.

ATTENUATION CHARACTERISTICS OF RADIO-ATMOSPHERICS

H. Bhattacharya, et al., J. Atmos. Terres. Phys., vol. 26, Feb. 1964, p. 263/271, 13 refs., A64-16136.

Analysis of observed waveform patterns of radio-atmospherics to obtain amplitude-frequency spectra and distances of origin. . . .

MAGNETIC TAPE RECORDING AND REPRODUCING OF ATMOSPHERIC NOISE WITH A WIDE DYNAMIC RANGE

E. C. Bolton, Rev. Sci. Instrum., vol. 35, March 1964, p. 377/380, A64-15313.

. . . can record and reproduce atmospheric noise with a dynamic range of 90 db. The frequency range is 1 to 25 kc with a one-half octave bandwidth and, by using frequency conversion, frequencies from 25 to 500 kc may be recorded with a maximum bandwidth of 10 kc.

SOME STATISTICAL PROPERTIES OF ELECTROMAGNETIC NOISE

D. G. Childers, et al., University of Southern California, Los Angeles, Rept. no. EE 107, Feb. 1964, 41 p., AD 437 776.

. . . developing a theoretical representation of the noise which can be used for the evaluation of various detection techniques. . . . used to determine the cross-spectral densities and cross-correlation functions between antenna array elements in the presence of the noise field only. Results for unpolarized noise are also obtained. . . . For certain spatial orientations between dipoles it is possible to reduce the noise cross-correlation between these antenna array elements to zero. This result should prove useful in future antenna design.

STEPPED STRUCTURE ON THE SUNRISE EFFECT IN ATMOSPHERICS ACTIVITY ON 27 KC/S

M. W. Chiplonkar, et al., Indian J. Pure Appl. Phys., vol. 2, Jan. 1964, p. 30/32, 6 refs., A64-16952.

. . . Data were obtained at Poona, India between January 1962 and January 1963. On several occasions, a step structure was observed instead of a single fall in the activity. Two and sometimes three steps were observed before the fall . . .

QUARTERLY RADIO NOISE DATA, SEPTEMBER, OCTOBER, NOVEMBER, 1962

W. Q. Crichlow, et al., National Bureau of Standards, Boulder, Colo., (NBS-TN-18-16) June 10, 1963, 124 p., 17 refs., N63-18361.

INFLUENCE OF NATURAL NOISE UPON ANTENNA SYSTEM PERFORMANCE

A. R. Giddis, IEEE Trans. Aerospace, vol. AS-1, no. 2, Aug. 1963, p. 287/300.

. . . effects of natural radio noise upon the performance of ground antenna systems . . . describes the spatial and spectral properties of the major sources of radio noise, and presents the results of a comprehensive program of machine computation of antenna temperature. . . . these results and those of a recently completed noise measurement program are used to evaluate the carrier-to-noise ratio at a ground receiving antenna which is tracking a space probe.

OTSENKA PARAMETROV AMPLITUDNOGO RASPREDELENIIA ATMOSFERIKOV, GENERIRUEMYKH IZOLIROVANNYM ISTOCHNIKOM (Estimation of the Parameters of Amplitude Distribution of Atmospherics Generated by an Isolated Source) (In Russian)

L. G. Makhotkin, Geomagnetizm i Aeronomiia, vol. 4, no. 1, 1964, p. 200/202, A64-17021.

. . . describe . . . by a logarithmically normal law whose basic parameter is a standard deviation σ. On the basis of a comparison of results obtained from sources located in various geographic regions, it is concluded that the mean values obtained for σ are found to be approximately 7 to 8 db.

STATISTICS OF ATMOSPHERIC RADIO INTERFERENCE (Translation)
L. G. Makhotkin, Geomagnetism and Aeronomy, vol. 3, no. 2, 1963, p. 230/236, 17 refs., A64-14857.

Determination of the basic statistical regularities characterizing the amplitude distribution of atmospheric radio interference, using the available information on their sources . . . The results of computation are found to be in agreement with the experimental data.

ELF AND VLF ATMOSPHERIC NOISE
E. L. Maxwell, et al., DECO Electronics, Inc., Boulder, Colo., Rept. no. 30PG, Jan. 1964, 59 p., AD 428 273.

Various parameters of atmospheric noise have been measured over a wide frequency range (20 c/s to 50 kc/s) at a variety of geographic locations. . . . Mean noise density values are given as a function of time block, season, and region and are compared with CCIR predictions. Standard deviations of the five minute averages are presented with probability plots of five minute averages. Finally, geographical variations are shown for data obtained over a wide latitude and longitude range.

CALCULATED STATISTICAL CHARACTERISTICS OF ATMOSPHERIC RADIO NOISE
T. Nakai, Proc. of the Res. Inst. of Atmospherics, Nagoya U., vol. 10, Jan. 1963, p. 13/24, 2 refs., N63-18222.

The poisson noise process is considered in which the pulses of rectangular form with a constant duration are arriving at the times determined by Poisson's distribution law, and the average number of the observed pulses per second, the average duration of the observed pulses per second, and the probability of time length which is occupied by the existence of the observed pulses in the noise process are deduced. . . .

MAGNETIC FIELD VARIATIONS IN VICINITY OF LIGHTNING DISCHARGES
H. Norinder, Uppsala U. (Sweden) Final scientific rept., AFCRL 64 78, 1 Oct. 1958-30 June 1963, 30 June 1963, 23 p., AD 434 772.

EXCITATION OF EARTH-IONOSPHERE CAVITY RESONANCES BY LIGHTNING FLASHES
E. T. Pierce, J. Geophys. Res., vol. 68, July 1963, p. 4125/4127, 11 refs., A63-20139.

Discussion of the limitations of a procedure for extrapolating HF radio noise from VLF data for return strokes of a flash. . . .

RADIO NOISE ANOMALIES IN AUGUST 1958
G. A. Samson, J. Geophys. Res., vol. 68, May 1, 1963, p. 2719-2726, 13 refs., A63-16745.

1.723: Electrification Noise

Included: Statics; Precipitation noise; Dielectric noise; Precipitation static.

Not Included: Electromagnetic interference inside equipment; Electromagnetic compatibility.

Cross References: Atmospheric electricity (1.722).

Principal Publications:

CORRELATION FUNCTION AND POWER SPECTRA OF RADIO LINKS AFFECTED BY RANDOM DIELECTRIC NOISE
D. S. Bugnolo, IRE Trans. Antennas Propagation, vol. AP-7, April 1959, p. 137/141.

. . . of an electromagnetic wave by an extension of the notions of time-variable linear networks.

EVALUATION OF AN INTERFERENCE BLANKER FOR USE IN CONDITIONS OF PRECIPITATION STATIC
R. D. Rantz (comp.), Central Experimental and Proving Establishment (Canada), July 1959, (CEPE rept. no. 1417; Encl. 3 to Air Attache, Ottawa, rept. no. TL-113-59), AD 226 162.

THE INFLUENCE OF PRECIPITATION ON RADAR CONTRAST
K. S. Shifrin, et al., Radio Engrg., vol. 14, no. 9, 1959, p. 92/102.

PRECIPITATION SCATTER AS AN INTERFERENCE SOURCE IN COMMUNICATION SATELLITE SYSTEMS
A. S. Dennis, IRE Internat. Conv. Rec., vol. 10, no. 1, March 1962, p. 145/151, 24 refs.

. . . Communication satellite systems operating at frequencies as high as 3 Gc are now in the active planning stage. A number of recent papers have dealt with the interference produced at the ground receiving sites of such systems by tropospheric scatter from sources below the radio horizon. However, theoretical and experimental data from the field of radar meteorology show that scattering by precipitation particles at 3 Gc can easily exceed the tropospheric scatter component by several orders of magnitude.

1.724: Turbulent Noise

Included: Plasma noise; Noise from boundary layer turbulence; Noise generated by physical movement of particles in the medium; Noise due to anomalies in the atmospheric refraction index; Noise from clouds and moist layers; Phase difference fluctuations.

Not Included: Re-entry propagation.

Cross References: Atmospheric noise (1.722); Precipitation static (1.723).

Principal Publications:

EFFECTS OF CLOUDS AND MOIST LAYER ROUGHNESS ON RANGE RATE ERRORS OF RADIO INTERFEROMETER TRACKING AND GUIDANCE SYSTEMS
R. M. Cunningham, et al., Technical Operations, Inc., Burlington, Mass., Rept. for 1 Aug. 1962-14 Feb. 1963, 3-July 1963, 106 p., Rept. nos. SR1, to B63 58, AFCRL 63 706, AD 423 866.

Undesirable noise in radio interferometer tracking systems at Cape Canaveral has been attributed to anomalies in the atmospheric refraction indexes that are associated with inversion layers or clouds. The detailed structure of such anomalies often includes a moist/dry air interface that is disturbed by convective patterns or by progagation of gravity or shear waves. In the present study, highly instrumented aircraft were used to gather data on the position, geometry, and composition of these waves or disturbances . . . Mathematical models were . . . applied . . . For the Mercury-Atlas 7 shot, the models produced noise value slightly less than the actual noise determined from the tracking traces.

AUTOCORRELATION CHARACTERICS OF PHASE-DIFFERENCE FLUCTUATIONS
A. V. Men', Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 2, Feb. 1963, p. 26/35.

. . . which occur in the propagation of waves in a turbulent medium are considered. Using a phenomenological description of the medium by means of a correlation function of Gaussian form, the autocorrelation coefficients for various paths are determined by taking into account the effect of transport both of "frozen" and "unfrozen" turbulence. . . .

SPECTRAL CHARACTERISTICS OF PHASE-DIFFERENCE FLUCTUATIONS
A. V. Men', Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 24/32.

The spectral characteristics of phase-difference (amplitude) fluctuations are determined for waves propagating in a turbulent medium. It is shown that these characteristics have a number of distinctive features in comparison with similar characteristics for fluctuations in absolute phase (amplitude). In particular, when measurements are carried out over large bases, the phase-difference fluctuation spectrum has, independently of the type of path, an oscillating behavior. A comparison of theory and experiment is made. . . .

COHERENT EXTRACTION OF SIGNALS FROM TURBULENT NOISE
D. H. Tack, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 78/88, 13 refs.

This paper reports the results of some theoretical and experimental studies of the extraction of signals from convecting and decaying fluid dynamic turbulent noise employing an analog correlation receiver. In addition, it presents an extension of the theory of correlator analysis for finite observation times to the case of a linear time-varying delay. . . . Noise of turbulent origin is . . . often encountered in the transmission medium. This paper treats the extraction of signals from a particular type of turbulence, known as boundary layer turbulence, . . . generally associated with the flow of viscous fluids such as air or water over rough surfaces. . . . problems involved in the extraction of sonar signals and acoustic noise signals from flow noise associated with fast submarines. . . .

1.725: Nuclear Noise

Included: Radio noise from nuclear explosions; Nuclear pulse effects in electronic equipment generating electric noise; Nuclear pulse radiation.

Not Included: Radiation damage to components and equipment.

Cross References: Propagation effects of nuclear explosions (1.641).

Principal Publications:

ELECTROMAGNETIC NOISE AND PROPAGATION OBSERVATIONS IN THE VICINITY OF A NUCLEAR REACTOR
W. W. Fain, et al., IRE Trans. Antennas Propagation, vol. AP-6, July 1958, p. 286/288.

INDUSTRY PROBES NUCLEAR PULSE RADIATION
B. Miller, Aviation Week, vol. 73, no. 6, Aug. 1960, p. 58/73.

. . . a pulse of radiation might scramble the memory of a computer in a missile guidance system or may prematurely trigger a decision circuit which would throw the guidance system off. Or the malfunctions might temporarily block radio transmissions from a satellite or a space vehicle.

EFFECTS OF HIGH-ALTITUDE NUCLEAR EXPLOSIONS ON RADIO NOISE
C.A. Samson, J. Res. Nat. Bur. Stand, vol. 64D, no. 1, Jan., Feb. 1960, p. 37/40.

EFFECTS OF NUCLEAR TESTS ON RADIO NOISE
Wire and Radio Commun., vol. 7, July 1960, p. 26.

NOISE SIGNALS AND CARRIER MODULATION ARISING IN ELECTRICAL CABLES DURING NUCLEAR PULSE IRRADIATION
E. Both, et al., IEEE Internat. Conv., Rec., Pt. 6, vol. 11, no. 6, March 1963, p. 128/138.

THE TRANSIENT BEHAVIOR OF TRANSISTORS DUE TO IONIZED RADIATION PULSES
R.S. Caldwell, et al., Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 483/491.

The detailed mechanism of secondary photocurrent generation in transistors due to short pulses of ionizing radiation is discussed quantitatively, and the results of 2 μsec (microsecond) flash X-ray experiments are explained. . . .

NUCLEAR PULSE EFFECTS IN CABLES
K. Ilrath, et al., Army Electronics Research and Development Lab., Fort Monmouth, N.J., Aug. 1962, 62 p., 3 refs; USAERADL-TR-2292, N63-18999.

An equivalent circuit for a piece of cable is developed and the differential equations of this circuit are solved under the conditions of a transient burst of nuclear radiation and under various ranges of cable bias voltage.

TRANSIENT RADIATION EFFECTS IN COAXIAL CABLES DUE TO GAMMA-NEUTRON RADIATION PULSES
H.W. Wicklein, Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 473/483.

Definitive good-geometry tests have been performed on RG-59B/U and RG-174/U coaxial cables at the Kukla pulsed reactor.

. . . The responsible mechanisms are Compton scattering, ion pair generation, and secondary emission. . . .

Related Publications:

RADIO EMISSION FROM AN ATOMIC EXPLOSION (In Russian)
A.S. Kompaneets, Zh. Eksper. Teor. Fiz., vol. 35, Dec. 1958, p. 1538/1544.

. . . radio waves are emitted due to the presence of a current in the ionized air. The duration of the oscillation in each half-wave is of the order of 10 μs.

EMISSION OF RADIO WAVES FROM DETONATIONS
B. Koch, C.R. Acad. Sci., vol. 248, April 1959, p. 2173/2175.

Transient em waves giving a field strength of about 600 μv/m close to an explosion of 750 g of high explosive were recorded using a receiver tuned to 24.1 mc. They are attributed to ionic rather than thermal effects.

INVESTIGATION OF RF NOISE GENERATION FROM SPACE VEHICLES
R.D. Wanselow, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 346/351.

Analytical and experimental studies have been made on RF noise generated by two types of ion propulsion engines, namely the cesium contact ion engine and the Penning discharge engine.

. . . No noise was experimentally observed from the cesium contact engine over the frequency spectrum of 38 to 2200 Mc, but the Penning engine exhibited electron cyclotron radiation. Preliminary conclusions of this study are that reliable communications systems with a vehicle involving a Penning discharge propulsion engine should probably be operated above the cyclotron and plasma frequencies. . . .

Section 1.73
Man-Made External Disturbances

This section deals with electrical noise and disturbances created by electrical and mechanical facilities. Only a number of selected references are included; no special search was made in sources other than those quoted in the introduction. Since this subject is of interest to power engineers and to mechanical engineers (automotive engineers), many additional references will be found in their specialized publications. Problems of this nature are only of secondary importance in space communications, because they do not yet occur in space. Ground stations are carefully placed in areas where such disturbances are unlikely.

1.732: Interference from Machines

Included: Radio interference from ignition systems; Car radio interference; Site noise.

Not Included: Interference suppression devices.

Principal Publications:

THE EFFECTIVENESS OF USING THE STANDARDS OF INDUSTRIAL RADIO INTERFERENCE EFFECTIVE IN THE U.S.S.R. TO IMPROVE THE RECEPTION OF RADIO BROADCASTING AND TELEVISION
V. V. Roditi, et al., Radio Engineering, vol. 13, no. 6, 1958, p. 75/86.

A method for determining the probability of the disturbing influence of residual industrial radio interference is described and the results of the corresponding calculations and an evaluation of the effectiveness of using the standards for some groups of interference sources are quoted.

UBER DAS AUSSENGERAUSCH KOMMERZIELLER ANTENNENANLAGEN (On the External Noise in Commercial Communications Installations) (In German)
W. Kronjager, et al., Nachrichtentech. Z. (NTZ), vol. 12, July 1959, p. 371/374.

INTERFERENCE FROM THE IONOSPHERE
M. L. Shapiro, Electronic Industr., vol. 18, March 1959, p. 77/78.

Skyward facing directional antennas are easy prey for ionospheric reflection interference. How to determine the possibilities of subjection to this source is this articles objective.

RADIO INTERFERENCE FROM IGNITION SYSTEMS (Comparison of American, German and British Measuring Equipment, Techniques and Limits)
A. H. Ball, et al., Proc. Instn. Elect. Engrs. Pt. B, vol. 108, no. 39, May 1961, p. 273/278.

SPECTRUM POLLUTION
R. P. Gifford, IRE Internat. Conv. Rec., Pt. 5, vol. 10, March 1962, p. 223/225.

. . . man-made noise . . . Means can be found, I am sure, to reduce radio noise radiation from electrical equipment . . .

CAR RADIO INTERFERENCE SUPPRESSION
J. C. Jennison, Proc. Instn. Radio Engrs. Australia, vol. 23, no. 4, April 1962, p. 258/266.

The manner in which an ignition system produces interference and the effect on the listener are briefly discussed. The paths by which this interference enters a car radio are described, together with measures to reduce the effect. . . .

R. F. INTERFERENCE CONTROL HANDBOOK
B. Kemp, Indianapolis, Indiana, Howard W. Sams and Co. Inc., 1962, 224 p.

. . . completely covers all phases of R. F. interference, with special emphasis on causes and cures. It is a reference for technicians, engineers and others concerned with electrical noise problems connected with the design, installation, operation and maintenance of electrical and electronic systems. . . .

SITE NOISE AND ITS CORRELATION WITH VEHICULAR TRAFFIC DENSITY
A. G. Ellis, Proc. Inst. Radio Engrs. Australia, vol. 24, no. 1, Jan. 1963, p. 45/52.

In the VHF and UHF ranges, one of the major parameters associated with the prediction of radiotelephone system performance is the effective noise factor. This factor is a combination of the receiver's internal noise factor, a relatively small and constant component, and another noise factor, called the site noise factor, which assesses the intensity of the noise fields enveloping the receiver's antenna. Although this latter component has long been known to vary from site to site, its magnitude for planning purposes has hitherto been arbitrarily set at one of several discrete levels, the one chosen being

determined solely by the size of the city in the vicinity of the site. This paper shows that predictions of greater accuracy are obtained when the site noise is related to the nearby traffic density, and as a result of the measurements taken at various sites in Victoria and South Wales, suggests the law between them. . . .

1.733: Noise Due to Magnetic Induction

Included: Interference from power lines; TIF = telephone influence factor; Induction of noise.

Not Included: Screening problems; Magnetic screening.

Principal Publications:

PROBLEMS RELATING TO HEAVY CURRENT CABLE INDUCTION IN TELECOMMUNICATION CABLES WITH INSULATED METALLIC CABLE SHEATHS
E. Widl, Nachrichtentech. Z., vol. 13, no. 5, May 1960, p. 233/240.

TELEPHONE INFLUENCE FACTOR (TIF) AND ITS MEASUREMENT
W. C. Ball, et al., Commun. Electronics, vol. 79, no. 52, Jan. 1961, p. 659/664.

. . . evaluation of noise originating from harmonic components present in power system voltages and currents. Magnetic fields set up by power currents, and electric fields set up by power voltages, tend to induce voltages in nearby telephone conductors. . . . the basic yardstick for gaging a particular power circuit as a potential noise source is the telephone influence factor (TIF). This factor is dimensionless and provides an index of the inductive influence of a power system wave shape. . . .

INTERFERENCE BETWEEN POWER LINES AND TELECOMMUNICATION INSTALLATIONS (In German)
J. Sajonz, Frequenz, vol. 15, no. 3, March 1961, p. 79/87.

A comprehensive paper, dealing, on restricted space, with risk of danger and noise disturbances, electric and magnetic induction, internal impedance of an induced line for both forms of induction . . .

Section 1.74
Communications Noise

This section is devoted to references on disturbances which one communications service or channel causes to another, or to disturbances which originate in communications plants but not inside communications equipment. Disturbances from navigation services (radar), or ionospheric sounding operations are also included.

1.742: Correlated Noise

Included: Crosstalk noise; Radar interference; Modulation splatter; Co-channel interference; Intermodulation noise; Cross loss; CW interference; Adjacent channel interference.

Not Included: RFI protection; Design of multiplex systems (2); Electromagnetic compatibility.

Cross References: Interference reduction in FM systems (Sect. 1.23).

Principal Publications:

RADAR INTERFERENCE TO MICROWAVE COMMUNICATION SERVICES
R. D. Campbell, Electrical Engng., vol. 77, Oct. 1958, p. 916/921.

OTHER-THAN-CO-CHANNEL INTERFERENCE WITH RESPECT TO TROPOSPHERIC SCATTER COMMUNICATION. PART A. CONSTANT BARELY AUDIBLE SIGNALS
S. Perlman, et al., Army Signal Radio Propagation Agency, Fort Monmouth, N.J., May 1959, 145 p., AD 209 737, (See also AD 304 350.

. . . A supplement is included covering co-band interference at 2000 Mc and second harmonic interference from 1000 Mc FPTS equipment.

ANALYSIS OF THE SPECTRAL SHAPE OF MODULATION SPLATTER
R. Price, IRE Nat. Conv. Rec., vol. 6, no. 8, March 1958, p. 119/127.

Transmitter overload gives rise to 'modulation splatter', an undesirable spreading of the transmitted spectrum beyond the normal band. Using gaussian noise to represent the modulating signal, splatter power spectrum is investigated for AM and single-sideband-suppressed-carrier (SSSC) transmitters.

REDUCTION OF ADJACENT-CHANNEL INTERFERENCE COMPONENTS FROM FREQUENCY- SHIFT-KEYED CARRIERS
A. D. Watt, et al., IRE Trans. Commun. Syst., vol. CS-6, Dec. 1958, p. 39/47.

FINDING RADIO-FREQUENCY INTERFERENCE LEVELS
J. G. Arnold, Electronics, vol. 32, no. 48, Nov. 1959, p. 71/73.

. . . how to estimate intermodulation products imposed on a transmitted frequency by an interfering transmitter.

REDUCTION OF CO-CHANNEL INTERFERENCE BY PRECISE FREQUENCY CONTROL OF TELEVISION PICTURE CARRIERS. PART II.
W. L. Behrend, RCA Rev., vol. 20, no. 2, June 1959, p. 349/364.

The visibility of co-channel television interference has maxima and minima at carrier offset frequencies which are multiples of frame frequency. Earlier subjective tests determined the reduction in visibility of co-channel interference which might be achieved by precise carrier frequency control for the condition of one station, at a 10- or 20 kilocycle offset, interfering with the desired station.

Additional subjective tests have been made for the following conditions: two offset stations simultaneously interfering with a desired station; an on-frequency station interfering with a desired on-frequency station; and a series of tests with moving pictures as the desired picture and as the source of visual interference from a co-channel station offset 10 or 20 kilocycles. . . .

REDUCING MUTUAL RADAR INTERFERENCE
K. H. Chase, et al., Electronics, vol. 32, July 1959, p. 39/43.

INTERCHANNEL INTERFERENCE IN F.M. AND P.M. SYSTEMS UNDER NOISE LOADING CONDITION (In Japanese)
M. Kuwabara, J. Inst. Elect. Commun. Engrs., vol. 42, no. 7, July 1959, p. 689/696.

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

A detailed analytical study of transient cross modulation in the detection of multiple-signal asymmetric-sideband systems is presented. Various signal conditions and detection methods are considered. The transient crosstalk in both an idealized system and in a practical system is determined. Calculations show that the peak amplitude of the transient cross modulation can be many times as large as the

steady-state cross modulation. It is shown that product or synchronous detectors can eliminate the effects of cross modulation. . . . if two signals are present at the detector, a sudden change in one of them causes a spurious change in the amplitude and phase of the other. This type of distortion will be called transient cross talk distortion to differentiate it from the normal cross talk between two or more steady carriers. A later section shows that the transient cross talk distortion can be many times the steady-state cross talk. . . .

NON-LINEAR NOISE IN FDM TROPOSPHERIC SCATTER VOICE COMMUNICATION SYSTEMS
L. P. Yeh, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 152/166.

. . . The total noise has mainly two origins: (a) nonlinear noise (sometimes called intermodulation noise or crosstalk) due to nonlinearity of the system components . . . and (b) other noises such as thermal noise inherent in the receiver and external noises . . .

RADIO-FREQUENCY INTERFERENCE CONSIDERATIONS IN THE TD-2 RADIO RELAY SYSTEM
H. E. Curtis, Commun. and Electronics, no. 47, March 1960, p. 64/70.

INTERMODULATION ON AMPLITUDE-MODULATED MULTI-CHANNEL LINE LINKS
J. C. H. Davis, et al., Proc. Instn. Elect. Engrs. Pt. C, London, vol. 107, no. 12, Sept. 1960, p. 342/352, 13 references.

. . . a method for estimating the total intermodulation noise power falling into any channel in the transmission band of an a. m. multi-channel line system with many repeater sections in tandem. These sections may be composed of widely varying lengths of cable imperfectly equalized by non-identical amplifiers whose in-band feedback, output load impedance and output network response all vary with frequency. . . .

VOICE IMMUNITY OF TONE OPERATED SWITCHING CENTERS
J. H. Guenther, et al., Commun. Electronics, vol. 79, no. 51, Nov. 1960, p. 553/557.

Tone operation of electronic switching centers is the natural outgrowth of 4-wire operation of communication systems using a radio link. . . . to determine what part of the spectrum should be utilized for the control tones. . . . The system here described was . . . for the Army field switchboard. . . . specifications . . .

ANALYSIS OF RFI IN TRANSMISSION LINES
D. C. Ports, et al., Electronic Industr., vol. 19, no. 7, July 1960, p. 93/100.

RADAR INTERFERENCE WITH MICROWAVE RADIO
R. L. Robbins, Bell Lab. Record, vol. 38, no. 4, April 1960, p. 142/145.

IMPROVED LINE IMPEDANCE STABILIZATION METHOD
J. Shaw, et al., Stoddart Aircraft Radio Co., Hallywood, Calif., Final rept., Oct. 1960, lv., AD 419 512.

. . . to develop improved or new techniques of measuring RF conducted interference at frequencies ranging from 14 kilocycles to 100 megacycles. . . . new and improved line impedance stabilization methods . . . (a) Application of the two-current-probe method for measuring impedance and current of actual impedance sources, . . . (b) Application of the use of half of a current probe for measuring surface currents. . . .

INTERMODULATION MEASUREMENTS ON MULTICHANNEL CARRIER EQUIPMENT
A. W. Thies, Proc. Instn. Radio Engrs. Austrailia, Sp. Issue on Measurements in Electronics, vol. 21, no. 10, Oct. 1960, p. 715/718.

NOISE AND INTERMODULATION PROBLEMS IN MULTICHANNEL CLOSED-CIRCUIT TELEVISION SYSTEMS
C. A. Collins, et al., Commun. Electronics, vol. 80, no. 57, Nov. 1961, p. 486/491.

In the past decade there has been a rapid growth in communication facilities designed to transmit television (TV) signals relatively short distances over coaxial cables. These systems handle six or more video signals which amplitude-modulate (AM) r-f (radio-frequency) carriers in the 8- to 220-mc (megacycle) range. The associated audio signals frequency-modulate (FM) r-f sound carriers whose rest frequencies are 4.5 mc away from their associated picture carriers. . . . This paper will discuss two problems. . . thermal noise and intermodulation products created by amplifier nonlinearity. . . .

INTERMODULATION NOISE IN L[illegible]AR F.M. SYSTEMS
R. I. Magnusson, Proc. Instn. Elect. Engrs. (GB), Monogr., 459 E., July 1961, 13 p.

By applying a series of detailed approximations to the Rice and Bosse theory of f. m. intermodulation noise, the recent formulae of Medhurst and Roberts for intermodulation noise/signal ratios in f. m. systems with white-noise

modulation and networks of polynomial frequency characteristics are extended in three respects: . . .

PROBABILITIES OF INTERFERENCE WITH MOBILE FIELD RADIO DERIVED FROM A FIELD-STRENGTH SURVEY AT 59 Mc/s
D.R. Thomas, Proc. Instn. Electr. Engrs. Pt. B, (London), vol. 108, no. 39, May 1961, p. 264/272, 25 refs.

. . . experimental investigation of common- and immediately-adjacent-channel interference areas for mobile radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. . . . Particular attention has been paid to investigating the distribution of field strength at each distance, which is shown to approximate closely to log-normal. It is also established that the variance of these log-normal distributions may be considered to have a single value of each type of country, irrespective of range. Protection ratios acceptable for satisfactory operation are determined from experimental observation of common- and adjacent-channel interference. . . .

PROBABILITIES OF INTERFERENCE WITH MOBILE FIELD RADIO DERIVED FROM A FIELD-STRENGTH SURVEY AT 59 Mc/s
Proc. Instn. Elect. Engrs., vol. 180 B, May 1961, p. 264/272.

. . . experimental investigation of common- and immediately-adjecent-channel interference areas for mobile radio networks, based on a field-strength survey at 59 Mc/s over flat and hilly country in north-west Germany. . . .

ON THE CAPACITY OF A BAND-LIMITED CHANNEL PERTURBED BY STATISTICALLY DEPENDENT INTERFERENCE
N. M. Blachman, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 48/55.

THE EFFECT OF STATISTICALLY DEPENDENT INTERFERENCE UPON CHANNEL CAPACITY
N.M. Blachman, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. S53/57, 10 refs.

Bounds are derived and plotted for the capacity of a band-limited communication channel that accepts signals of specified average power as input, adding to them white gaussian noise and interference of specified average power which may depend on the signal being sent and on all of the other signals in the code book. . . . The present paper deals with a game in which a code is first selected—including explicit methods for both encoding and decoding--with the intention that it be as resistant to interference of any kind as possible. Then a message is sent by means of this code, subject to additive interference which may depend on the message being sent (it might be inferred from a short sample of the beginning of the signal) and on the code. The pay-off is the amount of information that is reliably received. . . .

TELEVISION BROADCAST TRANSMITTER SERVICE AREA PREDICTION
M.W. Davies, Proc. Instn. Radio Engrs. Australia, vol. 23, no. 10, Oct. 1962, p. 555/575.

. . . service area of a television broadcast transmitter . . . Iso-service diagrams for adjacent channel and co-channel interference conditions are described. . . . typified by considering conditions for VHF transmitters in the Newcastle-Sydney-Illawarra area of New South Wales. . . .

UBER DEN ENTSTEHUNGSMECHANISMUS DES NEBENSPRECHENS SYMMETRISCHER LEITUNGEN (On Crosstalk Interference Over Symmetrical Lines) (In German)
W. Klein, Arch. Elekt. Uebertragung, vol. 16, Oct. 1962, p. 525/531.

. . . the fundamentals of the nearly-tranversal and the non-transversal cross-talk theory. Subsequently the loci of far-end intraquad and interquad crosstalk are derived by reference to the basic formulae of the nearly-transversal crosstalk theory and compared with measurements at frequencies up to Mc/s on a four-pair carrier cable and a twenty-pair local cable. . . .

INTERMODULATION NOISE IN LINEAR F.M. SYSTEMS
R.I. Magnusson, Proc. Instn. Elect. Engrs., (Pt. C), vol. 109, no. 15, March 1962, p. 32/44.

By applying a series of detailed approximations to the Rice and Bosse theory of f.m. intermodulation noise, the recent formulae of Medhurst and Roberts for intermodulation noise/signal ratios in f.m. systems with white-noise modulation and networks of polynomial frequency characteristics are extended in three respects: (a) to the calculation of the noise ratio at any modulation frequency, (b) to network real and imaginary characteristics of eighth and seventh degree, respectively, and (c) to the case of pre-emphasis. The theory is illustrated by application to the cases of a signal with C.C.I.R. pre-emphasis passing a stagger-tuned triple without and with group-delay equalization.

F.M. INTERFERING CARRIER DISTORTION: GENERAL FORMULA
R.G. Medhurst, Proc. Instn. Elect. Engrs., vol. 109, no. 44, March 1962, p. 149/150.

The problem of the distorting effect of an interfering carrier on f.m. systems is one of long-standing interest. . . . There is need for a formula of general validity giving the

distortion of an f.m. signal due to an interfering f.m. carrier modulated by intelligence of a different form from that of the wanted modulation . . . This situation may occur, for example, in the interaction of satellite communication systems and line-of-sight trunk-radio systems. . . . The required formula can readily be derived. . . .

INTERMODULATION NOISE IN FM TROPOSCATTER LINKS (Correspondence)
W. Sichak, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2113.

. . . approximate formula for the intermodulation noise produced by tropospheric scattering. . . .

COMPARATIVE PERFORMANCE OF DIGITAL DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF CW INTERFERENCE
F. G. Splitt, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 72/81.

. . . The performance of differential phase-shift, coherent phase-shift, amplitude keyed, frequency shift and time-shift binary digital data transmissions is determined.

COMPARATIVE PERFORMANCE OF DIGITAL DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF CW INTERFERENCE
F. G. Splitt, IRE Trans. Commun. Systems, vol. CS-10, no. 2, June 1962, p. 169/177.

. . . The results obtained can also be utilized to ascertain system performance in the presence of interference from similar systems and for certain classes of interrupted CW (ICW) interference. . . . The performance of differential phase-shift, coherent phase-shift, amplitude-keyed, frequency-shift and time-shift binary digital data transmissions is determined. . . .

REDUCING THE EFFECTS OF INTERSYMBOL INTERFERENCE WITH CORRELATION RECEIVERS
J. M. Aein, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 167/175.

. . . optimization of a class of linear receivers to minimize the effects of this interference. . . . The optimum decision level as well as optimum impulse response is determined for receivers with and without memory where a priori knowledge of the channel characteristics are available. . . .

INTERFERENCE APPLIED RESEARCH DATA COLLECTION AND ANALYSIS. MODULATION AND DETECTION TECHNIQUES FOR INTERFERENCE SUPRESSION
S. J. Andrzejewski, et al., Bendix Radio Div., Bendix Corp., Baltimore, Md., Final rept., RADC TDR63 148, AD 406 221.

. . . theoretical and practical problems involved in the selection of an optimum communication system, when the interference consists of a random distribution of friendly pulse radars are discussed. Four . . . techniques . . . i.e., wideband FM, pseudo-random spread spectrum, pulse position modulation, and pulse code modulation . . . required post-detection signal-to-noise ratio of at least 50 db . . . A PCM system using a redundancy feasibility model . . . was tested and evaluated under controlled field conditions, and the results are compared with the theoretical expectations.

A METHOD OF ESTIMATING THE 1% MINIMUM CROSSTALK LOSS (FOR VOICE FREQUENCIES IN A PAIRED CABLE WITHOUT EMPIRICAL DATA
D. Aviv, et al., IEEE Trans. Commun. Electronics, no. 69, Nov. 1963, p. 668/673.

. . . A mathematical method for estimating the crosstalk loss corresponding to a probability of occurrence of P% at a specific voice frequency is described. The method requires only the information in a given cable specification regarding unbalanced cable parameters and the cable manufacturer's inspection procedure.

A NOTE ON THE CORRELATION FUNCTION OF NONINDEPENDENT, OVERLAPPING PULSE TRAINS
E. D. Banta, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 160/161.

Biorci and Mazzetti have found a general formula for the correlation function of nonindependent, overlapping pulse trains; however, its application involves considerable mathematical difficulties in general. This paper shows how these difficulties can be avoided. . . .

A METHOD FOR PREDICTING INTERCHANNEL MODULATION DUE TO MULTIPATH PROPAGATION IN FM AND PM TROPOSPHERIC RADIO SYSTEMS
C. D. Beach, et al., Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 1/36.

. . . interchannel modulation due to multipath propagation on angle-modulation tropospheric scatter radio systems. Values of signal-to-intermodulation ratio, S/I, are calculated for various pairs of signal reflections in the troposphere, taking into account the base bandwidth and frequency deviation of the system, the antenna patterns, the path geometry, and climatic conditions during the "worst month" of propagation. The lowest value of S/I (worst intermodulation) computed for such paris of signal reflections is then corrected empirically to account for multiple reflections. The result represents the median value of S/I expected during the worst month of transmission on a specified path. . . .

INTERCHANNEL INTERFERENCE IN FM SYSTEMS PRODUCED BY CONTINUOUS RANDOM MODE CONVERSION IN CIRCULAR ELECTRIC WAVEGUIDE
L. H. Enloe, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2765/2786.

Long-distance, high-capacity transmission via the TE_{01} mode in circular waveguide is an attractive goal because the theoretical attenuation caused by heat loss decreases monotonically as the frequency of operation increases. However, continuous random mode conversion caused by the manufacturing or the laying of the waveguide causes severe random fluctuations with frequency in the transfer function of present-day waveguide, a fact which apparently eliminates all but the "toughest" modulation schemes, such as pulse code modulation and angle modulation.
In this paper, we present the derivation of a technique for analyzing the effects of continuous random mode conversion on an angle-modulation wave . . . The examples use typical state-of-the-art data and are significant in that they demonstrate that FM appears to be an attractive modulation scheme . . .

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J. C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . primary emphasis on the intersymbol interference problem. . . .

METHODS FOR CALCULATING DISTANCE SEPARATION FOR NONINTERFERING TRANSMISSIONS
A. J. Hoehn, IEEE Trans. Electromagnetic Compatibility, vol. EMC-6, Jan. 1964, p. 12/27, 6 refs., A64-15074.

. . . distance required between transmitters with co-channel frequency assignments so that interference between them may be held below a specified level . . . utilization probabilities resulting from communications traffic volume . . . A graphical-analytic method is developed which reduces the usual path attenuation vs distance charts to normalized form . . .

K TEORII PROKHOZHDENIIA SHIROPOLOSYNKH SIGNALOV V SISTEMAKH NAZEMNOI KOSMICHESKOI SVIAZI (Contribution to the Theory of Wide-Band Signal Transmission in Ground-Based Space Communications Systems) (In Russian)
A. V. Prosin, Radiotekhnika i Elektronika, vol. 8, Nov. 1963, p. 1822/1833.

. . . Developed is a method for calculating cross noise created by the dispersion-induced distortions in multichannel multiplexed FM communications systems based on the use of artificial Earth satellites.

CROSSTALK IN TIME DIVISION MULTIPLEX SYSTEMS (Correspondence)
L. Saporta, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 250/253.

An analysis of the interchannel crosstalk in time division multiplex system is given. The results apply to systems with a general linear transmission channel and with arbitrary sampling waveforms. . . .

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS-COMMUNICATION TYPE
R. D. Trammell, Jr., et al., Georgia Inst. of Tech., Engineering Experiment Station, Atlanta, Quarterly rept. no. 2, 15 May-15 Aug. 1963, Rept. no. 23, 15 Aug. 1963, 66 p., AD 423 645.

Qualitative common-channel interference tests were made on a wide-band FM system. The effect of simultaneous reception of two signals on the understandability of the desired received signal is reported. Two path interference tests were initiated on a radio relay system which employs time division multiplexing. . . .

Related Publications:

INTERFERENCE IN FM RECEPTION
J. Granlund, Res. Lab. Electronics, M.I.T., no. 42, Jan. 1949.

FREQUENCY-MODULATION INTERFERENCE REJECTION WITH NARROW-BAND LIMITERS
E. J. Baghdady, Proc. IRE, vol. 43, Jan. 1955, p. 51/61.

MAKING TRANSMITTERS RFI-FREE
C. E. Blakely, et al., Electronic Industr., vol. 19, no. 3, March 1960, p. 132/141, Many refs.

OPTIMUM-DE-CODING SYSTEM FOR THE TRANSMISSION OF THE MAXIMUM NUMBER OF PARAMETER VALUES IN THE PRESENCE OF NON-ADDITIVE NOISE
B. S. Fleishman, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 36/46.

. . . construction of a system of de-coding which for definite types of modulation will ensure that the maximum number of parameter values will be reliably transmitted in the presence of non-additive noise. . . .

METHOD OF INCREASING THE SELECTIVITY OF RECEIVERS FOR TWO AM SIGNALS WITH SUPERIMPOSED FREQUENCY SPECTRA
Yu. N. Babanov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 45/48.

. . . The presence in the receiving channel of the communication system of powerful oscillations

of an interfering station worsens the reception conditions and into a breakdown in communications. In order to design a system capable of eliminating the harmful effect of the interfering station, we shall make use of the fact that the probability that the carrier frequencies of the desired and interfering stations are coincident is very small. In other words, we shall assume that the carrier frequency ω_u of the unwanted station differs from the carrier frequency ω_w of the wanted station . . . The circuit is a special converter stage in which the band-pass filter F_2, tuned to the intermediate carrier frequency of the wanted station, is the anode load of a converter tube, while the circuit consisting of the narrow-band filter F_1 with variable tuning, a frequency multiplier (doubler), and a phase shifter serves to generate a special heterodyning voltage which is applied to the conversion grid of the tube. We . . . show how such a system of special IF amplifier stages is effective in eliminating the harmful effect of the signal of the unwanted station. . . .

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO FM SIGNALS AND NOISE

D. L. Schilling, Microwave Research Inst. of Brooklyn, N.Y., (Research rept. no. PIBMRI-1040-62), June 1962, 136 p., incl. illus. tables, refs., AD 295 555.

. . . Emphasis is placed on the system's response to frequency ramp modulated signals.

. . . The response of the system to an FM signal is obtained using a perturbation technique and perturbing about the solution to the nonlinear pendulum problem. A piecewise-linear solution is also presented . . .

BOOTHROYD AND INTERSYMBOL INTERFERENCE REDUCTION (Correspondence)

R. D'Attilio, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 257.

EXPERIMENTAL INVESTIGATION OF A METHOD FOR IMPROVING THE SELECTIVITY OF RADIO RECEIVERS FOR OVERLAPPING AM SIGNAL SPECTRA

Yu. N. Babanov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 27/30.

Results of experimental investigations on the separation of two AM signals with overlapping frequency spectra in radio receivers are reported. The experimental circuit with which the investigation was performed is given. . . .

A DIGITAL WIDE-BAND NONLINEAR RECEIVER CAPABLE OF NEAR OPTIMUM RECEPTION IN THE PRESENCE OF NARROW-BAND INTERFERENCE

J. C. Hancock, et al., IEEE Trans. Commun. Syst., CS-11, no. 3, Sept. 1963, p. 272/279.

In a wide-band communication system the additive disturbances in the channel are less likely to be white Gaussian noise than in narrow-band links. . . . illustrates how linear receivers can be made more optimum by incorporating a nonlinear transformation which precedes detection. Narrow-band AM stations are assumed to be the only additive disturbance in the channel. Adaptive techniques are also suggested . . .

A FUNCTIONAL ANALYSIS RELATING DELAY VARIATION AND INTERSYMBOL INTERFERENCE IN DATA TRANSMISSION

R. W. Lucky, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2427/2483.

A relationship is derived between the delay characteristic in a data transmission system and the distortion in the form of intersymbol interference created by the delay variation. The relationship is valid for small delay and involves a sequence of linear functionals, each of which has a particular significance. . . .

O VLIIANII FORMY SIGNALA NA EGO OBNARUZHENIE PRI NORMAL'NYKH KORRELIROVANNYKH POMEKHAKH (The Effect of Shape on Signal Detection in the Presence of Normal Correlated Noise) (In Russian)

V. F. Nesteruk, Radiotekhnika i Elektronika, vol. 8, Aug. 1963, p. 1319/1325.

. . . the problem of optimum signal detection for the conditions of correlated noise. An example of Markov noise is considered.

RECEPTION OF A PULSE PACKET IN THE PRESENCE OF CORRELATED NOISE

V. F. Nesteruk, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 8/14.

A method of calculating the optimum configuration of a packet of coherent pulses received on a background of correlated noise is described. The optimum configuration of the packet is found for Markov noise. A distinctive feature in the reception of a finite pulse packet is the fact that noise cannot be assumed to be uncorrelated. As a result, the probability of correct detection of a pulse packet will depend not only on the power level of the packet but also on the shape of the pulses of which the packet consists and on the power distribution over the packet . . .

THE APPLICABILITY OF SIGNAL DENSITY STUDIES IN INTERFERENCE PREDICTION

O. M. Salati, Inst. for Cooperative Research, Univ. of Pennsylvania, Philadelphia, Rept. no. IS63 UR6, RADC TDR63 359, suppl. 1, Dec. 1963, 265 p., AD 436 640.

. . . systematic procedure for studying the problems and interactions of communications systems. . . .

1.743: Pulsive Noise in Communications Channels

Included: Impulse noise on lines and cables; Models for impulse noise; Error clustering related to impulse noise; Hyperbolic error distribution.

Not Included: Noise suppression circuits; Noise cancellation techniques (2).

Cross References: Atmospheric noise (1.722); Analysis of pulsive noise (1.717).

Principal Publications:

NOISE MEASUREMENTS ON TELEPHONE CIRCUITS
H. C. Franke, Tele-Tech and Electronic Industries, vol. 14, March 1955, p. 85.

DETECTION OF ASYMMETRIC SIDEBAND SIGNALS IN THE PRESENCE OF NOISE
T. Murakami, et al., RCA Rev., vol. 19, no. 3, Sept. 1958, p. 388/417, 19 refs.

The first part of this paper analyzes three methods of detection of signals contaminated by fluctuation noise:
(1) Linear Envelope Detectors
(2) Product Detectors
(3) Exalted Carrier Detectors
A new ratio, the "video-to-noise-error ratio" is proposed for a more adequate quantitative evaluation of detector performance. . . . The second part of this paper analyzes the effects of impulse noise on the detection of asymmetric sideband signals. It is shown that product detectors eliminate the rectification of the noise envelope found in envelope detectors. This is of particular interest in assymmetric sideband systems where the noise output will be at relatively high frequencies. These can often be separated from lower frequency signals, making possible efficient impulse noise suppression.

STATISTICAL ERROR CONTROL OF A REALIZABLE BINARY SYMMETRIC CHANNEL
I. S. Reed, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1 Nov. 1959, 13 p., AD 241 453.

. . . It is shown how the statistics of a channel can be measured as the message is being received. A confidence level acceptance or rejection criterion is presented which is based on these measurements. In order to accomplish this aim, a phone line channel is studied. . . . binary symbols are distinguished from one another by 180° phase reversals of a carrier . . . noise . . . occurs in bursts . . . no a priori knowledge of the expected noise power. . . .

EVALUATION OF MESSAGE CIRCUIT NOISE
A. J. Aikens, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 879/909.

CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION
A. A. Alexander, et al., Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 431/476.

This paper presents the results of a nationwide data transmission field testing program on the telephone switched message network. Error performance using the FM digital subset is described and basic transmission characteristics such as net loss, bandwidth, envelope delay and noise are given.

THE TESTING OF DIGITAL DATA TRANSMISSION CHANNELS AND CIRCUITS
R. G. Enticknap, Proc. Nat Electronics Conf., vol. 16, Oct. 1960, p. 66/71, 9 refs.

. . . concentrated primarily on telephone circuits of a type generally available, aims at a better understanding of these transmission media, particularly in respect of the additive and multiplicative noise which appears to constitute the major source of errors in current data transmission systems.

. . . a number of phases: (1) the measurement of errors . . . (2) the measurement of additive noise . . . (3) the measurement of dynamic characteristics . . . involved both field and laboratory measurements. . . . While no results of these measurements are given, they are referenced in other papers. An attempt is made to summarize the program to date . . .

CAPACITY OF A BURST-NOISE CHANNEL
E. N. Gilbert, Bell Syst. Tech. J., vol. 39, no. 5, Sept. 1960, p. 1253/1265.

A model of a burst-noise binary channel uses a Markov chain with two states G and B. In state G, transmission is error-free. In state B, the channel has only probability h of transmitting a digit correctly.

MEASURED ERROR DISTRIBUTIONS ON THE BELL A-1 FACILITY OVER VARIOUS MEDIA
E. J. Hofmann, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 37/44.

Comparison of radio noise data for August 1958 with those for later years, showing that the Johnston Island nuclear explosions on August 1 and 12, 1958, affected the atmospheric radio noise over a wide area in the Pacific region. Graphs of the midnight noise level at several frequencies from 13 kc to 5 Mc illustrate apparent noise anomalies at Cook, Australia; Ohira, Japan; Byrd Station, Antarctica; and

Singapore. These anomalies resemble in several respects the well-marked effects previously noted at Kekaha, Hawaii.

RADIO EMISSION FROM CLOUDS
J. D. Sartor, J. Geophys. Res., vol. 68, Sept. 15, 1963, p. 5169/5172, A63-22370.

. . . Preliminary studies have revealed radio emission from colliding charged water drops at frequencies of the order of tens of megacycles, possibly higher. . . .

ON THE INTEGRATED FIELD INTENSITY OF ATMOSPHERICS
K. Sao, J. Atmos. Terrest. Phys., vol. 26, March 1964, p. 367/374, 7 refs., A64-16810.

Statistical approach to the evaluation of Rayleigh distribution noise. . . .

ELF AND VLF ATMOSPHERIC NOISE
E. L. Maxwell, et al., DECO Electronics, Inc., Boulder, Colo., Rept. no. 30P6, 10 Jan. 1964, 59 p., AD 428 273.

Various parameters of atmospheric noise have been measured over a wide frequency range (20 c/s to 50 kc/s) at a variety of geographic locations. . . . Mean noise density values are given as a function of time block, season, and region and are compared with CCIR predictions. Standard deviations of the five minute averages are presented with probability plots of five minute averages. Finally, geographical variations are shown for data obtained over a wide latitude and longitude range.

Related Publications:

PERFORMANCE OF SOME RADIO SYSTEMS IN THE PRESENCE OF THERMAL AND ATMOSPHERIC NOISE
A. D. Watt, et al., Proc. IRE, vol. 46, Dec. 1958, p. 1914/1923.

PHENOMENA OF SCINTILLATION NOISE IN RADAR-TRACKING SYSTEMS
J. H. Dunn, et al., Proc. IRE, vol. 47, May 1959, p. 855/863.

THE THEORY OF THE COSMIC BACKGROUND RADIO SIGNAL RECEIVED WITHIN THE IONOSPHERE
K. C. Budden, et al., Royal Society (London), Proceedings, Series A, vol. 277, Feb. 11, 1964, p. 365/384, 16 refs., A64-14769.

Study of the electric and magnetic fields to be expected within the ionosphere from a background source uniformly distributed across the sky. . . .

EFFECTS OF CLOUDS AND MOIST LAYER ROUGHNESS ON RANGE RATE ERRORS OF RADIO INTERFEROMETER TRACKING AND GUIDANCE SYSTEMS
R. M. Cunningham, et al., Technical Operations, Inc., Burlington, Mass., Rept. for 1 Aug. 1962-14 Feb. 1963, 3-July 1963, Rept. nos. SR1, to B63 58, AFCRL 63 706, 106 p., AD 423 866.

Undesirable noise in radio interferometer tracking systems at Cape Canaveral has been attributed to anomalies in the atmospheric refraction indexes that are associated with inversion layers or clouds. . . .

EXPERIMENTAL RESEARCH INVESTIGATION OF EXTREMELY LOW FREQUENCY PROPAGATION
G. R. Dunn, et al., Space General Corp., El Monte, Calif., Rept. no. 212R8, AFCRL 64164, Final rept. 28 Feb. 1964, 75 p., AD 437 777.

. . . Data which could be reduced to yield signal strength, attenuation rate, transmission path phase variations, and atmospheric noise amplitude probability distributions (APD) were recorded at the receiver site. . . .

NON-GAUSSIAN ATMOSPHERIC NOISE IN BINARY-DATA, PHASE-COHERENT COMMUNICATION SYSTEMS
B. Shepelavey, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 280/284.

Performance evaluation of a binary-data phase-coherent system is presented for the case when interference is confined to the non-Gaussian component of atmospheric noise. . . . a mathematical model of the non-Gaussian component of atmospheric noise in narrow bandwidths is formulated which, for high instantaneous noise voltages, coincides exactly with the empirical atmospheric noise data. . . .

PHYSICAL MEASUREMENTS FROM METEOROLOGICAL SATELLITES
D. Q. Wark, et al., National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md., April 1963, p. 85/88, 20 refs., N63-21368.

. . . the measurements of "Sferics" - RF emissions by lightning (from "atmospherics").

Error distributions have been obtained by experiments carried out using an automatic digital data error recorder which is described. Media include several land line telephone circuits and the Hawaiian cable. Both data and sync errors rates are shown, and their temporal and amplitude characteristics are examined. . . . The effectiveness of parity checkas an error-detecting device is also evaluated. . . .

USE OF STATISTICAL MOMENTS FOR SPECIFYING NOISE IN LONG-DISTANCE TELEPHONE CIRCUITS
B. B. Jacobsen, Elect. Commun., vol. 36, no. 3, 1960, p. 197/201.

. . . treats the problem: How should the tolerable noise power on a telephone circuit be expressed? The object is . . . to formulate it in a way that does not place any unnecessary restrictions on noise of any particular time distribution. An important requirement is that it should be realistic and in practice this means that very-intense noise must be accepted, but it must not occur too often or last too long. It has been proposed to specify the permissible amount of noise not by a distribution curve, but instead by its moments. . . . The purpose of the present paper is to consider the effect of specifying the permissible noise by its first three hourly moments. . . .

MODEL OF ERROR BURST STRUCTURE IN DATA TRANSMISSION
P. Mertz, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 232/240.

. . . assumes a distribution of burst durations that follows recent experimental data. It is multiple in form, and consists of a proportion of 1-bit bursts superimposed on a "triangular" continuous distribution. Some analysis shows the equivalence of this model with equal duration bursts, when the constant duration is suitably chosen. . . .

IMPULSE NOISE ON AN H-44 TELEPHONE CIRCUIT LOOPED FROM LEXINGTON, MASS., VIA WEST HAVEN, CONN."
R. R. Pfeiffer, et al., Lincoln Laboratory, Mass. Inst. Tech., Lexington, April 1960.

THE DESIGN OF AN "ERROR-FREE" DATA TRANSMISSION SYSTEM FOR TELEPHONE CIRCUITS.
B. Reiffen, et al., Lincoln Lab., MIT, Lexington, 22 Dec. 1960. AD 248 637.

. . . easily implemented codes can detect essentially all errors occurring in digital data sent over toll grade telephone circuits. A two-way communications system is described which uses these codes to detect the occurrence of errors and requests a retransmission of any data in error . . . The philosophy that guided the design of this system can be applied to other media where high noise bursts or low signal levels occur infrequently.

SOME RESULTS IN THE MEASUREMENT OF IMPULSE NOISE ON SEVERAL TELEPHONE CIRCUITS
H. L. Yudkin, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 222/231.

. . . Distributions of impulse noise, amplitude and duration are given. Comments are made on the interpretation of impulse noise statistics and the relationships between these and statistics of errors in data transmission are discussed. . . .

PHONE LINE DIGITAL TRANSMISSION STUDY
Hughes Aircraft Co., Culver, Calif., Sept. 1960, 240 p., (RADC TR 60-153), AD 244 193.

. . . Initially, the transmission characteristics of a variety of basic circuits and their combinations are detailed in terms of their attenuation-frequency response and their envelope delay-frequency response . . . Frequency stability, gain stability, compandor effects, echo, crosstalk and noise, and impulse noise are considered in turn. . . .

EFFECTS OF IMPULSE NOISE ON DIGITAL DATA TRANSMISSION
A. B. Bodonyi, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 355/361.

. . . basic characteristics of impulse noise and its effects on various types of binary data transmission systems. The sources and properties of such impulsive noise, in contrast to Gaussian noise, are discussed. . . . comparison among the three modulation schemes tested, namely, on/off carrier, frequency shift, and phase reversal keying.

EFFECTS OF IMPULSE NOISE ON DIGITAL DATA TRANSMISSION
A. B. Bodonyi, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Master's thesis., 11 Dec. 1961, 23 p., illus., 14 refs., (Research rept. no. PIBMRI-975-61), AD 285 511.

. . . basic characteristics of impulse noise . . . experimental comparative evaluation of bit error rates in presence of additive impulsive noise . . . three modulation schemes tested, namely on/off carrier, frequency shift and diphase (phase reversal keying, with coherent detection). . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., 3 Jan. 1961, (Rept. no. UA-1420-S-1), (RADC TR 61-58), AD 256 584.

. . . The properties of impulse noise are examined and the effect of impulse noise are examined and the effect of packed codes are investigated. . . .

MODEL OF IMPULSIVE NOISE FOR DATA TRANSMISSION
P. Mertz, IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 130/137.

STATISTICS OF HYPERBOLIC ERROR DISTRIBUTIONS IN DATA TRANSMISSION
P. Mertz, IRE Internat. Conv. Rec., pt. 8, vol. 9, March 1961, p. 160/166.

Error bursts in data transmission. . . . follow a hyperbolic rather than a Poisson distribution.

STATISTICS OF HYPERBOLIC ERROR DISTRIBUTIONS IN DATA TRANSMISSION
P. Mertz, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 377/382.

ON THE POTENTIAL ADVANTAGE OF A SMEARING-DESMEARING FILTER TECHNIQUE IN OVERCOMING IMPULSE-NOISE PROBLEMS IN DATA SYSTEMS
R. A. Wainwright, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 362/366.

IMPULSE-NOISE IN DATA LINE SYSTEMS
R. A. Whiteman, et al., Nat. Commun. Symp. Record, vol. 7, Oct. 1961, p. 289/301.

ON TELEPHONE ERROR CLUSTERING CONSIDERED AS AN ILLUSION
J. M. Berger, et al., Thomas J. Watson Research Center, Yorktown Heights, N. Y., 23 Oct. 1962, 44 p. incl. illus., table, refs., (Research Note. No. NC-152), AD 291 227.

A new explanation is given of the clustering of errors on telephone lines. It is claimed that this phenomenon is largely an optical-probabilistic illusion, and the claim is justified with the help of extensive data.

NOISE STABILITY FOR IMPULSE NOISE OF FREQUENCY TELECONTROL SYSTEMS (In Russian)
Y. I. Chugin, Avtomat. i Telemekh, vol. 23, no. 2, 1962, p. 222/241.

Noise stability is examined for f. m. telecontrol systems when the noise is an impulse noise occurring at random time and with random amplitude; the probability distribution of the noise amplitude is assumed to be known. First, the amplitude of the sinusoidal signal and the noise power at the output of a channel filter are determined for three types of receivers: (1) a wide-band discriminator without a limiter, (2) a narrow-band discriminator without a limiter, and (3) a discriminator with a limiter. . . . The optimal transmission band is then discussed in accordance with the minimum of the total error due to impulse noise and continuous fluctuating noise. . . .

TWO MEASURING TECHNIQUES FOR THE INVESTIGATION OF IMPULSE NOISE AND DROPOUTS ON TELEPHONE LINES
J. Kelly, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 585/590.

. . . The latter method provides a means of identifying the cause of errors during the transmission of digital data. . . . on a data circuit between Boston and Chicago. . . .

INVESTIGATION OF THE ERROR STATISTICS OF PULSE DATA UNDER NON GAUSSIAN NOISE CONDITIONS
K. Kupfmuller, Technische Hoschule, Darmstadt (Germany), Final technical rept., 1 Oct. 1961 - 30 Sept. 1962, 30 Sept. 1962, 7 p., AD 294 828.

. . . Noise recorded from heavily disturbed subscriber's lines was investigated. A data transmission system using amplitude modulation and a transmission speed of 1800 baud was built up and tests were carried out in the presence of line noise to study the receiver error rates.

MODULATION AND SIGNAL SELECTION FOR DIGITAL DATA SYSTEMS
R. M. Lerner, Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 661/669, 33 refs.

. . . Implications of the fact that the channel noise is not Gaussian, but impulsive in character, are briefly explored. . . .

THE ESTIMATION PROBLEM IN NULL-ZONE RECEPTION FEEDBACK SYSTEMS
J. J. Metzner, et al., New York U., Coll. of Engineering, N. Y., 15 Aug. 1962, 137 p., incl. illus., tables, 26 refs, (Scientific rept. no. 11), (AFCRL 62-742), AD 290 325.

... Methods of minimizing the undesirable effects of impulsive and burst-type noise are discussed.

ERROR BURST CHAINS IN DATA TRANSMISSION
P. Mertz, Rand Corp., Santa Monica, Calif., Feb. 1962, 28 p., 6 refs, (Memo. no. RM-3024-PR), AD 272 429.

Errors . . .come in bursts, and the bursts themselves also show bunching rather than complete randomness. This has been described with hyperbolic rather than classical Poisson laws. The error bursts form into occasional chains. Such chains are highly improbable in an all-Poisson distribution. Their expectancy has been determined under assumptions that within a chain distribution is Poisson, but the long-time distribution is hyperbolic . . . An estimate is also given of the longest expected chains in tests of given durations.

ERROR BURST CHAINS IN DATA TRANSMISSION
P. Mertz, IRE Internat. Conv. Rec., pt. 8, vol. 10, March 1962, p. 47/56.

. . . the bursts themselves also show "bunching" rather than complete randomness. This has been described with hyperbolic rather than classical Poisson laws. The error bursts form into occasional chains. Such chains are highly improbable in an all-Poisson distribution. Their expectancy has been determined under assumptions that within a chain the distribution is Poisson, but the long-time distribution is hyperbolic. The results show the moderate probability of the chains observed in experience. . . .

FURTHER ANALYSIS OF ERRORS REPORTED IN "CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION"
R. Morris, Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1399/1414.

The recorded error data from a field testing program reported on by Alexander, Gryb, and Nast have been further analyzed. New methods of analysis have given more information on the causes and nature of errors experienced by data in the switched telephone plant. The results obtained will enable workers in the field of error control to use the field test data more effectively. . . .
Effect of Dropouts . . .
Effects of Noise . . .
Role of the Test Word . . .
Relation to Error-Control Schemes . . .

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 3, 11 March - 10 June 1962, 10 June 1962, lv, incl. illus., tables, AD 282 947.

. . . Controlled impulse noise tests were conducted. . . . results show . . . the vsb modem is the most susceptible to impulse noise. . . .

ON THE BINARY DATA TRANSMISSION ERROR RATES DUE TO COMBINATIONS OF GAUSSIAN AND IMPULSE NOISE
L. R. Halsted, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Dec. 1963, p. 428/435.

Error rates are computed for a binary data transmission system subject to both Gaussian and impulse noise. The rates are displayed as a function of λT, where T is the signal duration and λ^{-1} is the average time between noise pulses. Poisson-distributed impulse noise and periodically recurring noise pulse clusters are considered. . . . The computed error rates illustrate, for data transmission systems subject to impulsive interference, the reduction in error rate that can be realized by increasing the signal duration. The simultaneous transmission of orthogonal signals is discussed. This makes it possible to use signals having a long duration without reducing the data rate or causing intersignal interference; this can be done without requiring additional bandwidth . . .

ROTATIONAL TRANSFORMATION OF SIGNALS
G. R. Lang, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 191/198.

A coding procedure based on a rotational transformation is applied to reduce the effect of non-Gaussian impulse noise in sampled data communication systems. The method, a near relative of the smearing techniques which have been suggested recently for continuous systems, provides a new and interesting view of many accepted coding systems and their relative properties. . . .

DATA TRANSMISSION ERRORS: COMPARISON OF LF RADIO WITH TELEPHONE FACILITIES
P. Mertz, Rand Corp., Santa Monica, Calif., Jan. 1963, 33 p., incl. illus., 13 refs, (Memo. no. RM-3413-PR), AD 295 650.

. . . error distribution . . . from the LF atmospheric noise illustrated a double type of distribution . . . approaches a purely random or Poisson type of distribution for shorter intervals of time, but approaches a bunched or hyperbolic type of distribution over the long run. . . . The long-time curve fits in pretty well with curves obtained from data on a variety of telephone facilities. It differs from them, first in following a much more systematic seasonal and hour-of-day trend, and second in not conforming so well to a strict hyperbolic law.

SOME ERROR CHARACTERISTICS OF A DATA COMMUNICATION SYSTEM
R. L. Townsend, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 69/72.

Data recorded during the multi-point line tests which were jointly conducted by American Telephone and Telegraph and International Business Machines Corporation were studied from the point of view of attempting to determine what typical error characteristics are likely to be present during normal operation in a data communication system operating over leased line facilities. . . . Error rates were found to be quite time variant. Statistical correlation between errors appeared to be caused by two separate mechanisms. One mechanism is a steady-state electrical noise which accounts for correlation between errors separated by times up to about 5 milliseconds. The second mechanism is a time-varying interference which accounts for correlation between errors separated by as much as several hours. . . .

Related Publications:

THE SUPPRESSION OF PULSE INTERFERENCE BY NON-LINEAR TRANSFORMATION OF THE FORM OF THE FREQUENCY SPECTRUM
A. A. Gorbachev, Radio Engineering, vol. 13, no. 1, 1958, p. 72/80.

AN EXPERIMENTAL INVESTIGATION OF THE EXTRAPOLATION METHOD OF SUPPRESSING PULSE INTERFERENCE IN BROADCAST RECEPTION
I. I. Medbedev, Radio Engineering, vol. 13, no. 6, 1958, p. 66/74.

LINEAR CANCELLATION TECHNIQUE FOR SUPPRESSING IMPULSE NOISE
E. J. Baghdady, IRE Wescon, Conv. Rec., vol. 7, Aug. 1960, p. 27/35.

COMMUNICATIONS THROUGH UNSPECIFIED ADDITIVE NOISE
W. L. Root, Inform. Control, vol. 4, no. 1, March 1961, p. 15/29.

. . . to suggest the feasibility . . . of applying a maximum or minimax type decision criterion to the design of the receiver, to

illustrate this decision criterion in two rather straightforward examples involving binary data links, and to look at the information rate which can be achieved. We are concerned here with the . . . problem . . . when the additive noise has no statistical regularity or predictability of which advantage can be taken. Thus the "noise" may be natural or man-made and subject to influences unknown to the communicators. Essentially the only restriction on the noise is that its power be bounded. . . .

AUTOMATIC ERROR-DETECTION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUIT DATA TRANSMISSION
W. G. Schmidt, Lincoln Lab., Mass. Inst. of Tech., Lexington, 27 Nov. 1961, 11 p., (Rept. no. 25G-5), AD 268 128.

. . . the data link error rate is primarily a function of terminal equipment reliability and several other factors, including the synchronization between transmitter and receiver. The general system, the logical design considerations, the hazards encountered, and the debugging and test methods used are described. . . .

A HIGH SPEED SYNCHRONOUS DIGITAL DATA TRANSMISSION MODEM
W. M. Groff, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 208/213.

. . . In a well designed modem (transmitter-receiver system), the primary cause of errors is impulse, or transient noise, and according to the literature, the type of modulation used is not a significant factor in reducing the effect of this noise on the error rate. . . . This paper describes the design and operation of a synchronous 4800 bit/second modem which utilizes quaternary, AM, suppressed-carrier, vestigial-sideband transmission. . . .

DATA LINE TECHNIQUES
Armour Research Foundation, Chicago, Ill., 1 April 1961, 458 p., 62 refs, AD 263 144.

. . . review of pertinent theoretical material and a survey of wire line digital communication techniques to support suggestions for improving channel utilization. Increased utilization dictates the use of longer code elements in terms of time-bandwidth units, extensive terminal line equalization, and anti-impulse noise techniques. The theoretically optimum encoding-decoding systems based on performance are multilevel differentially coherent PSK (phase shift keyed).

THE STABILITY OF A FREQUENCY REMOTE CONTROL SYSTEM IN THE PRESENCE OF PULSE NOISE
U. I. Chugin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 10 May 1962, 33 p., incl. illus., (Trans. no. FTD-TT-62-636 from Avtomatika i Telemekhanika, 23:2, p. 222/241, 1962), AD 286 132.

. . . calculating the noise stability of codes with series and parallel transmission of subcarriers. . . .

EVALUATION OF A BURST-ERROR CORRECTION CODE ON A GILBERT CHANNEL
D. G. Iram, Rome Air Development Center, Griffiss Air Force Base, N. Y., May 1962, 57 p. incl. illus., 8 refs, (RADC-TDR-62-189), AD 276 527.

. . . A technique for evaluating the improvement afforded a fading-type channel by the use of a burst-error correcting code is illustrated. The Gilbert model of a fading channel is then evaluated using this technique.

RECORDING AND VISUAL ANALYSIS OF NOISE ERRORS
A. E. Johanson, Commun. Electronics, vol. 81, no. 60, May 1962, p. 90/94.

. . . In a recent data transmission test, a method for visually evaluating the causes of errors was tried. Photographic reproductions of error messages were produced by the combined use of a magnetic tape recorder and a recording oscillograph. These were analyzed visually and the errors classified by cause into eight categories. In several of these categories, the fault lies in the terminal equipment, in the rest, apparently in the transmission channel. Examples are given of various types of errors encountered. . . .

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., pt. 4, vol. 4, March 1962, p. 161/173.

. . . The Gaussian noise is specified by its corresponding demodulated power density spectrum . . . and the impulsive noise by the statistics of its amplitudes (large-variance, zero-mean) and the times of occurrence of the impulses (Poisson's distribution is assumed but other distributions can be handled in a similar manner). . . .

AN IMPULSE NOISE CANCELLER (Correspondence)
W. L. Black, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 506.

. . . If the pulses occur infrequently and are sufficiently narrow, the disturbance they produce in one of two spectrally adjacent channels can be used to cancel the disturbance they produce in the other. The system described was designed to perform this cancellation, was built, and was tested. . . .

INCREASED NOISE IMMUNITY IN THE RECEPTION OF AM SIGNALS BY THE USE OF NONLINEAR FEEDBACK IN THE HIGH-FREQUENCY SECTION OF THE RECEIVER
A. A. Gorbachev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 2, Feb. 1963, p. 36/41.

The basic features of a method of suppressing pulse interference, based on the use of threshold feedback in the high-frequency section of the receiver are outlined. Experimental results are described. . . .

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Quarterly progress rept. no. 2, 11 Dec. 1962 - 10 March 1963, Motorola, Inc., Chicago, Ill., 10 March 1963, 35 p., AD 404 376.

. . . The cause of the errors is found to be impulse noise and photographs of the noise plus the signal is presented for discussion.

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 5, 11 Sept. - 10 Dec. 1963, 10 Dec. 1963, lv, Rept. no. 9, AD 430 726.

Field test results obtained while transmitting digital data over the AN/VRC-12 radio set are . . . at 41.5 mc using FSK and Di-phase modems. . . . impulse noise from passing vehicles and thunderstorms to multipath conditions from airplanes. . . . When no severe disturbances were present, many tests were conducted within a ten mile radius without encountering any errors. Near the range limit of the radio set (15 to 20 miles) error rates were found to vary from 10 to the minus 4 power to 10 to minus 2 power. The digital Encoder and digital Decoder constructed for the program are discussed. . . . The system is capable of providing error detection, random error correction, burst error correction and combinations of error correction and detection. Unique implementation in the decoder gives the system the capability of providing a large number of cyclic codes.

AN ANALYSIS AND SYNTHESIS PROCEDURE FOR FEEDBACK FM SYSTEMS. PART A CONVENTIONAL FM SYSTEMS. PART B FEEDBACK FM SYSTEMS
A. Wojnar, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 30 Sept. 1963, 49 p., Rept. no. TR 415, AD 421 921.

An investigation of frequency-compressive feedback FM systems . . . with emphasis placed on threshold behavior. A recent evaluation of the impulsive noise component by Rice is used. It is shown that this excess noise component predominates in the threshold region of most conventional FM systems. A new analytical expression (which agrees with experimental evidence) has been found for the location of the noise threshold. . . .

1.744: Interference from Ionospheric Sounders

Included: Interference potential of ionospheric sounding services.

Not Included: Descriptions of ionospheric sounders.

Cross References: Experimental evaluation of propagation media (1.639).

Principal Publications:

REDUCING INTERFERENCE IN IONOSPHERIC SOUNDING
K. Perry, Electronics, vol. 33, no. 22, May 1960, p. 118/120.

AN ANALYSIS OF THE INTERFERENCE POTENTIAL OF AN OBLIQUE IONOSPHERIC SOUNDER
H. Kimball, IIT Research Inst., Chicago, Ill., Aug. 1963, 28 p., ECAC TDR 63 6; ESD TDR 63 4, AD 417 357.

. . . effects of potential HF interference which might be produced by an ionospheric sounder operated between Navy communication stations near Washington, D. C. and Honolulu, Hawaii. The sounder uses a transmitter and receiver at each station and emits pulses of differing widths, at varying repetition rates, and with center frequencies distributed at selected points across the 2-32 mc band. The analysis considered interference to telephony, telegraphy, and facsimile, those being the three types of service predominant in that band. . . .

1.745: Circuit Interruptions

Included: Outages in communications plants.

Not Included: Failure tracing technique; Synchronization difficulties.

Cross References: Synchronization problems in PCM (1.523).

Principal Publications:

TELEGRAPHIEVERZERRUNGEN UND FEHLERHAUFIGKEIT BEI WECHSELSTROMTELEGRAPHIE INFOLGE VON UNTERBRECHUNGEN UND PHASENSPRUNGEN, TEIL I (Teletype Distortions and Error Probability in Voice Frequency Telegraphy due to Circuit Interruptions and Phase Transients) (In German)
H. Zuhrt, et al., Nachrichtentech. Z. (NTZ), vol. 12, June 1959, p. 311/317.

NOTES ON TRANSMISSION OF DATA AT 750 BAUDS OVER PRACTICAL CIRCUITS
P. A. Chittenden, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 22/28.

Experience of using a 750 baud phase-modulated data transmission equipment over commercial trunk circuits is described. The results show that short interruptions of the transmission path (which would in general be unnoticed on speech) rather than noise, is the most serious impairment with which the equipment has to contend, particularly since the interruptions are very difficult to locate.

This leads to the conclusions that . . . the assessment of the quality of a data path based on an average number of digit errors is unrealistic, and that error detection with repetition is . . . an equally effective. . . method. . .

DATA TRANSMISSION PERFORMANCE ON LONG-HAUL TELEPHONE FACILITIES
P. V. Dimock, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 29/36.

The effects on data transmission over circuits several thousand miles long on common types of long-haul voice transmission facilities have been investigated. Data signals were transmitted by frequency modulation at a rate of 750 bits per second, well within the bandwidth limitations of the circuits employed, and average noise was not a significant factor. Several hundreds of hours of continuous performance tests were made on each of the following types of facilities: multi-pair cable carrier systems (Type K), coaxial cable carrier systems (Type L), and microwave relay systems (TD-2).

It was found that the performance was generally characterized by periods of error-free transmission interposed by catastrophic degradations—or interruptions—of variable duration ranging from milliseconds to minutes. . . . curves showing the number of disturbances per 100 hours per 1000 miles that exceed various durations for the three types of facilities. . . .

MEASURED ERROR DISTRIBUTIONS ON THE BELL A-1 FACILITY OVER VARIOUS MEDIA
E. J. Hofmann, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 37/44.

. . . Both data and sync errors rates are shown, and their temporal and amplitude characteristics are examined. . . .

ERROR RECORDING AND ANALYSIS FOR DATA TRANSMISSION
C. M. Melas, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 54/65.

. . . The data. . . acquired is reduced to provide information on the duration and nature of error bursts and interruptions, as well as the length of error-free transmissions. . . .

TWO MEASURING TECHNIQUES FOR THE INVESTIGATION OF IMPULSE NOISE AND DROPOUTS ON TELEPHONE LINES
J. Kelly, et al., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 585/590.

. . . The latter method provides a means of identifying the cause of errors during the transmission of digital data. . . . on a data circuit between Boston and Chicago. . . .

FURTHER ANALYSIS OF ERRORS REPORTED IN "CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION"
R. Morris, Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1399/1414.

The recorded error data from a field testing program reported on by Alexander, Gryb, and Nast have been further analyzed. New methods of analysis have given more information on the causes and nature of errors experienced by data in the switched telephone plant. The results obtained will enable workers in the field of error control to use the field test data more effectively. . . .

Related Publications:

EXPERIMENTAL DATA TRANSMISSION SYSTEM FOR SWITCHED TELEPHONE LINES
H. Marko, et al., Elect. Commun., vol. 37, no. 3, 1962, p. 238/251.

. . . the system must be able to cope with noise caused by rotary selectors as well as with short-time interruptions not uncommon in carrier-system channels. . . .

1.748: Other Disturbances in Communications Plants

Included: Noise in tandem links; Noise accumulation in multi-section radio relay links; Disturbances due to aircraft reflections.

Not Included: Frequency division multiplex systems (2).

Cross References: Propagation problems in radio relay links (1.662); Very low frequency propagation (1.642).

Principal Publications:

THE WHITE-NOISE INTERFERENCE IN MULTICHANNEL TELEPHONE LINK SYSTEM
J. F. Golding, Electronic Engng., vol. 30, May 1958, 349/351.

THERMAL NOISE IN MULTISECTION RADIO LINKS
B. B. Jacobsen, Elect. Commun., vol. 36, no. 1, 1959, p. 42/59.

I. L. S. LOCALISER FEASIBILITY STUDY: THE MEASUREMENT OF THE BISTATIC ECHOING AREAS OF MODEL AIRCRAFT AS AN AID TO THE EVALUATION OF THE PROBLEM OF INTERFERENCE FROM OVERFLYING AIRCRAFT
P. Bowron, Royal Aircraft Establishment (Gt. Brit.), Aug. 1963, lv. RAE TN RAD846, AD 428 826.

. . . measurement of the echoeing areas of models of the Comet, Valiant, Victor and Vulcan aircraft for various bistatic angles and to estimate the volume of air-space within which an overflying aircraft may cause interference with a landing aircraft. It was found that in certain positions, overflying aircraft may present echoeing areas as great as 3,000 square metres.

ERROR RATE OF A CASCADED PAIR OF RAYLEIGH FADING COMMUNICATION LINKS (Correspondence)
H. D. Goldman, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 354/355.

NOMOGRAMS FOR THE STATISTICAL SUMMATION OF NOISE IN MULTIHOP COMMUNICATIONS SYSTEMS
B. Sheffield, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 285/288.

Several authors have shown methods for calculating the long-term fluctuation of noise power of multihop systems in which the propagation loss has a log-normal distribution such as in tropo-scatter FM. . . . shortcomings are remedied by two pairs of nomographs which eliminate the laborious exponential computations and permit the noise performance calculation to be made within seconds. . . .

Related Publications:

ERROR RECORDING AND ANALYSIS FOR DATA TRANSMISSION
C. M. Melas, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 54/65.

. . . data transmission tests made recently over the telephone networks of several European countries . . . evaluation of error correction or detection schemes. . . A repetitive 8-bit combination was used for transmission, and error checking was accomplished without the use of a synchronizing signal at the receiver. The character generator is also able to produce a long pseudo-random sequence, which is duplicated at the receiver for bit-by-bit error detection, providing a closer approximation of actual operating conditions. . . . The data thus acquired is reduced to provide information on the duration and nature of error bursts and interruptions, as well as the length of error-free transmissions. . . .

Section 1.75
Intentional Disturbances

Jamming is usually discussed in the restricted literature. The following collection of unrestricted publications is, therefore, only a small portion of the available literature.

1.750: Jamming

Included: Intentional disturbance of communications links by chaff.

Not Included: Anti-jamming methods; Electromagnetic intelligence; Electronic warfare.

Cross References: Correlated noise and distrubances (1.742).

Principal Publications:

JAMMING EFFECTIVENESS INSTRUMENTATION
C. H. Redwine, et al., Conf. Proc. Nat. Conf. Mil. Electronics, vol. 4, June 1960, p. 413/419.

I-F CROSS CORRELATION CANCELLERS
W. D. Nelson, et al., Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1961, p. 330.

In a jamming environment it is desirable to have a radar set which has sub-jamming capability, that is, a radar set which is capable of seeing a target through jamming. This paper is concerned with I-F Cross Correlation Cancellers. Two techniques. . . a Single I-F Side Lobe Canceller (SLC) which in general has the capability of cancelling a single side lobe jamming signal and second, a Polarization Canceller (PLC) which has the capability of seeking a receiver polarization that is orthogonal to the polarization of a single jammer. . . .

JAMMING IMPLICATIONS OF EXPERIMENTS ON INTERRUPTED SPEECH
D. W. Tufts, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 324/333.

MILITARY WEAPONS SYSTEMS IN A COUNTERMEASURES ENVIRONMENT
S. Adelman, et al., Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 257/261.

EFFECT OF PROPAGATION FADING AND ANTENNA FLUCTUATIONS ON COMMUNICATION SYSTEMS IN A JAMMING ENVIRONMENT
A. B. Glenn, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 43/60.

. . . The results are plotted for a large variety of fading conditions for both the desired and undesired signals and antenna fluctuations. . . .

ANTI-JAM COMMUNICATIONS
R. E. Heckert, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 262.

Communications security can be divided into four general classifications: (a) information security, (b) resistance to jamming, (c) authentication security, (d) emission security. . . . Secure communication systems that offer resistance to jamming invariably utilize some means of spreading the transmitted spectrum in a pseudo-random fashion unknown to the enemy jammer. . . . A method. . . utilizing digital pseudo-random keys is proposed which does not require a short synchronization key with its attendant jeopardy of jam-resistance characteristics. . . . A feasibility model of the frequency hopping system has been constructed and is in the process of being tested. . . .

OPTIMUM JAMMING OF INCOHERENTLY RECEIVED FSK SIGNALS
L. I. Bluestein, Lincoln Lab., Mass. Inst. of Tech., Lexington, 26 June 1963, 25 p., AFESD TDR 63 89, AD 413 482.

. . . found for a situation in which the two time-limited signals occupy separate frequency bands, and the receiver is ignorant of the RF phase of the signal. The jammer has at his disposal power-limited Gaussian noise . . . A quantity analogous to distance. . . defined; it is this quantity which the jammer seeks to minimize.

THE GUIDING OF AIRCRAFT UNDER RADAR-JAMMING CONDITIONS
Z. Guminski, Transl. into English from Naprowadzanie Samolotov w Warunkach Zaktocen Radiotokacyjnych (Warsaw), no. 6, 1962, p. 20/30, AD 298 224, N64-19193.

After an introductory description of passive and active radar-jamming methods, purposes, and results, the techniques of detecting the attacking aircraft through the interference are discussed. . .

RADAR JAMMING AND DECEPTION
R. B. Henery, Defense Documentation Center, Alexandria, Va., A Custom Abstract Search of Unclassified Citations, for Jan. 1953/ June 1963, July 1963, lv., AD 411 774.

RADIO JAMMING AND DECEPTION
R. B. Henery, Defense Documentation Center, Alexandria, Va., A Custom Abstract Search of Unclassified Citations, for Jan. 1953/ June 1963, July 1963, lv., AD 411 775.

POWER REQUIRED TO JAM A SATELLITE REPEATER
F. F. Yates, Aerospace Corp., El Segundo, Calif. Materials Science Lab., Dec. 1963, 18 p., refs., AD 428 375, AD 436 812, N64-14344.

A general expression is derived for the ratio of interference power to signal power required at the terminals of the receiving antenna of a communication satellite (in the bandpass of a communication channel) to reduce the performance of the channel to any specified minimum condition. The expression may be applied to the analysis of spread-spectrum multiple access systems as well as to the analysis of jamming vulnerability.

ANTI-JAM TROPOSPHERIC SCATTER THEORETICAL ANALYSIS
ITT Communication Systems, Inc., Paramus, N. J., Final rept., 15 June 1963, 133 p., ESD TDR 64 218, AD 431 197.

. . . theoretical investigation of the effect of radar chaff on the communication performance of tropospheric scatter communication systems using FDM-FM. . .

Related Publications:

AM TRANSMITTERS AS SSB JAMMERS
J. P. Costas, Proc. IRE, vol. 46, Dec. 1958, p. 1960/1961.

PRINCIPLES OF ELECTRONIC WARFARE
R. J. Schlesinger, et al., Englewood Cliffs, N. J., Prentice-Hall, Inc., 1961, 201 p.

DIVISION 1.8
COMPARISONS OF MODULATION SYSTEMS

A very difficult decision for space communications systems designers concerns the selection of the modulation method for a space link. This division has been assembled so as to bring references together which might be helpful in making this decision. The references are not restricted to publications which exclusively compare modulation methods of space links.

A general review section (1.80) is followed by an analytical section (1.81) with references to papers on criteria for the comparison of modulation systems. Normalizations, quality measures and analytical procedures for optimization with respect to special criteria are included in the subjects of this section. The organization of the other sections is along three dimensions: The nature of the signals (analog, 1.82, or digital, 1.83), the characteristics of the channels (linear and relatively noise free, 1.84, against time variable and noisy, 1.85) and the application of special equipment features (1.86). The specialized sections contain publications which compare various modulation methods under these particular channel characteristics, but also with respect to their ability to operate over special media (lines, 1.84, or radio, 1.85).

Section 1.80
General Comparisons of Modulation Systems

1.800: Comparative Reviews of Many Modulation Systems

Included: Books on modulation systems; Review articles on modulation systems; literature surveys; Bibliographies.

Not Included: Comparison of modulation methods for telemetry; Modulation methods for special space missions; Modulation problems in communications satellites.

Cross References: Fundamentals of modulation methods (Div. 1.1); Books on modulation in general (1.100).

Principal Publications:

COMPARISON OF MODULATION SYSTEMS
R. M. Page, IRE Conv. Rec., 1953, Pt. 8.

CHOOSING THE OPTIMUM TYPE OF MODULATION—A COMPARISON OF SEVERAL COMMUNICATION SYSTEMS
G. J. Kelley, IRE Trans. Commun. Syst., vol. CS-6, no. 1, June 1958, p. 14/21.

OPTIMUM TYPE OF MODULATION
J. H. Vogelman, IRE Trans. Commun. Syst., vol. CS-6, Dec. 1958, p. 62.

. . . conclusions reached in the paper by Kelley are based on some assumptions for which there is little or no justification.

INTER-RELATION AND COMBINATION OF VARIOUS TYPES OF MODULATION
W. D. Meewezen, Proc. Instn. Radio Engrs., Australia, vol. 20, Oct. 1959, p. 582/590.

INTERRELATION AND COMBINATION OF VARIOUS TYPES OF MODULATION
W. D. Meewezen, Proc. IRE, vol. 48, Nov. 1960, p. 1824/1832.

TELEMETRY SYSTEM PERFORMANCE—MEASUREMENT OF ERROR AS A FUNCTION OF COMMUTATION RATE
R. A. Porter, et al., Proc. Nat. Telemetering Conf., May 1960, p. 445/456.

ETUDE GENERALE COMPAREE DES SYSTEMES DE MODULATION EN VUE DES COMMUNICATIONS PAR SATELLITES ARTIFICIELS (General Comparative Study of the Modulation Systems With a View to Communications by Artificial Satellites) (In French)
G. Battail, International Scientific Radio Union (URSI), Symposium, Paris, France, Sept. 18-22, 1961, IN: Space Radio Communication, New York, Elsevier Publishing Co., 1962, p. 383/408, 14 refs., A63-14254.

Brief review of the characteristics of transmission modes and of signals to be transmitted. A classification is suggested for FM systems. An analysis of the transmission modes showing the predominance of the thermal noise is included, and patterns of the information theory are considered. Attention is called to Shannon's geometrical representation, and several parameters are introduced, relevant to the needed power, the bandwidth, and the required quality. The relations between such parameters are shown. The difficulty of increasing the duration T (introduced in the evaluation of the number of degrees of freedom) beyond a maximum value is noted.

FREQUENCY DIVISION TRANSMISSION SYSTEMS FOR MEASUREMENT DATA (In German)
H. Karger, et al., Arch. Tech. Messen, no. 322, Nov. 1962, p. 249/252.

. . . Various methods of modulation are surveyed, viz. frequency modulation, pulse repetition rate, pulse duration, pulse spacing, pulse code and pulse counting methods. . . .

CHOICE OF OPTIMUM MODULATION METHOD IN ACTIVE SATELLITE COMMUNICATION SYSTEMS
W. L. Wright, International Scientific Radio Union (URSI), Symposium, Paris, France, Sept. 18-22, 1961, IN: Space Radio Communications, New York, Elsevier Publishing Co., 1962, p. 409/424, Discussion, p. 425/428, A63-14255.

Examination of the problem of selecting the most suitable system of modulation for use over a radio path in which the SNR is severely restricted by the presently realizable system parameters. In comparing wide-band modulation systems, it is found that pulse-code together with information processing is more efficient than FM in the exchange of bandwidth for transmitter power, and in this respect pulse-code systems more nearly approach the ideal expressed by the Hartley-Shannon law. Practical examples considered indicate that a satellite intercontinental communications systems, carrying either 600 telephone channels or one television picture per broadband RF channel, could be designed (using either FM or PCM) to give the required quality of service with the satellite transmitter power not in excess of 5 watt. The FM system would require a bandwidth of at least 50 Mc for each direction of transmission, whereas the PCM equipment has a theoretical minimum bandwidth of about 20 Mc.

Related Publications:

A SURVEY OF PROGRESS REPORTED DURING 1955 IN TELEMETRY AND REMOTE CONTROL
K. M. Uglow, IRE Trans. Telem. Remote Cont., vol. TRC-3, no. 2, May 1957, p. 9/13.

COMMUNICATION EFFICIENCY OF SPACE TELEMETRY SYSTEMS
R. W. Sanders, Nat. Telem. Conf., May 1959, p. 4/13.

DESIGN STUDY OF AN INTEGRATED AIRBORNE TELEMETRY SYSTEM
H. Pruss, Telemetering Corp. of America, Sepulveda, Calif., Progress rept. no. 11 (Final), Aug. 1960, 23 p. incl. illus., Engineering rept. no. 707, AD 259 562.

. . . in the following phases . . . (1) determination of accuracy and data requirements, (2) theoretical analysis of modulation methods. . . .

USAF 480L AIRCOM PROGRAM SYSTEM DESIGN. VOLUME III. TRANSMISSION SUBSYSTEM DESIGN
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. IC5-61-TN-2, AD 258 527.

. . . presents transmission subsystems as design modules. In categorizing and describing these modules, these transmission subsystems have been included that are now available or potentially available within the 1961-1964 AIRCOM time period. . . .

INFORMATION THEORY. AN ASTIA REPORT BIBLIOGRAPHY
H. W. Miles, Armed Services Technical Information Agency, Washington, D. C., 1 Jan. 1962, 35 p., AD 269 800.

. . . References are included for documents catalogued by ASTIA from 1953 through 1 January 1962 . . . communication systems . . . data transmission systems . . .

OPTIMUM SYSTEM ENGINEERING FOR SATELLITE COMMUNICATION LINKS WITH SPECIAL REFERENCE TO THE CHOICE OF MODULATION METHOD
W. L. Wright, et al., J. Brit. Instn. Radio Engrs., vol. 23, May 1962, p. 381/391.

MULTIPURPOSE RECEIVER DESIGN STUDY
Philco Corp., Palo Alto, Calif., Final rept., Rept. no. WDL-TR1850, 28 Sept. 1962, 333 p. incl. illus., tables, AD 286 985.

. . . to meet functions required of tracking stations for the majority of anticipated space programs through 1970. . . . to function in the frequency bands of 100 mc to 10 gc. Discussions include the use of standard detection methods plus phase and frequency feedback techniques for detection of received signals including wide-band FM, narrow-band FM, PM, AM, and multiple angle modulations. Reliability and maintainability evaluations are also included.

1.802: Comparisons of the Three Classes of Analog, Sampled and Digital Modulation Systems

Included: Comparison of modulation systems for communications links on power supply networks.

Not Included: Digitization of analog information sources (2); Protective encoding of information (2); Comparison of telemetry systems.

Cross References: Comparisons between various analog modulation systems (1.820); Comparisons between various discrete modulation systems (1.830); Analog modulation methods (Div. 1.2); Digital modulation methods (Div. 1.3); Sampled modulation methods (Div. 1.4); PCM = pulse code modulation (Div. 1.6).

Principal Publications:

NOISE STABILITY OF TELEMETRY SIGNAL TRANSMISSION ON CHANNELS WITH NOISE FLUCTUATIONS
V. A. Kashirin, et al., Automat. Remote Control, vol. 19, Aug. 1958, p. 746/758.

COMPARISON OF PCM AND PPM FOR RADAR COMMAND
S. Kazel, Proc. Nat. Symp. Telem., Sept. 1958, no. 9.3, p. 1/12.

. . . For PCM, it is shown that when the effects of both quantization noise and noise breaking through the receiver threshold are considered, there is optimum number of pulses which results in maximum S/N improvement. For PPM, it is shown that when both edge-shift noise and noise breakthrough are considered, there is an optimum deviation that maximizes the output S/N ratio. . . . under the assumed system limitations, PPM is superior to PCM in regard to maximum reliable range, S/N improvements, and minimum required bandwidth. . . .

COMPARATIVE MERITIS OF ANALOG AND DIGITAL TELEMETERING
L. C. Watson, et al., Proc. Nat. Telemetering Conf., May 1959, p. 14/24.

COMPARISON OF MODULATION SYSTEMS FOR TELECOMMUNICATION ON POWER SUPPLY NETWORKS (In Italian)
E. Belardinelli, et al., Energia Elett., vol. 37, no. 11, Nov. 1960, p. 1004/1011.

The signal/noise characteristics of various methods of modulation are compared. It is concluded that, for single speech circuit, AM is preferred, with SSB working when more than one channel is required. PCM is best suited to be transmission of metering and control signals.

THE CASE FOR DIGITAL TELEMETRY
F. W. Lehan, et al., Proc. Nat. Aeron. Electronics Conf., vol. 8, May 1960, p. 463/467.

STATISTICAL EVALUATION OF DIGITAL–ANALOG SYSTEMS FOR FINITE OPERATING TIME
R. B. Northrop, et al., IRE Trans. Automatic Control, vol. AC-5, no. 2, June 1960, p. 118/128.

A frequency-domain mathematical model for comparing the performance of a linear sampled-data channel to a linear continuous channel is developed. . . . The model allows an explicit algebraic definition of ensemble mean-squared error, after a finite operating time, by application of residue theory. . . . The technique developed is utilized to evaluate the ensemble mean-squared error due to processing a vehicle velocity estimate . . . in a digital computer. . . . This problem is of fundamental importance in present-day pure inertial, pure Doppler, or inertial-Doppler navigation systems. The effect of quantization, inherent in the process of analogue-to-digital conversion, may be included in this evaluation. . . .

EVALUATION OF MODULATION METHODS FOR RANGE TELEMETRY
M. B. Rudin, IRE Conv. Rec. Pt. 5, vol. 8, March, 1960, p. 17/28.

COMMUNICATION EFFICIENCY COMPARISON OF SEVERAL COMMUNICATION SYSTEMS
R. W. Sanders, Proc. IRE, vol. 48, April 1960, p. 575/588.

COHERENT SYNCHRONOUS SAMPLED DATA TELEMETRY SYSTEMS
W. V. Rusch, et al., JPL Res. Summary, no. 36-8, Feb./March 1961, p. 41/51.

. . . certain types of data sources are of a sampled nature; i.e., commutators are employed which sample a given source periodically. Sampled data signals also afford an inherent degree of synchronization which can be used advantageously in a communication system. . . . For the evaluation and comparison of various modulation and detection systems, a generic performance criterion must first be stipulated. One of the simplest to measure and to calculate is a mean-square error criterion, which will be discussed in the next section. On this basis, a wide class of coherent synchronous communications systems will then be analyzed. . . . Conclusions . . . PAM appears to be better than PDM and PSK by a factor of three among the modulation methods which may be demodulated by linear synchronous detection, only because the average power is the criterion. If a peak power criterion were used, the three systems would behave equally well. . . .

A COMPARISON OF SEVERAL TYPES OF MODULATION
C.S. Weaver, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 96/101.

. . . various modulation-demodulation combinations which may be used in data-link systems. Both digital and analog transmission systems are discussed. . . . It is shown that there is no one binary information transmitting system that is superior under all circumstances. Analog systems are discussed in terms of mean-square error (variance), and this criterion provides a convenient method for comparing digital and analog systems. . . . A time multiplex PAM system is discussed, along with crosstalk and noise level considerations for such a system. . . .

SYNTEZ KOMPLEKSNOI SISTEMY, SOSTOIASHCHEIIZ NEPRERYVNOGO I DISKRETNOGO KANALOV (Synthesis of a Complex System Consisting of a Continuous and a Discrete Channel) (In Russian)
I. B. Chelpanov, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Jan.-Feb. 1964, p. 154/164, refs., A64-16982.

. . . procedure for determining the impulse transfer function of the filters in a complex two-channel system subject to noise. The analysis is based on the condition of minimum error spread, for the case where the flow of information in one channel is continuous, while in the other channel it takes place at discrete moments of time.

MODULATION CONSIDERATIONS FOR THE TRANSMISSION OF REAL-TIME SPACE TELEVISION
J.A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., SSD TDR63 117, 13 May 1963, 13 p., AD 406 315.

. . . the baseband signal was assumed: (1) digitally encoded and modulated on a carrier as binary PCM/PM; and (2) analogue modulated as wideband FM . . . The performance and complexity of these two approaches were then reviewed with parameters typical of a moon mission. In comparing the digital to the analogue approach, it was found that the analogue system was superior in all respects, e.g., simplicity, reliability, and spacecraft power. Identical comparisons as the foregoing were necessary to establish the modulation techniques for Telstar and Relay the world's first wideband communication satellites. It is not surprising, therefore, that these satellites utilize analogue wideband FM with frequency-following receivers.

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Phase 3 report, Final rept., Feb. 1962, Feb. 1963, RADC TDR63 147, May 1963, 175 p., AD 407 343.

The maximum likelihood estimation of FM-modulated signals is investigated. . . . threshold phenomenon in FM reception with an ideal discriminator and a postdetection Wiener filter for the case of a random modulation function. . . . bounds on the performance of PCM systems for transmitting analog information . . . compared with theoretical bounds for systems of prescribed complexity. The analysis of the optimization of N-ary digital systems operating over a dispersive channel, which was begun during a previous phase of the contract, is further advanced.

PRELIMINARY STUDY OF MODULATION SYSTEMS FOR SATELLITE COMMUNICATION
S. Plotkin, Hughes Research Labs., Malibu, Calif., (NASA CR-51993; Rept. 6R), June 1963, 69, 22 refs., N63-23817.

. . . A comparative study of power and bandwidth requirements for SSB, FM, and PCM modulation systems is given, as related to multiple-access satellite communications. Composite power-loading factors for multichannel speech are treated as a function of the number of channels. . . Multiple access considerations show that serious difficulties arise in both all FM and all-PCM systems. Thus, the concluding modulation system choice is SSB for the up link, and wideband FM for the down link. It was further concluded that frequency division multiplex is preferable to time division multiplex.

AN EXPERIMENTAL COMPARISON BETWEEN A PULSE AND A FREQUENCY-MODULATION ECHO-RANGING SYSTEM
L. Kay, J. Brit. Instn. Radio Engrs., vol. 20, no. 10, Oct. 1960, p. 785/796.

. . . The results show that a previous theoretical study by the author can be used as the basis of the design of a frequency-modulation system which may compare very favorably with a pulse system designed for the same purpose. . . .

THE STRUCTURE OF EFFICIENT DEMODULATORS FOR MULTIDIMENSIONAL PHASE MODULATED SIGNALS
H. L. Van Trees, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 261/271.

. . . the authors treat the AM case in detail and indicate that the equations for the PM case suggest mechanization schemes. . . . a common multiple-carrier modulation scheme PM_n/PM is discussed. . . . show that . . . estimators are essentially optimum for the multilink FM, and FM_n/FM case. . . .

Section 1.81

1.810: Analytical Background for the Comparison of Modulation Methods

Included: Definitions of error probabilities; Description of an ideal receiver; Communications efficiency; Figure of merit of communications systems; Bounds on communications; Definition of message circuit noise; Telemetering accuracy; Concepts of signal-to-noise ratio; Signal power contrast; Signal energy contrast; Reliability of communications methods; Definition of transmission rate; Information transfer efficiency; Standard communication rating systems; Signal-to-noise density ratio.

Not Included: Detection and decision theory (2); Error correcting codes (2).

Cross References: Fundamentals of modulation methods (Div. 1.1); Analysis of analog modulation methods (Sect. 1.21); Analysis of digital communications methods (Sec. 1.31); Fundamentals of sampling modulation methods (Sect. 1.41); Analysis of pulse code modulation methods (Sect. 1.51).

Principal Publications:

OPTIMUM TYPE OF MODULATION
(Correspondence)
J. H. Vogelman, IRE Trans. Commun. Syst., vol. CS-6, no. 2, Dec. 1958, p. 62.

INTER-RELATION AND COMBINATION OF VARIOUS TYPES OF MODULATION
W. D. Meewezen, Proc. Instn. Radio Engrs. Australia, vol. 20, Oct. 1959, p. 582/590.

EVALUATION OF MESSAGE CIRCUIT NOISE
A. J. Aikens, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 879/909.

. . . measuring some physical attribute of the electrical noise such that two noises that are judged to be equally interfering are assigned approximately equal numerical magnitudes. To give meaning to such magnitudes, the scale of measurement is related by way of subjective assessment into terms useful to telephone engineering. . . .

THE COMPARISON OF DIGITAL COMMUNICATION SYSTEMS
C. W. Helstrom, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 141/150.

. . . Two methods are proposed for comparing the performances of digital communication systems differing in the number of available signals, in bandwidth, in rate of transmission, and in complexity. . . . The concept of 'strictly comparable systems' is introduced; for these the two methods lead to the same ranking. . . . The advantage over binary systems of systems of higher order, in which more than one kind of signal can be transmitted, is illustrated.

COMMUNICATION EFFICIENCY COMPARISON OF SEVERAL COMMUNICATION SYSTEMS
R. W. Sanders, Proc. IRE, vol. 48, no. 4, April 1960, p. 575/588.

METHODS OF COMPARISON AND EVALUATION OF COMMUNICATION SYSTEMS
L. Valcik, et al., Armour Research Foundation, Chicago, Ill., 26 July 1960, AD 244 887.

A study was made leading to the development of methods for comparing and evaluating long-range point-to-point communication systems. This technical note summarizes the initial stage of a review of factors affecting the choice of modulation for use with the various propagation modes. . . . a review of AM, FM, and PM principles, discussion of matched filters and correlation detectors, a short summary of propagation effects on some types of signals. Emphasis is on the theoretical performance of digital AM, FSK, and PSK systems under certain non-fading conditions. An extensive list of references is included.

METHODS OF COMPARISON AND EVALUATION OF COMMUNICATIONS SYSTEMS (Volume I)
Armour Research Foundation, Chicago, Ill., Technical rept. on Phase I, (RADC TR 60-97A), 31 March 1960, 144 p., incl. illus., AD 239 198.

. . . leading to the development of methods for comparing and evaluating long-range point-to-point communication systems. . . . following factors are discussed: theory, availability of mode, region of the spectrum suitable for the mode, special topography requirements, range capability and transmission loss, available bandwidth, fading characteristics, and typical antenna characteristics. A total of seventeen modes are discussed.

METHODS OF COMPARISON AND EVALUATION OF COMMUNICATIONS SYSTEMS. (Volume II)
Armour Research Foundation, Chocago, Ill., Technical rept. on Phase I, 31 March 1960, 1v., incl. illus., AD 239 199.

TECHNIQUES FOR COMPARING MODULATION METHODS FOR DATA TRANSMISSION OVER TELEPHONE CHANNELS
W. R. Bennett, et al., IRE Trans. Commun. Syst., vol, CS-9, no. 3, Sept. 1961, p. 239/243.

—A program has been initiated for study of complete data communication systems by a general purpose analog computer. Complete PM and FM systems including transmitter, receiver, and channel have been simulated. Illustrative results and a discussion of criteria of performance are presented.

ERROR PROBABILITIES OF LINEAR CODES AT HIGH SIGNAL-TO-NOISE RATIO
E. C. Posner, et al., JPL Res. Summary, no. 36-13, Dec. - Jan. 1961, p. 37/38.

The problem is this: given an (n, k) linear code, should one transmit the k information bits uncoded using a given time per symbol, or should one use the code with a time per symbol shorter by a factor of k/n, and thus have a lower signal-to-noise ratio? Here the criterion can be based upon either p_w or p_b (Sec V-E-1); as the symbol error probability in the channel approaches zero, it will be seen that the two criteria give the same result as to whether to use the code.

EFFECTIVENESS OF ERROR-CORRECTING CODES COMPARISON OF BIT ERROR PROBABILITIES
JPL Res. Summary, no. 36-13, Dec. - Jan. 1961, p. 32/37.

. . . the "word bit error probability, " . . . defined . . . one uses maximum likelihood decoding (that is, decoding into the closest word) . . . Another definition of bit error probability is P_b, the "expected bit error probability, "which is defined . . .

COHERENT SYNCHRONOUS SAMPLED DATA TELEMETRY SYSTEMS
W. V. Rusch, et al., JPL Res. Summary, no. 36-8, Feb. - March 1961, p. 41/51.

. . . For the evaluation and comparison of various modulation and detection systems, a generic performance criterion must first be stipulated. One of the simplest to measure and to calculate is a mean-square error criterion . . . On this basis, a wide class of coherent synchronous communications systems will then be analyzed. . . .

DETERMINATION OF THE FUNCTION OF AN IDEAL RECEIVER
N. L. Teplov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 30/38.

Functions of an ideal receiver are defined, depending on the statistical structure of information and on the signal form. Parameters of an almost ideal receiver are shown. . . .

CODES, ENERGY CONTRAST, AND TRANSMISSION RATE
J. H. Van Horn, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 256/267.

CLASSIFICATION AND EVALUATION OF COHERENT SYNCHRONOUS SAMPLED-DATA TELEMETRY SYSTEMS
A. Viterbi, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Technical rept. no. 32-123, 15 June 1961, 10 p., AD 260 585.

An analysis is given of the various types of continuous wave and pulse modulation for the transmission of sampled data over channels perturbed by white gaussian noise. Optimal coherent synchronous detection schemes for all the different modulation methods are shown to belong to one of two general classes: (1) linear synchronous detection, and (2) correlation detection. The figures of merit, mean-square signal-to-error ratio and bandwidth occupancy, are determined for each system and compared.

COMPUTER STUDY OF DESIGN CRITERIA FOR CONTROL SYSTEMS
R. A. Bruns, JPL Res. Summary, no. 36-14, Feb. - March 1962, p. 19/22.

. . . to establish criteria whereby control system performance might be evaluated . . . A comparison between IES (integral-error-squared) and IAE (Integral-absolute-error) for a second-order linear attitude control system was presented in RS 36-11 for disturbance step function inputs. Two additional criteria . . . which weight the time function are: ITES (integral-time-error-squared) and ITAE (integral-time-absolute error). . . .

TELEMETRY WITH A SMALL NUMBER OF QUANTIZATION LEVELS
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug. - Sept. 1962, p. 66/67.

. . . (1) Can a reduction in the number of quantization levels result in a decrease in the variance of the estimate? (2) Which system should be used if the number of quantization levels is reduced; i.e., should one use the increased time available to take more observations or should one increase T and keep the number of observations constant? The results of an investigation into these questions are given . . .

A CRITERION FOR THE STATISTICAL COMPARISION OF COMMUNICATION SYSTEMS

T. L. Grettenberg, Lockheed Aircraft Corp., Sunnyvale, Calif., (Rept. no. 6-90-62-22), Feb. 1962, 153 p. incl. illus., 25 refs., AD 275 467.

The methods of comparing statistical experiments are investigated as possible criteria for comparing communication systems. It is found that one method of comparision (the divergence criterion) is implied by each of the comparison criteria considered. . . . may be used to select an optimum communication system from a class of communication systems to be compared. This procedure is illustrated in four signal-selection problems.

ON COMPARING THE MODULATION SYSTEMS

J. C. Hancock, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 45/50.

Numerous investigators in the past have compared the various modulation and detection systems from different viewpoints. The purpose of this paper is to unify these comparisions for analog and digital systems. Fundamental concepts of the modulation and detection process are discussed as well as figure of merits for comparision . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART I. INFORMATION EFFICIENCY OF BINARY COMMUNICATION SYSTEMS

J. C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Ind., ASD TDR 62-611, pt. 1, July 1962, 121 p., incl. illus., tables, 18 refs., AD 284 450.

. . . evaluating various combinations of modulation and detection in both symmetric and non-symmetric modes of binary communications operation. . . . A new criterion called information efficiency is defined which is based on realizable information . . .

OPTIMAL PROPERTIES OF STANDARD TELEMETRY

L. H. Harper, Jr., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug. - Sept. 1962, p. 69/71.

. . . It is the purpose of this note to prove the following theorem concerning the sum of the absolute values of the edge differences. Theorem . . . the standard assignment is optimal with respect to the criterion of the sum of the absolute values of all differences corresponding to single errors.

SPAN: A PRACTICAL COHERENT SYSTEM ANALYSIS METHOD

J. C. O'Brien, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 56/62.

The need for an exact, universal performance measure, suitable for expressing the dynamic laws of system behavior, is generally recognized. For several years, Nortronics . . . has been actively engaged in research to define such a unit for use in systems engineering and design projects. . . . merely statistical or semi-statistical measure is inadequate . . . because of the lack of causal coherence in a statistical representation. Logical causality is the principal basis of engineering design. A universal, mathematically descriptive "yardstick" . . . desirable. . . . Such a measure is currently to be found in various limited areas of scientific technology. Examples are the entropy measure of availability of heat energy in thermodynamics, the Laplacian equation for the flow rate of energy density in classical physics, and the subjective measure of availability of decisions which is called information content flow or "negentropy" rate, in information and communication theory. . . . The result has been designated the SPAN (System Performance Analysis) method. It still requires considerably more validation to merit acceptance as a rigorous analytical tool. . . .

CODING FOR SOURCE AND CRITERION

E. C. Posner, et al., JPL Res. Summary, no. 36-14, Feb. - March 1962, p. 33.

. . . important is the "criterion of fidelity," . . . usually a word or bit error probability. However, there are many practical situations where . . . the criterion of fidelity should not be taken as an error probability. . . . For example, if the data are to be used for parameter estimation, the variance of the estimate is a proper criterion.

DIGITAL COMMUNICATION STUDIES, PART I. COMPARATIVE PROBABILITY OF ERROR AND CHANNEL CAPACITY. PART II. ASYNCHRONOUS TIME-MULTIPLEXING OF MULTICHANNEL SPEECH SOURCES

M. P. Ristenbatt, et al., Office of Research Administration, U. of Michigan, Ann Arbor, (Tech. rept. no. 133; Rept. no. 4251-2-T), March 1962, 128 p., incl. illus. tables, 41 refs., AD 275 480.

. . . This treatment should help structure the selection of modulation and coding methods for proposed communication systems. . . . some fundamental principles, terminology, and methods of comparing are suggested.

DEVELOPMENT OF A STANDARD COMMUNICATION RATING SYSTEM

D. L. Scidmore, et al., Minneapolis-Honeywell Regulator Co., Seattle, Wash., Rept. no. 872, (RADC TDR 62-70), 5 Jan. 1962, 144 p., incl. illus. refs., AD 274 545

. . . useful for comparision and evaluation of communication systems. . . . Propagation modes used are examined to determine that they fit within the mathematical requirements. Finally a means of processing and presenting the ratings for comparision and evaluation is devised. The rating system evolved has few limitations, is quite flexible and easily used, and is applicable to a wide range of point-to-point communications problems.

OPTIMUM DECODING AT LOW SIGNAL-TO-NOISE RATIOS

E. C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug. - Sept. 1963, p. 155/156.

. . . Two criteria of performance are used: expected number of information bits in error, and probability of word error. . . .

KRITERII TOCHNOSTI TELEIZMERENIIA PRI VOZDEISTVII POMEKH KANALA SVIAZ (Criterion for Telemetering Accuracy in the Presence of Communication-Channel Noise) (In Russian)

N. V. Pozin, Avtomatika i Telemekhanika, vol. 24, Dec. 1963, p. 1712/1717, A64-13120.

Determination of the telemetering error induced by channel noise and instability of telemetering devices. A dimensionless criterion, termed the noise-proof factor, is derived for the analysis of the effectiveness of interference killing in individual telemetering techniques.

METHODS OF THRESHOLD SIGNAL RECEPTION IN THE PRESENCE OF NOISE

J. Seidler, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson, AFB, Ohio, 7 Oct. 1963, 139 p., AD 424 402.

. . . The relationship between the conventional concept of signal to noise ratio and the concepts of decision theory are discussed.

BOUNDS ON COMMUNICATION

D. Slepian, Bell Syst. Tech. J., vol. 42, no. 3, May 1963, p. 681/707.

Six parameters of importance in many communication systems are: (a) the rate at which digital information is transmitted; (b) the bandwidth of the system; (c) the signal power of the transmitted signals; (d) the noise power of disturbances in transmission; (e) the error probability in digits recovered at the receiver output; (f) the length of time that the transmitter and receiver can store their inputs . . . In a series of curves, this paper describes the boundary between compatible and incompatible sets of parameter values. In the model studies, it is assumed that the disturbance is additive Gaussian noise with constant power density spectrum in the transmission band.

A NOTE ON THE WORD ERROR PROBABILITY ASSOCIATED WITH A SEQUENCE OF DIGITS HAVING UNEQUAL ERROR PROBABILITIES (Correspondence)

F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 492/493.

. . . in cases where the interference is nonstationary or where a quantized frequency modulation (QFM) transmission is perturbed by colored noise, the digit error probabilities will be unequal. These unequal digit error probabilities lead to cumbersome expressions for the probability distribution function for the number of ones in the error sequence and the word error probability. It is to the simplification of these problems that this note is addressed. . . .

ANALOG-TO-DIGITAL CONVERSION BY POLYNOMIAL FITTING

J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-21, April - May 1963, p. 171/175.

. . . In the investigation here, the measure of the "closemess of fit" of the reconstructed time function . . . to the original function . . . will be the average mean-squared error . . .

QUANTIZING FOR MAXIMAL SIGNAL-TO-NOISE RATIOS

R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct. - Nov. 1963, p. 209/211.

In SPS 37-23, Vol. IV, the author derived expressions for the optimal quantization levels and thresholds to minimize quantization noise. Another measure of quality in the reconstructed data is the reconstructed-signal-to-noise ratio rather than the ordinary signal-to-noise ratio. Expressions are derived here for the optimal level and threshold values when such a criterion is assumed.

ON COMPARING DIGITAL SYSTEMS
(Correspondence)
W.J. Walbesser, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 247/249.

. . . It is the purpose of this communication to describe a basis for comparing arbitrary discrete communication channels, i.e., systems characterized by general rectangular probability matrices, which is both intuitively satisfying and contains within it the results described above for N-ary systems. . . .

MINIMUM SIGNAL TO NOISE-DENSITY RATIOS FOR TRANSMISSION OF TELETYPE AND SPEECH
F.F. Yates, Aerospace Corp., Los Angeles, Calif., Rept. no. TDR269 4111 7, SSD TDR63 215, Jan. 1964, 9 p., AD 429 202.

The signal-to-noise requirements of a phase modulation communication channel are considered for the transmission of teletype and voice for certain specified performance criteria. Three typical communication services are analyzed: 100 wpm teletype - 1/20 letter error rate; 3 kc voice - 80% word intelligibility, and 3 kc voice - 30 db output baseband signal-to-noise ratio. The transmission requirements are expressed in terms of the minimum signal-to-noise density ratio required in the pre-detection bandwidth of the signal demodulator. . . .

Related Publications:

A NOTE ON THE APPLICABILITY OF ERROR CORRECTING CODES
J.E. Palmer, Conf. Proc. Natl. Conv. Mil. Electronics, vol. 4, June 1960, p. 190/193.

. . . In order to properly evaluate the performance of an error correcting code, it is necessary to consider both the increased immunity to errors and the decreased ability to transmit information. Such an evaluation technique will be described in this paper, using several numerical examples of the use of this evaluation technique . . .

CRITERIA FOR COMPARISON CONTROL SYSTEMS
R. A. Bruns, JPL Res. Summary, no. 36-11, Aug. - Sept. 1961, p. 23/26.

In order for an adaptive control system to function in a widely varying environment, it must have some reference standard based on a design criterion. This report is an investigation of two such criteria.
With the emphases on the minimum-energy criterion, it seems advisable to minimize the integral-error-squared function of a given control system. Many other criteria have been suggested . . . such as integral-absolute-error . . . the control system must steer the space-craft to the required destination with a minimum fuel consumption. . . . it appears logical to begin by minimizing the integral-error-squared signal (IES) generated by a given disturbance on the system; also, it is mathematically convenient.

RELIABILITY PRINCIPLES IN COMMUNICATION NETWORKS
L.S. Schwartz, ITT Communication Systems, Inc., Paramus, N.J., Rept. no. ICS 61 TM 6, ESD TDR 63 691, 29 Sept. 1961, 26 p., AD 430 421.

FURTHER COMMENTS ON THE RELIABILITY OF NETWORKS
L.S. Schwartz, ITT Communication Systems Inc., Paramus, N.J., Rept. no. 61TM8, ESD TDR 63 692, 31 Oct. 1961, 9 p., AD 430 620.

ERROR PROBABILITIES FOR OPTIMAL CODES IN A GAUSSIAN CHANNEL
T. Kailath, JPL Res. Summary, no. 36-14, Feb. - March 1962, p. 39/41.

In a paper in 1959 Shannon (Ref 6) derived several lower and upper bounds on the error probability . . . for an optimal code signalling over a channel perturbed by additive white noise. . . . the final results were remarkably elegant. . . . it seems desirable to obtain as much of an understanding of the results and the methods of obtaining them as possible. In 1956 Shannon (Ref 7) described a general and powerful technique for obtaining such results. These techniques were delineated earlier in a paper by Cramer (Ref 8). In this report we shall give a brief discussion of the essentials of this method and show how it can be used to obtain, in a special case, the results of Shannon.

ERROR-CORRECTING CODES AT VERY LOW SIGNAL-TO-NOISE RATIOS
E.C. Posner, JPL Res. Summary, no. 36-14, Feb. - March 1962, p. 34/36.

. . . one is interested in the asymptotic performance of the code as the signal-to-noise ratio approaches zero. This asymptotic result is needed in order to compare the thresholding properties of error-correcting encoding with the performance of other encoding systems.

EUROPEAN-MEDITERRANEAN TROPOSPHERIC SCATTER COMMUNICATION SYSTEM PERFORMANCE SPECIFICATION IN-BAND SIGNALING EQUIPMENT
ITT Communication Systems, Inc., Paramus, N.J., Rept. no. 61, ESD TDR63 694, 1 April 1962, 14 p., AD 430 415.

GRUNDSATZLICHE BETRACHTUNG ZUR ANWENDUNG PSYCHO-PHYSISCHER GESETZE FUR DEN ENTWURF VISUELLER NACHRICHTENSYSTEME
(Fundamental Considerations for the Application of Psycho-Physical Laws for Designing Picture Transmission Systems)
(In German)
A.J. Seyler, Arch Elekt. Uebertragung, vol. 17, Feb. 1963, p. 51/63, 45 refs.

. . . derivation of fidelity criteria . . . man acts as an information sink and thus the fact of receiving a certain message cannot be used as an objectively defined fidelity criterion. Rather, the system quality is defined by the criterion of preserving the illusion of direct communication, i.e., by the subjectively unimpaired sensation of sensory stimuli. . . .

THEORY OF RAMDOM FUNCTIONS WITH APPLICATION TO NOISE IN RADIO RECEIVERS
A. J. Siegert, IN: Symposium on Engineering Applications of Random Function Theory and Probability, First, Proceedings, New York, John Wiley and Sons, Inc., 1963, p. 68/87, 14 refs., A63-14766.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, vol. 1, Jan. 1964, p. 43/51.

. . . The unified result is achieved by exploiting a fundamental relationship between noncoherent and coherent operation. Also, some useful and not widely-known mathematical techniques involving the Q function are presented and utilized in the derivations. . . .

Section 1.82

1.820: Comparison of Analog Modulation Systems

Included: Comparison of AM with FM; Comparison of DSB with SSB; Analog transmission systems for digital data.

Not Included: Analog encoding methods (2).

Cross References: Comparison of the various SSB methods (1.223); Analog modulaltion methods (Div. 1.2).

Principal Publications:

SELECTION OF MODULATION FOR SPEECH COMMUNICATION
G. J. Kelley, Electronics, vol. 31, no. 28, March 1958, p. 56/59.

OVERMODULATION OF A CARRIER BY SINE WAVE AND GAUSSIAN NOISE
D. R. Rothschild, Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 724/735.

. . . The analysis is based on formulation of a basic model of an AM transmitter and an idealized modulation characteristic. Appropriate parameters are defined to characterize the degree of modulation, including over-modulation. . . .

COMPARISON TESTING OF MODULATION MODES FOR HIGH-FREQUENCY GROUND-TO-AIR VOICE COMMUNICATIONS
D. E. LeBrun, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TR-59-55), May 1959, 15 p., AD 213 785.

Tests are described which were conducted to obtain a practical comparison between (1) single sideband suppressed carrier (SSBSC); (2) double sideband amplitude modulated (DSB-AM); (3) double sideband suppressed carrier (DSBSC); and (4) pilot carrier or synchronous single sideband (SSSB). These tests were conducted over a period of one year. Data were gathered by means of sequentially transmitting phonetically-balanced (PB) word lists via the various modes, and analyzing the recorded results for intelligibility. The transmissions were between Rome, New York, and a C-131 aircraft which was flown extensively in the United States and the West Indies. . . . Results obtained were significantly in favor of the SSBSC.

IDEAL BINARY PULSE TRANSMISSION BY AM AND FM
E. D. Sunde, Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1357/1426.

. . . It is shown that intersymbol interference can be avoided in binary pulse transmission by FM without the need for a wider channel band than in double-sideband AM, for equal pulse transmission rates . . . partial pulse shaping by premodulation and post-detection low-pass filters is also considered.

MODULATION
S. Weber, Electronics, vol. 32, no. 43, Oct. 1959, p. 103/105.

Optimum modulation method is required for best use of the propagation medium.
Engineers are not always agreed on what is optimum
Amplitude Modulation -
Frequency Modulation -
Pulse Modulation -
Single Sideband -
Double Sideband

ANALYSIS OF ANGLE MODULATION COMMUNICATIONS SYSTEMS
M. F. Easterling, et al., JPL. Res. Summary, vol. 1, no. 36-10, June/July 1961, p. 30/36.

The investigation of angle modulation communications systems utilizing phase-locked demodulators has continued. The first purpose is to compare the performance of phase modulation (PM) and frequency modulation (FM) communications systems under the constraint that the receiving system utilize only phase-locked demodulators. The second purpose is to provide a sound analytical basis for the design of analog telemetry systems (Ref 21). The consideration of the FM phase-locked demodulator is of interest because of recent work (Refs 22 to 26) on FM discriminators with negative feedback.

A SURVEY OF SINGLE-SIDEBAND AND ASSOCIATED TECHNIQUES FOR VOICE COMMUNICATION

A. L. Rock, et al., Research Inst., U. of Michigan, Ann Arbor, (Tech. rept. 117; 3899-42-T), Jan. 1961, 103 p., AD 257 017.

. . . synchronous communication, compatible single-side-band, exalted carrier reception, etc. were included to make the report more comprehensive and to emphasize the importance of these alternative techniques for radio-telephone communications . . .

ON COMPARING THE MODULATION SYSTEMS

J. C. Hancock, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 45/50.

Numerous investigators in the past have compared the various modulation and detection systems from different viewpoints. The purpose of this paper is to unify these comparisons for analog and digital systems. Fundamental concepts of the modulation and detection process are discussed as well as figures of merit for comparison . . .

OPTIMUM COHERENT DEMODULATION OF CONTINUOUS MODULATION SYSTEMS

A. J. Viterbi, JPL Space Progr. Summ. vol. 4, no. 37-16, June/July 1962, p. 50/54.

The parameter of the carrier which is modulated may be amplitude or angle; the latter includes both phase and frequency modulation. These three forms of modulation will be compared for the purpose of demonstrating the potential improvement in output signal to noise ratio (SNR) for angle modulation relative to amplitude modulation. . . .

THEORY AND PERFORMANCE LIMITATIONS OF ANALOG SYSTEMS

W. M. Brown, et al., IEEE Trans. Mil. Electronics, vol. MIL-8, no. 2, April 1964, p. 102/113.

A unified view of the large amount of progress which has been made in the analysis of systems such as radar, communications, imaging systems, etc., is presented. The basic theory of complex parameter systems and the role of phase lock in such systems is given . . . Performance limitations due to phase errors, stochastic delays, and clipping are discussed . . . some results of filtering for the modulus of a complex signal . . . some problems in scatter communications. . . .

AN ANALYSIS OF PCM TRANSMISSION VIA SINGLE SIDEBAND

R. Gardner, et al., RCA Defense Electronic Products, New York, 1 May 1963, 191 p., AD 406 700.

. . . to determine the relative merits of single-sideband transmission as against FM transmission of multichannel (e. g. 12-channel) PCM signals . . .

Related Publications:

PERFORMANCE STANDARDS AND TEST SPECIFICATIONS FOR VOICE MESSAGE AMPLITUDE AND BANDWIDTH COMPRESSION EQUIPMENT

ITT Federal Labs., Palo Alto, Calif., Final rept., ESD TDR 63 690, 31 Oct. 1960, 83 p., AD 430 118.

. . . performance standards . . . now in service are based upon electrical measurements, such as the frequency response, the signal-tp-noise ratio, and the percent of signal distortion. . . .

HILBERT TRANSFORMS AND MODULATION THEORY

F. F. Kuo, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 51/58.

Hilbert transforms are important in repsenting certain modulated signals. In this tutorial paper we will explore the use of Hilbert transforms in the theory of amplitude modulation, especially single sideband . . .

PRELIMINARY STUDY OF MODULATION SYSTEMS FOR SATELLITE COMMUNICATION

S. Plotkin, Hughes Research Labs., Malibu, Calif., (NASA CR-51993; Rept. 6R), June 1963, 69 p., 22 refs, N63-23817.

. . . A comparative study of power and bandwidth requirements for SSB, FM, and PCM modulation systems is given . . . the concluding modulation system choice is SSB for the up link, and wideband FM for the down link. It was further concluded that frequency division multiplex is preferable to time division multiplex.

Section 1.83

1.830: Comparison of Discrete Modulation Systems

Included: Comparison of binary and m-ary digital systems; Comparison of higher order discrete systems.

Not Included: Error correction coding methods (2); Comparison of coded with uncoded transmissions (2).

Cross References: Digital modulation methods (Div. 1.3); Sampling modulation methods (Div. 1.4); Pulse code modulation (Div. 1.5). 1.4); Pulse code modulation (Div. 1.5).

Principal Publications:

COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
J. G. Lawton, Proc. Nat. Aeron. Electronics Conf., June 1957, p. 128/132.

THEORETICAL COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N. Y., May 1958, 69 p., AD 148 803.

Ground-Air data communication links are analyzed and compared on the basis of the error probability attained as a function of the received signal-to-noise ratio. For the case of frequency-shift keyed (FSK) modulation it is shown that the lowest error rate can be obtained by using a detector which incorporates two matched filters and a synchronized sampling and decision circuit.

EVALUATION AND OPTIMIZATION OF DIGITAL COMMUNICATION SYSTEMS
S. S. L. Chang, et al., New York U. Coll. of Engineering, N. Y., Jan./June 1958, 100 p., AD 160 807.

FEHLERSICHERHEIT BINÄRER UBERTRAGUNGEN BEI VERSCHIEDENEN MODULATIONSARTEN (Vulnerability to Errors of Binary Transmission for Different Modulation Methods) (In German)
H. J. Held, Nachrichtentech. Z., vol. 11, June 1958, p. 286/292.

COMPARISON OF BINARY DATA TRANSMISSION SYSTEMS
J. G. Lawton, Proc. Conf. on Mil. Electronics, June 1958, p. 54

EVALUATION AND OPTIMIZATION OF DIGITAL COMMUNICATION SYSTEMS
S. S. L. Chang, et al., New York U. Coll. of Engineering, N. Y., Final Scientific rept., 14 Jan. 1958-14 Jan. 1959, (Rept. no. AFCRC TR-59-110), Jan. 1959, 30 p., AD 211 102.

IDEAL BINARY PULSE TRANSMISSION BY AM AND FM
E. D. Sunde, Bell Syst. Tech. J., vol. 38, Nov. 1959, p. 1357/1426.

COMBINED DIGITAL PHASE AND AMPLITUDE MODULATION COMMUNICATION SYSTEMS
C. R. Cahn, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 150/155.

. . . investigated for the asymptotic case of a high signal-to-noise ratio. A simple and excellent approximation to the probability of error is derived for both coherent and phase-comparison demodulation. In addition, a simple expression is derived for the asymptotic degradation of phase-comparison demodulation. . . . When the number of bits per sample of the signal is large, a combination of digital amplitude and phase modulation is found to make more efficient use of transmitter power than phase modulation alone.

COMPARISON OF PSK VS FSK AND PSK-AM VS FSK-AM BINARY-CODED TRANSMISSION SYSTEMS
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 87/100.

. . . in the presence of additive white Gaussian noise. . . based on the relative probability of error, operating range, required system bandwidth, and system frequency instability. The important subjects of improvement thresholds, some aspects of statistical decision theory, and channel characterization are briefly discussed.

(Correction)
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 272.

. . . Comparison of PSK vs FSK and PSK-AM vs FSK-AM Binary-Coded Transmission Systems, which appeared on pages 87-100 of the June 1960, issue.

THE COMPARISON OF DIGITAL COMMUNICATION SYSTEMS
C. W. Helstrom, IRE Trans. Commun. Syst., vol. CS-8, Sept. 1960, p. 141/150.

MODULATION AND SIGNAL SELECTION FOR DIGITAL DATA SYSTEMS
R. M. Lerner, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 2/14, 28 refs.

The statistical decision model of a communication channel is used to discuss a variety of signal modulation techniques intended to overcome the problems met in the use of voice-bandwidth channels for high performance digital data transmission. The importance of proper transmission of timing and word-start information is emphasized. . . . It is pointed out that in the presence of additive white Gaussian noise, the performance of such simple-waveform systems as AM, Phase Reversal, and FSK is the same to within a few db. . . . the implications of the fact that the channel noise is not Gaussian, but impulsive in character are briefly explored.

COMMUNICATION EFFICIENCY COMPARISON OF SEVERAL COMMUNICATION SYSTEMS
R. W. Sanders, Proc. IRE, vol. 48, April 1960, p. 575/588.

THE NEW MASS COMMUNICATIONS
H. Sherman, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 1.

High speed data transmission as a new communications service is growing under our eyes into a mass information exchange, second only to voice communications as a major communications service. . . .

DIGITAL TELEMETRY TESTING PROGRAM
M. F. Easterling, et al., JPL Res. Summary, no. 36-8, Feb./March 1961, p. 57/65.

. . . tests are being carried out to verify the theoretical evaluations of various systems . . . Partial results of these tests are being reported . . . Digital systems fall within one of two broad categories, i.e. . . either bit-by-bit detection or coded-word detection. They are further categorized into types of modulation and various mechanizations. . . .

DIGITAL METHODS IN SPACE COMMUNICATION
S. C. Ghose, (International Scientific Radio Union (URSI), Symposium, Paris, France, Sept. 18-22, 1961.), IN: Space Radio Communication, New York, Elsevier Publishing Co., 1962, p. 447/469, A63-14258.

Description of a scheme, by which reliable, wideband, two-way radio communication can be established between two fixed areas situated many thousands of miles away from each other, by using an active repeater contained within a satellite in orbit. It is recommended that digital modulation of the RF carrier operating at microwave frequencies be used instead of the better known wideband FM transmission system. Block diagrams of the individual parts of the complete communication circuit are given. Adequate guard bands are also indicated, together with the room for additional RF channels which can be picked up or dropped at will. After discussing the digital modulation of the RF carrier, time-sequential waveforms are shown in detail, starting from the electrical analog of a harmonic motion at the transmitter and finishing with the recreated version of the same analog waveform at the output terminals of the final receiver. The possible performances of this system are analyzed.

COMPARISON OF DIGITAL MODULATION SYSTEMS
R. C. Hansen, (International Scientific Radio Union (URSI), Symposium, Paris, France, Sept. 18-22, 1961.), IN: Space Radio Communication, New York, Elsevier Publishing Co., 1962, p. 470/475, A63-14259.

Comparison, on the basis of both error rate and efficiency, of bi-phase and bi-orthogonal modulation. It is shown that the sophisticated orthogonal systems offer only 3 to 5 db advantage at a cost of greatly increased system complexity.

TRUNK TERMINAL TELEGRAPH AND DATA TRANSMISSION SYSTEM
H. Place, et al., ITT Federal Labs., Nutley, N. J., July 1961, 135 p., AD 430 081.

A number of high speed data transmission equipments (data modems), which were in the development and early test stages eighteen months ago, are now available in the industry. Several modems have proved reliable and practical when operated at signaling rates in the order of 2400 bits per second. Characteristics of telephone transmission line parameters and certain vagaries of the telephone network itself are still restricting low-error, high reliability performance at signaling rates over 3000 bits per second. . . . progress made during the past eighteen months in data modem development and manufacture, . . . detailed equipment descriptions covering ten leading data modems; data modem error performance test results; ancillary data transmission equipments; and an updated data transmission bibliography.

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE—A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS
E. Arthurs, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 336/372.

. . . m-level Phase Shift Keyed, m-level Amplitude Shift Keyed and m-level Frequency Shift Keyed. Corresponding probability of error curves are derived, compared and discussed with reasonable detail. . . .

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS (PHASE 2 REPORT)
H. D. Becker, et al., Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Rept. for Jan. 1961-Jan. 1962, (Rept. no. UA-1420-S-2), (RADC TDR 62-134), 20 Feb. 1962, 311 p. incl. illus., refs., AD 276 847.

. . . analysis of the degradation of the performance of noncoherent binary FSK and carrier keyed systems due to a frequency offset of the received signal. The optimization of systems operating over dispersive channels in the presence of nonwhite, gaussian noise is treated and the effects of mediumphase perturbations on the performance of digital systems are analyzed. Partial orderings of digital channels specified by their transition probabilities are also investigated.

SURVEY OF DIGITAL COMMUNICATIONS
C. A. Deutschle, Hughes Aircraft Co., Culver City, Calif. Rept. on 480L System, (Rept. no. TR-1), (ESD TDR 62-158), 15 April 1961, 386 p., incl. illus. tables, 7 refs., AD 277 176.

Discrete message types. . . Transmission requirements and techniques. . . Cryptography . . . Transmission media. . . Error control. . . Comparative evaluations. . .

AN ANALYSIS OF CASCADED BINARY COMMUNICATION LINKS
H. D. Goldman, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 291/299.

. . . the error probabilities of cascaded links have been found for the following modulation techniques:

1) Coherent phase-shift keying (CPSK)
2) Coherent frequency-shift Keying (CFSK)
3) Coherent carrier keying (CCK)
4) Noncoherent frequency-shift keying (NCFSK)
5) Differentially coherent phase-shift keying (DCPSK) . . .

ON COMPARING THE MODULATION SYSTEMS
J. C. Hancock, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 45/50.

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART I. INFORMATION EFFICIENCY OF BINARY COMMUNICATION SYSTEMS
J. C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind. Tech. rept. on Improved Information Transfer Efficiency of Wideband Systems, (ASD TDR 62-611, pt. 1), 121 p., July 1962, incl. illus., tables, 18 refs., AD 284 450.

. . . conventional binary systems are analyzed. . . . Performance curves showing information efficiency and probability of error as functions of S/N are given. A similar analysis is given for a group of matched filter systems which includes both coherent and noncoherent matched filter detection of amplitude and frequency shift keyed signals.

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART II. BINARY COMMUNICATIONS SYSTEMS USING WIDEBAND SIGNALS
J. C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961-June 1962 on Improved Information transfer Efficiency of Wideband Systems, (ASD TDR 62-611, pt. 2), July 1962, 151 p., incl. illus., 16 refs, AD 284 451.

. . . The analysis of binary systems (using a signal-space concept) . . . The application of linear receivers. . . Nonlinear receivers. . . Time compression methods. . . Adaptive receivers.

DIGITAL COMMUNICATION STUDIES. PART I. COMPARATIVE PROBABILITY OF ERROR AND CHANNEL CAPACITY. PART II. ASYNCHRONOUS TIME-MULTIPLEXING OF MULTICHANNEL SPEECH SOURCES.
M. P. Ristenbatt, et al., Office of Research Administration, U. of Michigan, Ann Arbor, (Tech. rept. no. 133; Rept. no. 4251-2-T), March 1962, 128 p., incl. illus., tables, 41 refs., AD 275 480.

. . . M-ary bi-orthogonal signals are deemed best for low S/N if probability of error is stringent. Binary and M-phase signals appear best for medium and large S/N. This treatment should help structure the selection of modulation and coding methods for proposed communication systems. . . .

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R. O. Rowlands, IRE Internat. Conv. Rec. Pt. 4, vol. 10, March 1962, p. 185/189.

. . . Five common binary detection systems are analyzed and formulas are derived for the signal-to-noise ratios required to give the same probabilities of error in each system. The effects of varying the duration of the signal and the bandwidth of the noise are discussed for each system, and the region is defined within which the detectability of the signal is improved by clipping. . . .

COMPARATIVE PERFORMANCE OF DIGITAL DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF CW INTERFERENCE
F. G. Splitt, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 72/81.

. . . The performance of differential phase-shift, coherent phase-shift, amplitude keyed, frequency shift and time-shift binary digital data transmissions is determined. . . .

(No Title)
J. J. Tsimbidis, Motorola, Inc., Chicago Ill., Quarterly progress rept. no. 3, 11 March-10 June 1962, 10 June 1962, 1v., incl. illus., tables, AD 282 947.

Results obtained in back-to-back white noise testing of the various modems . . . Problems of crosstalk and transmission levels encountered in the AN/TCC-7 white noise tests are also discussed. Controlled impulse noise tests were conducted. . . . results show . . . the vsb modem is the most susceptible to impulse noise. . . . A system for recording impulses encountered in field testing and how it may help in the study of data transmission is discussed. The amplitude and delay characteristics of the AN/VRC-12 radio set are presented in graphical form. . . . Noise quieting curves of the AN/TRC-24 radio set are discussed and the performance of the various modems over the radio set operating near and on the FM threshold is reported. The results of field cable testing of the modems are presented in tabulated form with a more detailed discussion of hits and drop outs in this transmission link.

ON COMPARING N-ARY SYSTEMS (Correspondence)
J. K. Wolf, IRE Trans. Commun. Systems, vol. CS-10, No. 2, June 1962, p. 216/217.

. . . when comparing transmission systems with alphabets of various sizes, a comparison of the probabilities of error per character is not . . . easily interpreted. . . . The purpose of this note is to illustrate one surprising result . . . it will be shown that the relative performance of the systems may depend upon the size of the information alphabet for which the error probabilities are computed and then compared. . . .

THE THEORETICAL COMPARISON OF THREE DIGITAL SYSTEMS FOR SPACE TELEMETRY (In French)
J. Dupraz, Onde Electr., vol. 43, no. 432, March 1963, p. 298/310.

. . . theoretical comparison of three digital systems . . . relate the orthogonal binary codes of which the possibilities have recently been discovered . . . to the PCM non-redundant code . . . results of the theory of statistical detection . . . techniques of demodulation . . . criterion used for comparison is the efficiency coefficient β as defined by Sanders . . . derive the advantages and disadvantages of orthogonal codes. This allows a considerable increase in the range of the circuit for a given radiated power but at the cost of a considerable increase in the bandwidth.

RELIABILITY IMPROVEMENT OF DIGITAL COMMUNICATION USING REDUNDANCY IN UNCERTAINTY REGION RECEPTION
L. Kurz, New York U. Coll. of Engineering, N. Y. Scientific rept. no. 13, AFCRL Rept. no. 63 187, June 1963, 78 p., TR no. 40077, AD 414 370.

. . . it is shown that communication links using orthogonal digit coding afford greater reliability than corresponding links using binary digit coding. . . .

TRANSMISSION OF NUMERICAL INFORMATION (In French)
M. Poliet, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 106/116.

. . . flexibility and many applications of transmission systems using numerically coded data . . . development of these systems . . . because of the development of transistors which by their size and their characteristics make it possible to construct small devices.

DATA TRANSMISSION FOR MILITARY COMMUNICATION: PARAMETERS AND CAPABILITIES
J. Polyzou, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 454/464, 40 refs.

. . . a difficult problem for system designers because there are so many different types of communications facilities with widely differing characteristics which must be considered. Additionally, the system designer must consider the type of digital data modulation which best serves his purposes, the economics of the various approaches and a host of related problems such as clocking, synchronization, standardization, etc. . . . discussion . . . includes delay distortion, noise, multipath distortion, bandwidth and amplitude response, transmit level, level variations, frequency translation errors, synchronization, standardization, cost considerations and facilities characteristics. . . .

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Quarterly progress rept. no. 3, 11 March 1963-10 June 1963, Rept. no. 7, 10 June 1963, 38 p., AD 417 754.

Field test results of various modems operating over the AN/VRC-12 radio set are presented. Map profiles of each data link are shown and the average error rates are given for digital data transmission at rates from 300 to 4800 bps. Photographs of the frequency spectra generated by each modem at their various bit rates are presented and used to discuss the relative

bandwidth requirements of the modems. The performance of the FSK (AN/TYC-1, XC-2), Di-Phase and Quad-phase modems in the presence of a controlled impulse noise test while operating at 1200 bps is shown in graphical form. A multi-frequency modem is being constructed for the HF data transmission study phase of the contract. The modem will have the capability of 18 bit rates and will be used in the investigation of the short range HF data transmission. System block diagrams of the multi-frequency modem are presented and the performance of the clock generator and clock recovery circuits is discussed. The limits of the code's error correcting and detecting capability are shown, and the code's performance when these capabilities are exceeded. . .

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Motorola, Inc., Chicago, Ill. Quarterly progress rept., no. 5, 11 Sept.-10 Dec. 1963, Rept. no. 9, 10 Dec. 1963, AD 430 726.

. . . The digital Encoder and digital Decoder constructed for the program are discussed. . . Unique implementation in the decoder gives the system the capability of providing a large number of cyclic codes.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 43/51.

ON COMPARING DIGITAL SYSTEMS (Correspondence)
W. J. Walbesser, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 247/249.

Related Publications:

RELIABLE FAIL-SAFE BINARY COMMUNICATIONS
J. J. Metzner, et al., IRE Wescon Conv. Record, vol. 4, Part 5, 1960, p. 192/206.

FREQUENCY ERROR EFFECTS ON A BINARY COMMUNICATION SYSTEM UTILIZING COHERENT INTEGRATORS
H. J. Juda, et al., Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 247/253.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

DATA TRANSMISSION OVER A NOISY GAUSSIAN CHANNEL (In Swedish)
L. H. Zetterberg, K. Tekn. Hogsk. Handle, no. 184, 1961, 87 p., 46 refs.

. . . A binary coded 2-signal system is compared with a system using error-correcting codes, and also with a multi-signal system, the systems being rates according to the tolerated noise level.

SIMPLE DELTA MODULATION SYSTEM
F. W. Arter, Proc. Instn. Radio Engrs., Australia, vol. 23, no. 9, Sept. 1962, p. 517/523.

The transmission performance of coded pulse modulation systems in the presence of high levels of channel noise is discussed and Delta Modulation systems are compared briefly with Pulse Code Modulation systems. The design of an experimental Delta Modulation system for speech transmission is presented for a required set of performance specifications. A feature of the system is its fully transistorized circuitry. . . .

INTRODUCTION TO AEROSPACE VEHICULAR DIGITAL COMMUNICATIONS
L. B. Hallman, Jr., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 57.

. . . papers contained in this issue of the IRE Transactions on Aerospace and Navigational Electronics. . .

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Intern. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

PULSE-FREQUENCY MODULATION
R. W. Rochelle, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 107/111.

. . . It is shown that PFM with quantized frequencies has the same communication efficiency in the presence of additive white Gaussian noise as a corresponding set of coded binary sequences with an equal number of quantized levels. . . .

CONDITIONS FOR OPTIMUM DIGITAL COMMUNICATIONS WITH APPLICATION TO DELTA MODULATION
T. Fine, Cruft Lab., Harvard U., Cambridge, Mass., TR399, 5 March 1963, 39 p., AD 405 053.

. . . binary communication systems. . .

DEMODULATION AND DETECTION EFFICIENCY OF AN UNCODED, COHERENT, BIORTHOGONAL DIGITAL CHANNEL IN GAUSSIAN NOISE
G. L. Fultz, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 204/210.

In uncoded, coherent subcarrier communication systems, data is usually demodulated from the subcarrier by multiplying the received subcarrier with a locally generated reference and then detecting the data with a matched filter, . . . From the results of the . . . discussion, the data demodulation and detection efficiency of the Mariner 2 demodulator

was questioned and subsequently analyzed. The results of the investigation are presented below.

SIGNALING WITH FREQUENCY-SHIFT-KEYED COSINE WAVES
E. D. Hanson, et al., Army Electronics Research & Development Labs., Fort Monmouth, N. J., AE RDL TR2363, Nov. 1963, 21 p., AD 436 824.

A very efficient binary signaling technique (from the standpoint of bandwidth utilization) is described. The power density spectrum. . . compared with that of sinusoidal diphase and rectangular diphase. . . .

ADAPTIVE TECHNIQUES FOR THE OPTIMIZATION OF BINARY DETECTION SYSTEMS
H. J. Kushner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 107/117.

PRINCIPLES OF SYSTEMATIC CODING FOR ERROR CORRECTION
B. W. Russell, Electronic Warfare Div., Air Force Avionics Lab., Aeronautical System Div., Wright-Patterson Air Force Base, Ohio, Rept. for Jan. 1962-March 1963, ASD TDR 63 439, June 1963, 36 p., AD 411 767.

. . . an elementary discussion of the principles of systematic, or "group" binary codes as used in digital type communications systems. . . . The problem of comparing the information transfer efficiency of coded and uncoded systems is considered and quantitative results are given for a couple of simple short codes.

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE
I. A. Tsikin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 1/11.

. . . The hypothesis that orthogonal systems, in the wide sense, ensure maximum noise immunity in a channel with indeterminate signal phase in the presence of additive fluctuation noise was first advanced by L. M. Fink. . . A rigorous proof of this statement is given for the special case of binary systems with Rayleigh fading of the signal. Considerations are also developed for optimum choice of signals with non-Rayleigh fading and for the noise immunity of multiposition systems. . . .

Section 1.84

1.840: Comparison of Modulation Systems Operating Over Line Communications Facilities

Included: Comparison of modulation methods for non-Gaussian channels; Comparison of modulation methods operating over voice channels; Comparison of modulation methods over cascaded channels; Comparison of phase shift keying with frequency shift keying over telephone lines.

Not Included: Multiplex systems (2); Error correction coding (2); Adaptive communications systems (2).

Cross References: Channel characteristics of voice channel facilities (Sect. 1.65); Pulsive noise in communications channels (1.743).

Principal Publications:

CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION
A. A. Alexander, et al., Bell Syst. Tech. J., vol. 39, no. 3, May 1960, p. 431/476.

This paper presents the results of a nationwide data transmission field testing program on the telephone switched message network. Error performance using the FM digital subset is described and basic transmission characteristics such as net loss, bandwidth, envelope delay and noise are given.

DATA TRANSMISSION OVER STANDARD VOICE COMMUNICATION FACILITIES
H. Fiege-Kollmann, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 223/232.

. . . The system described is based upon application of waveshapes. Practical performance in both white and impulsive noise will be discussed . . . certain properties of telephone circuits will be outlined in statistical presentation . . .

PHONE LINE DIGITAL TRANSMISSION STUDY
Hughes Aircraft Co., Culver City, Calif., (RADC TR 60-153), Sept. 1960, 240 p., AD 244 193.

An experimental and theoretical study program was undertaken to determine the characteristics of wireline circuits and equipments and their joint capability for supporting data transmission. Initially, the transmission characteristics of a variety of basic circuits and their combinations are detailed in terms of their attenuation-frequency response and their envelope delay-frequency response. The merits of equalization are considered. . . . Frequency stability, gain stability, compandor effects, echo, crosstalk and noise, and impulse noise are considered in turn. The subject of modulation (and data modems) is discussed and relative performance evaluated. The subject of error control by means of coding techniques is treated, and a representative

transmission problem discussed to demonstrate application of such techniques. Lastly, the economic aspects of a sample facility are considered in some detail.

EFFECTS OF IMPULSE NOISE ON DIGITAL DATA TRANSMISSION
A. B. Bodonyi, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Master's thesis, (Research rept. no. PIBMRI-975-61), 11 Dec. 1961, 23 p., illus., 14 refs., AD 285 511.

. . . basic characteristics of impulse noise and effects of impulse noise on various types of binary data transmission systems . . . method . . . for the experimental comparative evaluation of bit error rates in presence of additive impulsive noise. . . . three modulation schemes tested, namely on/off carrier, frequency shift and diphase (phase reversal keying, with coherent detection). . . . conclusions . . . (1) The choice of modulation scheme has a lot greater effect on the overall error rates in presence of impulse noise than it does for the gaussian case. (2) The simple error-detecting and error-correcting systems, designed to combat the effects of gaussian noise, can be utilized only to a fraction of their theoretical advantage in case of impulse noise. (3) The best results can be obtained from the coherent PSK system at high signal-to-noise ratios.

FREQUENCY-SHIFT MODULATION OF BINARY-CODED SIGNALS FOR TRANSMISSION OVER TELEPHONE CIRCUITS
M. Jeppsson, Elect. Commun., vol. 37, no. 2, 1961, p. 103/116.

TRANSMISSION OF DATA OVER TELEPHONE-TYPE CIRCUITS
W. T. Jones, Elect. Commun., vol. 37, no. 2, 1961, p. 87/102.

PULSE TRANSMISSION BY AM, FM AND PM IN THE PRESENCE OF PHASE DISTORTION
E. D. Sunde, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 353/422.

SOME RESULTS OF DATA TRANSMISSION TESTS OVER LEASED TELEPHONE CIRCUITS
G. A. Wildhagen, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 271/275.

. . . using two different sets of terminal equipments. The first applied phase-reversal modulation (PM), the second, frequency-shift keying (FSK). The transmission speeds were 750 or 1625 baud in the former and 750 or 1500 baud in the latter case. Nine different circuits, having an average length of 980 km, were tested

COMPARISON OF THE NOISE STABILITY OF RECEIVERS OF SIGNALS WITH FREQUENCY AND SINGLE BAND MODULATION FOR FLUCTUATING NOISE
N. G. Zubchenko, Telecommunications, no. 7, Dec. 1961, p. 830/833.

DATA LINE TECHNIQUES
Armour Research Foundation, Chicago, Ill., 1 April 1961, 458 p., 62 refs., AD 263 144.

. . . a review of pertinent theoretical material and a survey of wire line digital communication techniques to support suggestions for improving channel utilization. Increased utilization dictates the use of longer code elements in terms of time-bandwidth units, extensive terminal line equalization, and anti-impulse noise techniques. The theoretically optimum encoding-decoding systems based on performance are multilevel differentially coherent PSK (phase shift keyed).

CONSIDERATIONS IN THE CHOICE OF THE OPTIMUM DATA TRANSMISSION SYSTEMS FOR USE OVER TELEPHONE CIRCUITS
A. P. Clark, J. Brit. Instn. Radio Engrs., May 1962, p. 331/355.

A COMPARISON OF THE MERITS OF PHASE AND FREQUENCY MODULATION FOR MEDIUM SPEED SERIAL BINARY DIGITAL DATA TRANSMISSION OVER TELEPHONE LINES
F. G. Jenks, et al., J. Brit. Instn. Radio Engrs., vol. 24, no. 1, July 1962, p. 21/36, 12 refs.

. . . This paper indicates briefly why phase and frequency modulation are the best alternatives for general use and then examines in detail the relative merits of these two methods of modulation. The conclusions drawn from this study have been substantiated by measurements of error rate carried out on a number of p.m. and f.m. receivers working under conditions where comparisons could validly be made . . . It is clearly shown that phase modulation has significant advantages over frequency modulation in the data transmission application.

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 3, 11 March-10 June 1962, 10 June 1962, 1v., incl. illus., tables, AD 282 947.

Results obtained in back-to-back white noise testing of the various modems . . . Problems of crosstalk and transmission levels encountered in the AN/TCC-7 white noise tests are also discussed. Controlled impulse noise tests were conducted. . . . results show . . . the vsb modem is the most susceptible to impulse noise. . . . A system for recording impulses encountered in field testing and how it may help in the study of data transmission is discussed. The amplitude and delay characteristics of the AN/VRC-12 radio set are presented in graphical form. . . . Noise quieting curves of the AN/TRC-24 radio set are discussed and the performance of the various modems over the radio set operating near and on the FM threshold is reported. The results of field cable testing of the modems are presented in the tabulated form with a more detailed discussion of hits and drop outs in this transmission link.

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 4, 11 June-10 Sept. 1962, 10 Sept. 1962, 35 p., incl. illus. tables, AD 290 754.

White noise tests were performed on the diphase modem at 600 and 1200 bps. Performance of an AN/TYC-1 (SC-2) over the AN/TCC-7 in the presence of white noise was also evaluated and the results of these tests are presented in graphical form. Performance tests of the modems operating over the AN/TCC-44 time multiplex communications link were initiated. Tests of modem operation over tandem channels of the AN/TCC-7 were completed. The tests of modem compatibility with an AN/VRC-12 radio link setup in the laboratory were completed. . . . The channel characteristics of an AN/TCC-7 system connected through an AN/TRC-7 cable system were also continued.

ERROR STATISTICS AND CODING FOR DIGITAL DATA TRANSMISSION OVER TELEPHONE AND TELETYPE CIRCUITS (Correspondence)
A. B. Fontaine, Proc. IEEE, vol. 51, no. 3, March 1963, p. 474/475.

. . . in an earlier paper where four data systems, A-1, CTDS, Kineplex and Milgo, were used to collect over 2000 hours of error data with toll-grade, private microwave and K-carrier telephone circuits . . . additional data presented here are for two 60-wpm teletype circuits and for two 1200-bit/s telephone circuits; one is a forward propagation tropospheric scatter circuit in Alaska and the other a private wire service in the United Kingdom.

THE TELEPHONE CHANNEL CAPACITY OF TRANSMISSION LINES
D. A. Gray, Proc. Instn. Radio Engrs., Australia, vol. 24, no. 7, July 1963, p. 583/589.

The attenuation of transmission lines used for telephone transmission varies very nearly as the square root of frequency . . . In this paper the maximum number of telephone channels which can be obtained on such a line using AM-FDM, FM-FDM, and PCM-TDM is calculated as a function of line attenuation at a reference frequency, transmitted power level, and signal-to-noise ratio. At moderate and high transmitting levels SSB-AM usually permits the greatest number of channels to be derived. . . .

RESULTS OF DATA TRANSMISSION TESTS OVER TELEPHONE LINKS (In French)
J. Labeyrie, Onde Electr. vol. 43, no. 431, Feb. 1963, p. 94/105.

. . . outlines the results of data transmission tests which have been carried out under the direction or with the cooperation of the C. N. E. T., over both normal and special telephone links. . . . statistical analysis of recordings . . . pattern of errors (interval between errors, size of error groups, interval between erroneous blocks of numbers, etc.).

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 4, Rept. no. 8., 11 June-10 Sept. 1963, 10 Sept. 1963, 1 v., AD 424 183.

Experimental results . . . over existing military voice communication systems . . . error rates are given for various field conditions . . . various modulation techniques such as FSK, diphase and quad-phase modulation were tested over these communication links . . . include white noise, impulse noise, and frequency translation tests . . . photographs of the spectra generated by the modems at their various bit rates (150 to 4800 bps) are presented and used to discuss the bandwidth requirements of each modem.

PAM, PDM, AND PCM TECHNIQUES IN APPLICATION TO DIGITAL TELEMETRY ON VOICE BANDWIDTH FACILITIES
C. Yanis, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 139/151.

. . . The requirements of these telemetry modes in terms of line conditions, tone equipment, and terminal equipment is examined. Conclusions are reached regarding adaptability to high speed, multiplexing, and hardware requirements.

INTERSTATION DATA. TRANSMISSION STUDY
Philco Corp., Palo Alto, California, Final rept., (Rept. no. WDL-TR 2017), 28 Feb. 1963, 1v., incl. illus., tables, AD 297 409.

. . . equipment to transmit data through a single voice channel. . . . requirements placed on transmission medium, transmission rates, equalization provided, size, weight, prime power requirement. . . . media include: wire lines, HF radio, microwave line of sight, and the various scatter propagation techniques. . . . reliability, error rate, and availability. Error detection and error correction for both white noise and burst error interference are considered. It is concluded that long word codes (100-500 bits) with error detection is the most promising technique, but that a feedback path is required.

Related Publications:

HIGH-SPEED TRANSMISSION OF NUMERICAL DATA OVER TELEPHONE CHANNELS
A. Girinsky, et al., Elect. Commun., vol. 36, no. 4, 1960, p. 248/262.

. . . information is transmitted in the form of binary digits . . . equipments that adjust the speed of transmission to the characteristics of the transmission network. . . . There is no

direct-current component in the signaling code that would be lost in passing through a repeater or transformer. . . . the receiver is automatically synchronized by the transmitter to provide good reliability and ready adaptability to all types of telephone systems. . . .

ON THE DETECTION OF STOCHASTIC SIGNALS IN ADDITIVE NORMAL NOISE
D. Middleton, Lincoln. Lab., MIT, Lexington, 28 Dec. 1960, AD 250 287.

Optimum detection of FSK and on-off normal noise backgrounds is examined. . . . Also included in the present study is a general treatment of colored-noise backgrounds . . .

SOME RESULTS ON THE EFFECTIVENESS OF ERROR-CONTROL PROCEDURES IN DIGITAL DATA TRANSMISSION
W. R. Bennett, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 58/65.

. . . Emphasis has been placed on the recurrent codes, when subjected to actual errors collected from Data-Phone test calls . . .

ERROR STATISTICS AND CODING FOR BINARY TRANSMISSION OVER TELEPHONE CIRCUITS
A. B. Fontaine, et al., Proc. IRE, vol. 49, no. 6, June 1961, p. 1059/1065.

A HIGHLY VERSATILE CORRECTOR OF DISTORTION AND IMPULSE NOISE
E. D. Gibson, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 343.

. . . A device at the receiving station corrects both amplitude and delay distortion. This device is continuously and easily adjustable and much more accurate, in general, than conventional equalizers.

. . . utilizes a "scrambler" (or predistorter) . . . called the ISIC (Inter-Symbol Interference Corrector) and a fixed, "smear" filter. The descrambler consists of another ISIC and a "desmear" filter.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

. . . the theory of equidistant and nearly equidistant codes is extended to the case of nonwhite Gaussian noise. It is shown that efficient codes perform better than equidistant codes if the noise is nonwhite; i.e., properly chosen waveforms are more efficient than binary coding. . . .

DATA SYSTEM TESTS USING SIMULATED TRANSMISSION IMPAIRMENTS
F. T. Andrews, Jr., Commun. Electronics, vol. 80, no. 58, Jan. 1962, p. 590/596.

. . . This test equipment, together with conventional random-data signal generators and error comparators, makes possible the evaluation of data systems with a wide range of transmission characteristics. . . .

AN AM VESTIGIAL SIDEBAND DATA TRANSMISSION SET USING SYNCHRONOUS DETECTION FOR SERIAL TRANSMISSION UP TO 3,000 BITS PER SECOND
F. K. Becker, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 97/101.

. . . appears to be economically advantageous when compared with other systems of the same speed capability. . . .

THE STABILITY OF A FREQUENCY REMOTE CONTROL SYSTEM IN THE PRESENCE OF PULSE NOISE
Yu. I. Chugin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force, Base, Ohio, (Trans. no. FTD-TT-62-636 from Avtomatika i Telemekhanika, 23:2, p. 222/241, 1962, 10 May 1962, 33 p., incl. illus., AD 286 132.

The stability of a frequency remote control system under the action pulse noise with a known law of amplitude distribution is determined. The influence of the structure and parameters of a receiver upon its noise stability is investigated. A method is examined for calculating the noise statility of codes with series and parallel transmission of subcarriers. . . .

COBI DATA TRANSMISSION TESTING IN THE UNITED KINGDOM
P. L. Grant, Lincoln Lab., Mass. Inst. of Tech., Lexington, (Rept. no. 25G-8), (AFESD TDR 62-82), 27 March 1962, 20 p., incl. illus., 2 refs., AD 275 152.

. . . summarizes the data obtained during the measurement of the coded biphase (COBI) data transmission modem over the private wire services in the United Kingdom. . . .

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

. . . Basically, it is shown that subdividing the decision interval (O, T) and coding each subinterval using optimum waveforms is a more efficient method of combatting the impulse noise than using optimum waveforms in the full decision interval. . . . A non-linear detector suppresses the contributions of subintervals with impulsive noise - i.e., the decision at the receiver is essentially based on the subintervals with no impulsive noise. . . . the concept of an ideal discarding detector is introduced.

EXPERIMENTAL DATA TRANSMISSION SYSTEM FOR SWITCHED TELEPHONE LINES
H. Marko, et al., Elect. Commun., vol. 37, no. 3, 1962, p. 238/251.

. . . the system must be able to cope with noise caused by rotary selectors as well as with short-time interruptions not uncommon in carrier-system channels. . . . The return path

of the (basically duplex) telephone line can be utilized for backward signals, such as proceed to send or repeat. . . . Frequency modulation has been favored because of its simplicity of equipment and adjustment and the minor effects of changes in signal-to-noise ratio. . . .

THE ESTIMATION PROBLEM IN NULL-ZONE RECEPTION FEEDBACK SYSTEMS
J. J. Metzner, et al., New York U., Coll. of Engineering, N. Y., (Scientific rept. no. 11), (AFCRL 62-742), 15 Aug. 1962, 137 p., incl. illus., tables, 26 refs., AD 290 325.

When signal-strength correlation is appreciable over as few as ten digits, overall system-performance is only slightly less efficient than would be attained with exact knowledge of the channel conditions. Methods of minimizing the undesirable effects of impulsive and burst-type noise are discussed.

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J. C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . Applying signal design concepts to eliminate intersymbol interference in a communication channel entails a priori knowledge of the impulse response of the channel, and this in itself is a major task for most time varying links. . . . we first investigate the advantages of signal design techniques if this a priori information is known. . . .

ROTATIONAL TRANSFORMATION OF SIGNALS
G. R. Lang, IEEE Trans. Inform. Th., IT-9, no. 3, July 1963, p. 191/198.

A coding procedure based on a rotational transformation is applied to reduce the effect of non-Gaussian impulse noise in sampled data communication systems. The method, a near relative of the smearing techniques which have been suggested recently for continuous systems . . .

AN EXPERIMENTAL COMPARISON OF SOME ERROR-DETECTING CODES
J. N. Prewett, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 423/431.

. . . The effectiveness of these error-detecting codes is compared by simultaneous transmission over 200 miles of rented G. P. O. telephone line. A constant-ratio code, a row-and-column parity code and a multi-diagonal-parity code are built into a 128-digit message. Both f. m. and p. m. systems are used at 750 bauds. The results are collected on punched paper tape and analyzed by computer. . . . The results show that whilst constant-ratio codes may be adequate for 50 bauds, more elaborate schemes are required at higher speeds. . . .

Section 1.85

1.850: Comparison of Modulation Systems Operating over Radio Facilities

Included: Comparison of modulation systems over fading channels; Comparison of modulation systems over multipath circuits; Comparison of modulation systems under heavy interference; Comparison of modulation systems over time variant channels; Comparison of modulation systems over doppler shifting channels.

Not Included: Adaptive communications techniques (2); Anti-multipath communications systems (2); Variable rate data transmission systems (2); Diversity reception techniques (2).

Cross References: Characteristics of point-to-point radio channels (Sect. 1.66); Characteristics of HF channels (1.644); Analysis of time variant channels (Sect. 1.61).

Principal Publications:

ON THE CONDITIONS FOR OBTAINING A HIGH INFORMATION HANDLING CAPACITY IN COMMUNICATION CHANNELS WITH RANDOM VARIATIONS IN THEIR PARAMETERS
V. I. Siforov, Telecommunications, no. 1, 1958, p. 1/8.

FACTORS AFFECTING MODULATION TECHNIQUES FOR VHF SCATTER SYSTEMS
J. W. Koch, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 77/92.

COMPARISON OF DIFFERENT TRANSMISSION TECHNIQUES FOR LONG-RANGE COMMUNICATIONS SYSTEMS
W. E. Morrow, Jr., Proc. Nat. Aeron. Electronics Conf., vol. 7, May 1959, p. 130/133.

CERTAIN PROPERTIES OF COMMUNICATION SYSTEMS WITH FADING TYPE INTERFERENCE
E. ' L. Blokh, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 9, 1960, p. 1/9.

. . . Such systems are compared with those having ordinary additive interference. The information capacity of these systems is also compared. The use of correcting codes is studied. . . .

QUESTIONS OF POTENTIAL INTERFERENCE RESISTANCE WHEN THE SIGNAL FADES
D. D. Klovskii, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 24/35.

Criteria are obtained for single coherent and non-coherent reception of discrete messages for an ideal receiver in the presence of fluctuating interference and rapid smooth fadings of the signal. The probability density of the envelope of the signal reaching the receiver is assumed to be distributed according to the generalized Rayleigh law. . . . The minimum probability of faulty reception is calculated for certain classes of systems. . . .

FM AND SSB RADIOTELEPHONE TESTS ON A VHF IONOSPHERIC SCATTER LINK DURING MULTIPATH CONDITIONS
J. W. Koch, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 183/186.

CRITERIA FOR THE ULTIMATE CAPABILITY OF THE OPTIMIZED TROPOSPHERIC SCATTER SYSTEM
C. A. Parry, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 187/192.

DATA TRANSMISSION TESTS ON TROPOSPHERIC BEYOND-THE-HORIZON RADIO SYSTEM
F. E. Willson, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 40/43.

. . . Tests were made at 750 or 1300 bits per seconds employing both double sideband AMP and FM methods of data modulation. In the single-link tests the data performance was determined for various transmission parameters such as median channel noise, peak channel noise, radio received carrier level, and order of diversity. Data were satisfactorily transmitted on a 2400-mile circuits consisting of nine different beyond-the-horizon paths and six line-of-sight paths. The FM-type data modulation was notably superior to the AM type.

(No Title)
S. Chang, et al., Electronics Research Lab., Northeastern U., Boston, Mass., Final rept., 31 May 1961, 126 p., AD 264 765.

The basic factors in multipath and some existing systems of reducing these defects, are examined together with conjectures on possible modifications of these systems to improve bandwidth-time utilization . . . two special classes of 2-3 channels, the complete erasure channel . . . fractional erasure channel, are presented . . . A slope method for 3-3 and 2-3 channels is also discussed. A mathematical analysis of the ambiguity function for three classes of waveforms, and a theorem on the unimodular linear transformation of the ambiguity plane, are presented. Two novel schemes of detection, an a posteriori probability computer for a digital communication channel with memory, and an asynchronous demodulator for double-sideband (carrier suppressed) transmissions, are studied. A theoretical comparison is made on the relative per-word reliabilities in a digital channel between the uncoded case and the case where an error-correcting code is used at the same energy and time-bandwidth per word.

ANALYSIS OF FIVE MODULATION TECHNIQUES FOR CASCADED BINARY COMMUNICATION LINKS PERTURBED BY ADDITIVE GAUSSIAN NOISE AND RAYLEIGH FADING
H. D. Goldman, et al., New York U. Coll. of Engineering, N. Y., (Scientific rept. no. 7), 6 Nov. 1961, 50 p., AD 270 285.

. . . cases of constant and Rayleigh-distributed signal levels. An exact expression is derived for over-all error probability for any number of links with constant signal levels. The reliability of five modulation techniques are examined when independent and dependent Rayleigh fading is present on the cascaded system . . . The results of these analyses afford the designer a basis for a suitable trade-off between number of relays and individual link reliabilities for a specified over-all system reliability.

BINARY ERROR RATES IN FADING FDM-FM COMMUNICATIONS
D. E. Johansen, IRE Trans. Commun. Systems, vol. CS-9, no. 3, Sept. 1961, p. 206/214.

. . . in a fading environment FDM-FM . . . it is shown that an FDM-FM data system does not perform as well as does the equivalent FDM-SSB system by an amount in the order of 10 db.

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Buffalo, N. Y., (Rept. no. UA-1420-S-1), (RADC TR 61-58), 3 Jan. 1961, AD 256 584.

. . . performance of several types of Phase Shift Keyed (PSK) systems, as determined by the relationship of the error probability to signal-to-noise coherent, binary and m-state PSK systems, and the effects of frequency offset, cross-talk and thermal noise on the performance of these systems are considered. The performance of m-state differentially coherent multiplexed PSK data links operating over a Rayleigh fading tropospheric

scatter link is analyzed. The properties of impulse noise are examined and the effect of impulse noise are examined and the effect of packed codes are investigated. Moment detection, which refers to a decision technique based on the use of temporal moments is investigated both analytically and experimentally.

THEORETICAL PERFORMANCE BOUNDS FOR VARIABLE DATA RATE TRANSMISSIONS ON FADING CIRCUITS

J. N. Pierce, Air Force Cambridge Research Labs., Bedford, Mass., (AFCRL-959), Nov. 1961, 9 p., AD 269 796.

. . . a means of counteracting adverse effects of fading. Theoretical bounds on attainable improvements are derived as a guideline to more exhaustive studies. It is shown that relatively simple suboptimum systems offer virtually as good performance as the most elaborate system.

NEW METHODS FOR ESTIMATING DISTORTION IN MULTIPATH SIGNAL PROPAGATION (English Translation)

V. A. Smirnov, Telecommunications, no. 5, May 1961, p. 9/17.

Two energy methods for estimating multipath signal distortion are presented. Both methods are applicable to any form of signal modulation. Hence the methods serve as a means of quantitative comparison of different communication systems. . . . Analytical expressions are given for the magnitude of the distortion for different forms of signal modulation.

A LONG RANGE DIGITAL COMMUNICATIONS SYSTEM

A. J. Strassman, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 383/389.

. . . high-frequency, digital data communication system using the quantized frequency-modulation (QFM) technique and the quantized phase-modulation (QPM) technique. QFM is a synchronous frequency shifting technique that can provide a predetermined amount of gap protection between successively transmitted pulses on the same subchannel frequency. The design of the system provides for a basic bit rate of 1000 bits/sec. and is capable of expansion to 8000 bits/sec. System peripheral equipments provide digital inputs from facsimile and voice (Vocoder), as well as from multispeed teletype. Highly miniaturized modular construction is used throughout for all equipments installations.
These systems operate in the 2 - to 36-Mc high-frequency bands and have been tested at ranges in excess of 5000 miles.

EFFECTS OF AMPLITUDE AND PHASE FLUCTUATIONS ON THE PERFORMANCE OF DIGITAL DATA SYSTEMS IN FADING FDM-FM AND FDM-SSB SYSTEMS

H. D. Becker, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 93/100.

. . . Emphasis is placed on the theoretical performance of differentially coherent phase-shift keyed (DCPSK) systems in which DCPSK data is transmitted on subcarriers over a frequency-division multiplex single-sideband (FDM-SSB) or an FDM-FM transmission system, such as employed in typical tropospheric scatter links. . . .

THEORETICAL STUDY OF ON-OFF TRANSMISSION OVER GAUSSIAN MULTIPLICATIVE CIRCUITS

P. A. Bello, et al., Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 76/92.

. . . performance of an . . . "intermittent" binary communication system employing forward and feedback channels with statistically independent flat fading. Ideally, such a system transmits data on the forward channel only when the received signal is sufficiently strong to allow reliable detection, the feedback channel bieng used to provide the transmitter with the necessary receiver signal-to-noise ratio information. In practice . . . feedback link errors will degrade system performance . . . This paper presents an exact determination of error probabilities including the effects of . . . feedback link errors . . . an approximate optimization of the parameters of such a system is carried through and performance curves are given for this optimized system.

THE INFLUENCE OF FADING SPECTRUM ON THE BINARY ERROR PROBABILITIES OF INCOHERNET AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS

P. A. Bello, et al., IRE Trans. Commun. Systems, vol. CS-10, no. 2, June 1962, p. 160/168.

Previous derivations . . . have assumed that the fading rate is so slow that fluctuations within a bit may be ignored. This slow fading assumption is removed in the present paper which derives general expressions for the binary error probabilities of incoherent and differentially coherent matched filter receivers emploing post-detection diversity combining. In the analysis it is assumed that the transmitted signals occupy a bandwidth much smaller than the coherence bandwidth of the medium so that "flat" fading may be assumed. In addition, it is assumed that the amplitude and phase fluctuations produced by the medium have the same statistical character as those of narow-band Gaussian noise. . . .

JAMPROOF AUTOMATIC FREQUENCY CONTROL. VOLUME 1. ANALYTIC STUDIES

A. Bond, et al., Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., (Rept. no. BSR-546, vol. 1), (ASD TR 61-661, vol. 1), Jan. 1962, lv., 28 refs., AD 270 529.

A study of modulation, detection and correction techniques was undertaken to develop design criteria for communication equipment that could provide adequate performance when subjected to severe doppler shifts and other effects encountered in communications from rapidly moving vehicles. . . .

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS

D. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept. incl. illus., tables, refs., (Rept. no. F-1008-1), (RADC TDR 62-314), 14 June 1962, 293 p., AD 286 504.

. . . covering both adaptable receivers and repeat-request feedback systems using error-detection codes. The study on error-detecting codes deals with a multi-stage error-detection repeat-request system in which the receiver performs error detection on small blocks of binary digits and requests a repeat of each block in which an error is detected . . . Optimum thresholds are determined for use in dual-rate transmission over fading channels in conjunction with error-detection coding. The remaining studies deal with adaptable receivers. One investigation demonstrates the utility of a rake-type system for orbital dipole channels. The rake system studied is a generalization fo the conventional rake system and has the advantage of allowing analog as well as digital modulation.

EXPERIMENTAL EVALUATION OF AN OPTIMUM DETECTOR FOR FSK TRANSMISSION THROUGH A RAYLEIGH FADING CHANNEL

E. E. Cossette, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TDR 62-554), Nov. 1962, 22 p., incl. illus., 6 refs., AD 291 892.

. . . This receiver was instrumented, through use of simulation techniques, to evaluate experimentally the performance of such a system. The measurements resulted in a family of curves giving the probability of transmission error as a function of the ratio of signal energy per bit to noise power density with the keying interval as a parameter. The results showed an improvement over existing FSD receivers.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS

A. B. Glenn, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 168/173.

. . . Three basic types of communication systems were investigated. The first system employs large bandwidth signal duration product (WT) orthogonal signals with quadrature detection. The next two systems employ a WT product approximately equal to one. These last two systems were the noncoherent frequency shift keyed (FSK) and the differentially coherent phase shift keyed (DPSK) . . . In addition to the desired signal fading, an undesired signal is also assumed to be subject to statistically independent Rayleigh fading with the same signal spectral density as the desired signal plus an undesired signal which is not fading. . . .

AN ANALYSIS OF CASCADED BINARY COMMUNICATION LINKS

H. D. Goldman, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 291/299.

. . . The use of satellite relays appears to be particularly advantageous for wideband VHF and UHF global communications. . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATIONS SYSTEMS. PART III. A WIDEBAND ADAPTIVE COMMUNICATION SYSTEM

J. C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961- June 1962, on Improved Information Transfer Efficiency of Wideband Systems, July 1962, 218 p., incl. illus., 60 refs., (ASD TDR 62-611, pt. 3), AD 284 452.

. . . capable of monitoring the medium through which it must perform while simultaneously transmitting information and continuously adjusting its modes of operation so as to optimize its performance with respect to a performance criterion chosen a priori. Statistical methods are applied to the adaptive communication problem. Communicating through a random multipath channel with additive noise is considered. . . . A major conclusion taken from these expressions is that the probability of error in no case depends directly on the channel gain, but rather is a function of the total average energy received from all propagation modes.

HIGH FREQUENCY RADIO DATA TRANSMISSION THROUGH MULTIPATH DISTURBANCE

J. C. Hansen, Mitre Corp., Bedford, Mass., (Technical memo. no. TM-3359), (ESD TDR 62-327), 13 Sept. 1962, 18 p., incl. illus., 14 refs., AD 290 538.

There exists an urgent requirement to increase the reliability of high frequency radio communications. A degradation of performance can occur during periods of high signal strength due to multipath disturbance. This phenomenon, along with a number of proposed methods of solution, are described.

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Stanford Electronics Labs., Stanford U., Calif., (Technical rept. no. 1002-2), April 1962, 89 p., incl. illus., 24 refs., AD 291 447.

. . . Analysis is undertaken in sufficient depth to give guidance in the selection of design parameters of various type of systems. . . . comparison . . . of the performance potentials of different communication techniques. Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sounding effort, the signal characteristics, and the channel characteristics. . . . The performance characteristics of a class of radiometric signal-detection techniques that require no channel-sounding provisions are analyzed. . . . The results appear to be very attractive when relatively large channel bandwidths are available. . . . For many types of multipath channels, the advantages of seeking generally optimum communication techniques are somewhat limited.

MULTIPATH AND SCATTER COMMUNICATION TECHNIQUES
D. P. Harris, IRE Internat. Conv. Rec., pt. 8, vol. 10, March 1962, p. 161, 16 refs.

. . . results of an investigation of random-multipath-and scatter-communication channels and of communication techniques applicable to such channels. The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channels models. . . .

MULTIPATH AND SCATTERED COMMUNICATION TECHNIQUES
D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., Tech. rept. on Flight Sciences, (rept. no. 6-90-62-42), May 1962, 10 p. incl. illus., 16 refs., AD 275 343.

. . . The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channel models. The performance characteristics of a class of incoherent communication techniques that require no channel-sounding provisions are considered. Power requirements and bandwidth requirements per unit information transmission rate are evaluated and compared for these techniques and for differentially coherent narrow-band techniques under similar conditions.

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . performance analysis of some digital communication techniques that can be used when most other techniques fail. Error-probability expressions are derived and evaluated for a wide range of possible operating conditions. Effective use of available signal power is found to be possible on badly behaved channels, provided there is sufficient bandwidth available for the optimization of performance. . . . a class of digital communication systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. The magnitudes of the shifts are to be selected such that the received waveforms, (corresponding to different possible transmitted-pulse positions) can be observed independent, . . .

A COMPARISON OF ERROR RATES FOR COHERENT AND PHASE-COMPARISON DETECTION OF TWO- AND FOUR-PHASE DIGITAL SIGNALS IN THE PRESENCE OF RAYLEIGH CARRIER FADING (Correspondence)
C. R. Laughlin, et al., Proc. IRE, vol. 50, no. 4, April 1962, p. 468/469.

ERROR PROBABILITIES FOR COHERENT MULTICHANNEL RECEPTION THROUGH RICIAN FADING
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 159/165.

COMPARATIVE PERFORMANCE OF DIGITAL DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF CW INTERFERENCE
F. G. Splitt, IRE Internat. Conv. Rec., pt. 8, vol. 10, March 1962, p. 72/81.

COMPARATIVE PERFORMANCE OF DIGITAL DATA TRANSMISSION SYSTEMS IN THE PRESENCE OF CW INTERFERENCE
F. G. Splitt, IRE Trans. Commun. Syst., vol. CS-10, No. 2, June 1962, p. 169/177.

. . . The results obtained can also be utilized to ascertain system performance in the presence of interference from similar systems and for certain classes of interrupted CW (ICW) interference. . . . The performance of differential phase-shift, coherent phase-shift, amplitude-keyed, frequency-shift and time-shift binary digital data transmissions is determined. . . .

DATA TRANSMISSION INVESTIGATION
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 4, 11 June - 10 Sept. 1962, 10 Sept. 1962, 35 p., incl. illus., tables, AD 290 754.

. . . The tests of modem compatibility with an AN/VRC-12 radio link setup in the laboratory were completed. . . .

MULTIPURPOSE RECEIVER DESIGN STUDY
Philco Corp., Palo Alto, Calif, Final rept. (Rept. no. WDL-TR 1850), 28 Sept. 1962, 333 p. incl. illus., tables, AD 286 985.

. . . to meet functions required of tracking stations for the majority of anticipated space programs through 1970. . . . to function in the frequency bands of 100 mc to 10 gc. Discussions include the use of standard detection methods plus phase and frequency feedback techniques for detection of received signals including wide-band FM, narrow-band FM, PM, AM, and multiple angle modulations. Reliability and maintainability evaluations are also included.

DESIGN OF RELIABLE LONG-DISTANCE AIR-TO-GROUND COMMUNICATION SYSTEMS INTENDED FOR OPERATION UNDER SEVERE MULTIPATH PROPAGATION DISTURBANCES

K. W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 67/78.

A survey of the principal methods of improving the reliability of long-range digital communication systems . . . Special modulation techniques as well as redundant transmission of pulses, redundant in time and in carrier frequency, are described as methods to counteract the effects of multipath distortion in connection with the proper special demodulation and diversity reception techniques. . . . for an air-to-ground communication system, in which Doppler shift has to be considered in addition to the multipath distortion, high reliability can be obtained if quantized frequency modulation (QFM) and time redundancy are properly applied. . . .

INTERFERENCE APPLIED RESEARCH DATA COLLECTION AND ANALYSIS. MODULATION AND DETECTION TECHNIQUES FOR INTERFERENCE SUPPRESSION

S. J. Andrzejewski, et al., Bendix Radio Div., Baltimore, Md., Final rept., RADC TDR 63 148, AD 406 221.

. . . theoretical and practical problems involved in the selection of an optimum communication system, when the interference consists of a random distribution of friendly pulse radars are discussed. Four . . . techniques . . . i.e., wideband FM, pseudo-random spread spectrum, pulse position modulation, and pulse code modulation . . . required post-detection signal-to-noise ratio of at least 50 db . . . A PCM system using a redundancy feasibility model . . . was tested and evaluated under controlled field conditions, and the results are compared with the theoretical expectations.

FEHLERWAHRSCHEINLICKEIT BINARER UBERTRAGUNGSVERFAHREN BEI STORUNG DURCH RAUSCHEN UND SCHWUND
(Error Probability of Binary Transmission Systems Under Fading Conditions Over Noisy Channels) (In German)

P. Besslich, Arch. Elekt. Uebertragung, vol. 17, April 1963, p. 185/197, 16 refs.

Under the assumption of white Gaussian noise and eccentric Rayleigh fading the error probabilities of binary transmission systems are calculated, a distinction being made for the known types of modulatiom between coherent (phase-sensitive) and non-coherent demodulation. The influences of automatic phase and a amplitude control as well as of the modulation factor are taken into account. Known results are obtained as special cases. . . . It is seen that even weak fading causes a considerable increase in the error probability. Under the same fading and demodulation conditions, the error probabilities of all modulation methods can be stated by the same expressions as functions of a generalized signal-to-noise ratio. This shows that amplitude keying and frequency-shift keying are theoretically equivalent under all conditions encountered, if the mean transmitting power is the same, while values are verified by a model test. . . .

FEHLERWAHRSCHEINLICHKEIT BINARER UBERTRAGUNGEN BEI MEHRFACH-EMPFANG UND BEI FREQUENZSELEKTIVEM SCHWUND
(Error Probabilities for Binary Transmission with Diversity Reception Under Selective Fading Conditions) (In German)

P. Besslich, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 271/277.

The error probabilities of binary transmission systems are calculated for Rayleigh fading and optimum diversity reception of n-th order and shown as functions of the error probability with non-diversity reception. Although the error probability of non-coherent transmission methods is reduced more by diversity reception than in the case of coherent methods, the coherent systems remain decidedly superior in diversity reception. . . .

DIGITAL TRANSMISSION IN MEDIA OF VARIABLE TIME DELAY

E. M. Bradburd, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 438/442.

. . . requires suitable techniques for bit synchronization, bit identification and time division multiplexing. Increasing refinements in these techniques are needed in the progression from networks of two nodes connected by a single link to a number of nodes joined by tandem links and thence to networks of higher connectivity. The addition of link encryption and multiplexing of information imposes even more severe constraints. . . . the three key terms in this analysis . . .

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS

A. B. Glenn, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 57/68.

. . . effects of fading rate on the performance of binary digital communications systems. The performance of three systems is evaluated from the aspect of probability of error per information bit when the desired and undesired signals are subject to statistically independent Rayleigh fading. Diversity reception is not included in the system comparison. The results . . . apply only for a nonselective fading environment . . . The first system, called the quadrature detection system, employs large-bandwidth signal duration product (WT) . . . The next two systems employ a WT product approximately equal to one. These . . . were the noncoherent frequency-shift keyed (FSD) and the differentially coherent phase-shift keyed (DPSK) . . .

A FEASIBILITY STUDY OF LONG-RANGE AERO-MOBILE DATA COMMUNICATION

G. L. Grisdale, In: Electronics Research and Development for Civil Aviation Conference, London, England, Oct 2-4, 1963, Collected preprints, Institution of Electrical Engineers, 1963, p. 1/7, A64-12814.

. . . automatic radio telegraphy for ranges up to 2,000 miles . . . The merits of many proposed communication methods are examined, as well as different modulation systems . . .

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA

D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., 6 July 1963, 96 p., AD 410 286.

. . . some specific techniques for communicating through noisy, randomly time-varying multipath channels are considered . . . Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sound effort, the signal characteristics, and the channel characteristics. The performance characteristics of a class of radiometric signal detection techniques that require no channel sounding provisions are analyzed. . . .

TIME-VARIANT COMMUNICATIONS CHANNELS

T. Kailath, Stanford Electronics Labs., Stanford Univ., Calif., Rept. nos. SEL 63 106, TR 7050 1, Aug. 1963, 19 p., AD 420 482.

. . . broken down into five areas– methods of channel representation, methods for measuring the instantaneous and average behavior of the channel, the derivation of suitable receiver structures for communication over such channels, the evaluation of the performance of such receivers, and studies of signal selection and coding techniques to increase the speed and reliability of communication.

ERROR PROBABILITIES FOR RICIAN FADING MUTICHANNEL RECEPTION OF BINARY AND N-ARY SIGNALS

W. C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, (NASA CR-51853; JPL Tech. Rept. 32-450), June 3, 1963, 24 p., 26 refs., N 63-22895.

. . . derived for two different forms of multireceivers (the coherent and noncoherent), which are used with binary and N-ary signaling through the Rician fading multichannel . . .

ERROR PROBABILITIES FOR N-ARY NON-COHERENT MULTIRECEIVER RECEPTION THROUGH THE RICIAN FADING MULTICHANNEL

W. C. Lindsey, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 105/109.

AN INTEGRAL EQUATION ARISING IN MULTICHANNEL COMMUNICATION PERFORMANCE CHARACTERISTICS

W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 156/158.

Suitable for specifying the performance characteristics for a non-coherent multilink communication system employing two correlated equiprobable, equal-energy signals . . .

OPTIMUM PULSE TRANSMISSIONS FOR MULTIPATH CHANNELS

J. G. Proakis, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 64G3, AFESD TDR 63 101, 16 Aug. 1963, 38 p., AD 416 639.

. . . problem of modulation and demodulation techniques for communicating through fluctuating multipath channels has . . . performance of an incoherent M-ary communication system operating via a fluctuating multipath channel is computed under very restrictive conditions on the channel behavior, namely that the received signal consists of resolvable, independently Rayleigh fading paths each of which has been corrupted additively by independent gaussian noise. Probility of error expressions are . . . generalizations of results obtained earlier by Turin, Hahn, and Pierce. From these expressions the optimum time duration for pulse transmissions is computed for two channels–the orbital dipole channel and the moon.

DATA TRANSMISSION INVESTIGATION

R. F. Salava, Quarterly progress rept no. 3, 11 March 1963 - 10 June 1963, Rept no. 7; 10 June 1963, 38 p; AD 417 754.

Field test results of various modems operating over the AN/VRC-12 radio set are presented. Map profiles of each data link are shown and the average error rates are given for digital data transmission at rates from 300 to 4800 bps. Photographs of the

frequency spectra generated by each modem at their various bit rates are presented and used to discuss the relative bandwidth requirements of the modems. The performance of the FSK (AN/TYC-1, XC-2), Di-phase and Quad-phase modems in the presence of a controlled impulse noise test while operating at 1200 bps is shown in graphical form. A multi-frequency modem is being constructed for the HF data transmission study phase of the contract. The modem will have the capability of 18 bit rates and will be used in the investigation of the short range HF data transmission. System block diagrams of the multi-frequency modem are presented and the performance of the clock generator and clock recovery circuits is discussed. The limits of the code's error correcting and detecting capability are shown, and the code's performance when these capabilities are exceeded . . .

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 5, 11 Sept. - 10 Dec. 1963, Rept. no. 9, 10 Dec. 1963, lv., AD 430 726.

Field test results obtained while transmitting digital data over the AN/VRC-12 radio set . . . at 41.5 mc using FSK and Di-phase modems. . . . impulse noise from passing vehicles and thunderstorms to multipath conditions from airplanes. . . .

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE (Translation)
I. A. Tsikin, Telecommunications and Radio Engineering, Part 2 - Radio Engineering, July 1963, p. 1/11, 5 refs., A64-15462.

Proof of the starement that orthogonal signals in the wide sense ensure maximum noise immunity in a channel with indeterminate signal phase. The special case of binary systems with Rayleigh fading of the signal is considered, with development for optimum signal choice with non-Rayleigh fading, and for noise immunity of multiposition signals. It is pointed out that the operating principle of an optimum receiver is the same in the presence of Rayleigh fading as in its absence. . . . demonstrating that orthogonality in the wide sense is also necessary in the case of codes with a base greater than two. . . .

COMPARISON OF SIGNALLING EFFICIENCY IN WIDEBAND COMMUNICATIONS SYSTEMS
J. W. Ye, Mitre Corp., Bedford, Mass., Rept. no. TM3851, ESD TDR63 437, Oct. 1963, 15 p., AD 422 599.

. . . comparing the system performance improvement in a coded correlation communication system under heavy jamming environment for the following forms of message encoder and decoder: (1) simple reduction of the transmission rate, (2) simple reduction of the same symbol, and (3) application of error-correcting codes. The error-correcting codes were found to perform uniformly better than the other two schemes. . . .

Related Publications:

SIMPLE CODES FOR FADING CIRCUITS
H. B. Boelcker, Jr., IRE Trans. Commun. Syst., vol. CS-6, no. 2, Dec. 1958, p. 47/52.

Four relatively simple, redundantly-coded, binary communication systems are considered under certain limiting conditions of signal fading. White noise is assumed to be the only source of errors. A nonredundant, synchronous teletype system is used as a standard of comparison . . . Only two forms of degradation are considered here, channel fading (flat, uniform fading over the channel bandwidth) and additive white Gaussian noise.

ERROR PROBABILITIES FOR BINARY SYMMETRIC IDEAL RECEPTION THROUGH NONSELECTIVE SLOW FADING AND NOISE
G. L. Turin, Proc. IRE, vol. 46, Sept. 1958, p. 1603/1619.

POTENTIAL NOISE SUPPRESSION UNDER CONDITIONS OF SIGNAL FADING
L. M. Fink, Radio Engng., vol. 14, no. 9, 1959, p. 1/14.

The optimum criterion is deduced for separate reception of discrete messages in the presence of noise, when the signal is subjected to Rayleigh type fading. For certain classes of system the minimum probability of error is calculated as a function of the ratio of the energy of a signal element to the specific noise power.

PULSE PHASE-CHANGE SIGNALING IN THE PRESENCE OF IONOSPHERIC MULTIPATH DISTORTION
S. G. Lutz, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 102-110.

SOME COMPUTATIONS OF ERROR RATES FOR SELECTIVELY FADING MULTIPATH CHANNELS
G. L. Turin, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 431/440.

The probability that an ideal receiver makes an error in receiving a binary transmission through a noisy, selectively fading, discrete-multipath channel can often be related to the probability that the difference of two quadratic forms in complex normal variables, in itself a quadratic form is less than a given constant. An expression for this error probability is presented and conditions are discussed under which this expression may be easily evaluated. . . .

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1960, p. 1613/1629.

THE INFORMATION CAPACITY OF SYMMETRICAL LINKS WITH VARIABLE PARAMETERS FOR AN UNLIMITED FREQUENCY BAND
L. M. Fink, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 7, 1960, p. 33/46.

. . . calculated for a given ratio of signal power to spectral density of white noise over as wide a frequency band as is convenient, provided the methods of coding are limited to discrete symmetrical codes. . . .

SIGNAL PROCESSING IN RADAR ASTRONOMY. COMMUNICATION VIA FLUCTUATING MULTIPATH MEDIA
R. Price, et al., Lincoln Lab., MIT, Lexington, 6 Oct. 1960, AD 246 782.

. . . the results are equally applicable to communication problems in which the propagation medium has significant multipath spread and fluctuation rate. A signal received from such a target or channel is a perturbed version of the transmission, which frequency and time (delay) spreads were produced by multiple random modulation superimposed by the target (or channel) on the original modulation of the transmission. Special cases of the deep fluctuating target, namely the fluctuating point target and the very slowly fluctuating deeptarget, are also considered.

ON THE DESIGN OF A HIGHLY RELIABLE HF DIGITAL COMMUNICATION SYSTEM. PROBLEMS, DESIGN PROCEDURES AND THE DESCRIPTION OF A PROPOSED DESIGN
K. Otten, National Cash Register Co., Dayton, Ohio, Rept. 3-4S, Oct. 1961, 38 p., AD 269 891.

. . . using pulse redundancy, it was concluded that statistical information on the correlation between disturbances must be known . . . From other information and by analogy, important design characteristics . . . can be qualitatively extrapolated: (1) Wide bandwidth (greater than 3 kc) to permit effective utilization of frequency diversity, (2) Interleaving of sub-bits from various information-bits to permit effective utilization of time diversity, (3) Use of short-duration pulses followed by long dead periods to provide high potential protection against multipath distortion by self-interference, and (4) Use of a demodulation technique which utilizes, rather than rejects, multipath signal contributions. However, it was also concluded that it is entirely feasible to design and build a 3 kc bandwidth system which will offer substantial performance advantages over an FSK (frequency shift keying) system.

ON OPTIMAL DIVERSITY RECEPTION
G. L. Turin, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 154/166.

. . . The ideal probability-computing M-ary receiver is derived for a fading, noisy, multi-diversity channel, in which the link fadings may be mutually correlated, as may the link noises. The results are interpreted in terms of block diagrams involving various filtering operations. Two special cases, those of very fast and very slow fading, are considered in detail.

UNIVERSAL COMBINED RADIO RELAY AND TROPO SCATTER EQUIPMENT APPENDICIES I-XIII. VOLUME II
ITT Communication Systems, Inc., Paramus, N. J., (Rept. no. C1183-TR-5), (RADC TR 60-246, vol. 2), 15 July 1961, 207 p., AD 261 093.

. . . Modulation methods for line-of-sight and beyond-the-horizon radio communication links . . .

PREDETECTION DIVERSITY COMBINING WITH SELECTIVELY FADING CHANNELS
P. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 32/42.

. . . If the instantaneous fading is not uniform over the width of the channel, the resulting channel incoherence will reduce the efficacy of the phase correlation. One way to avoid this difficulty is to divide the selectively fading channel into "flatly" fading subchannels and perform the necessary phasing and combining operations per subchannel. . . . This paper considers this question with reference to FDM-SSB binary data transmission and matched filter reception, wherein a pilot tone is used both for deriving proper phase correction and for providing the weighting necessary for maximal ratio combining. . . .

UPPER BOUND TO THE CAPACITY OF A LINEAR TIME-VARYING CHANNEL WITH ADDITIVE GAUSSIAN NOISE
G. D. Forney, Jr., Lincoln Lab., Mass. Inst. of Tech., Lexington, (Rept. no. 34G-10), (AFESD TDR 62-144), 26 Sept. 1962, 15 p., incl. illus., 10 refs., AD 287 453.

EFFECT OF PROPAGATION FADING AND ANTENNA FLUCTUATIONS ON COMMUNICATION SYSTEMS IN A JAMMING ENVIRONMENT
A. B. Glenn, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 43/60.

. . . The results are plotted for a large variety of fading conditions for both the desired and undesired signals and antenna fluctuations. . . .

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS

G. Lieberman, RCA Rev., vol. 23, no. 3, Sept. 1962, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given . . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantiles of error probability as well as the mean probability of error.

H-F PROPAGATION SIMULATION

R. Mather, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., (Rept. no RADC TDR 62-473), Nov. 1962, 21 p. incl., 6 refs., AD 288 924.

. . . to be simulated on an analog computer and compared with experimental data collected over a 3800-km path. The experimental complex consists of a transmitter site located in the Panama Canal Zone and a receiver site at Stockbridge, N.Y. Vertical ionospheric sounders are located along the transmission path and are used to measure the spatial distribution of electron density in the volume of interest. A method is described whereby this spatial distribution of electron density is programmed into the analog computer in order that the Hamiltonian equations describing ray paths may be solved. In addition to producing frequency vs. time plots for comparison with the experimental data, the simulator also gives results not easily measured in the field, such as take-off angle, angle of arrival, group time, phase time, off-path deviation, and height of reflection. . . .

M-ARY TRANSMISSIONS WITH LINEAR FILTERING ON RAYLEIGH FADING CIRCUITS

J.N. Pierce, Air Force Cambridge Research Labs., Bedford, Mass., (AFCRL 62-150), March 1962, 13 p., incl. table, 7 refs., AD 275 436.

On a nonfading circuit, arbitrarily small error rates can be achieved by using uncoded M-ary transmission with linear receiver filtering. . . . on a Rayleigh fading circuit. . . . improvement obtained in communicating binary data with M-ary transmissions is equivalent to a saving in transmitter power of less than 4.6 db. . . .

EUROPEAN-MEDITERRANEAN TROPOSPHERIC SCATTER COMMUNICATION SYSTEM PERFORMANCE SPECIFICATION IN-BAND SIGNALING EQUIPMENT

ITT Communication Systems, Inc., Paramus, N.J., Rept. no. 61, 1 April 1962, 14 p., AD 430 415.

. . . covers one type of voice frequency signalling equipment for use in the System which utilizes tone signals transmitted within the limits of the voice frequency channel.

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM

National Cash Register Co., Dayton, Ohio, Quarterly progress engineering rept. no. 3, 1 Dec. 1961 - 28 Feb. 1962, (rept. no. 3-3Q, 15 April 1962, 1 v., AD 275 058.

. . . provides highly reliable operation in the presence of multipath propagation and doppler shift. . . .

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM

National Cash Register Co., Dayton Ohio, Quarterly progress engineering rept. no. 4, 1 March - 31 May 1962, (Rept. no. 3-4Q), 15 July 1962, 1v., incl. illus., tables, AD 282 698.

. . . development of special modulation, demodulation digital control and coding equipment . . .

INVESTIGATION OF ACTIVE DOPPLER VELOCITY SENSOR

Raytheon Co., Sudbury, Mass., Final engineering rept. June 1960-Jan. 1962, (Rept. BR-1516), (ASD TDR 62-23), 12 Jan. 1963, 64 p., AD 269 717.

. . . The following doppler sensor areas were given particular consideration: (1) modulation techniques . . .

THE EFFECT OF FREQUENCY SELECTIVE FADING ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS

P.A. Bello, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 170/186.

The presence of frequency-selective fading in a communication channel limits the maximum data rate capability of conventional communication systems. . . . receivers employing post-detection diversity combining. . . . it is assumed that the fading is slow enough so that over a few bits at least the channel transfer function remains constant. In addition, it is assumed that the amplitude and phase fluctuations on a received carrier have the same statistical character as those of narrow-band Gaussian noise. . . .

HC-273 MODULATOR/DEMODULATOR FOR HF RADIO LINKS

E. Enriquez, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 92/101.

. . . in spite of greatly favorable s/n ratio, pulse smear . . . requires the use of relatively long pulses . . . this implies low signaling rates on a per-subchannel basis. . . . four-phase

modulation of the subcarrier provides the means to attain higher than normal bit rates . . .

ON THE SELECTION OF AN ORTHOGONAL SIGNAL ENSEMBLE FOR THE TRANSMISSION OF BINARY DATA
L. R. Halsted, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 66/74.

. . . considers binary data transmission systems in which signal interference may be caused by a combination of signal blanking and fading, additive impulse noise, and additive nonwhite gaussian noise. For each disturbance the paper shows how the error rate can be improved by the suitable choice of a signal ensemble, and it discusses the choice of a good signal ensemble for a given combination of these disturbances. The systems are assumed to use ideal linear correlators for signal detection and to have minimum bandwidth for transmitting the data in binary form. The paper also illustrates the role of n-by-n orthogonal matrices in the choice of a signal ensemble to transmit a block of n information bits. . . .

A RAKE SYSTEM FOR LUNAR RELAY COMMUNICATIONS
S. Kasowski, IEEE Intern Conv. Rec., Pt. 8, vol. 11, March 1963, p. 197/214, 15 refs.,

. . . The transmission technique investigated is a multilevel, matched filter type using wideband, binary, pseudorandom sequences. It is studied specifically for transmission of digitalized information on a moon bounce link, i.e., for communication between two distant ground stations using the moon as a reflective scatterer relay.

THE NOISE IMMUNITY OF OPTIMUM HIGHER BINARY CODES
N. P. Khvorostenko, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1963, p. 1/8.

Expressions characterizing the noise immunity of Wagner's correction scheme for FSK and PSK systems are obtained under the following conditions: fluctuation noise is present, the amplitudes of the received signals are Rayleigh distributed, and no correlation exists between either fading or noise at instants of sampling different positions of a code word.

It is shown that Wagner's correction scheme is optimum in the sense of minimizing the mean probability of incorrect detection of a code word, and is sufficiently close to optimum in the sense of minimizing the mean probability of incorrect detection of each information symbol of this code word. . . .

A TECHNIQUE FOR IMPROVING THE TRANSMISSION RELIABILITY OF A FADING CHANNEL
S. Kitces, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 154/162.

. . . In a channel where the duration of a fade is much longer than that of a code word, the common low-order error-correcting codes, although easily implemented, do not materially increase transmission reliability.

A technique is proposed which enables one to use simple codes to combat fading by transmitting the individual bits of a code word, not in succession, but separated in time by the length of expected fades. This transforms a channel with a correlated error pattern into one with random errors across the code words. The gaps between the bits of the code word are taken up by bits from other code words arranged in a similar fashion. . . .

SIMULATION OF A FADING MEDIUM
R. Krulee, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 233/240.

Despite the extensive use of HF and scatter techniques on long-haul circuits, surprisingly little is yet understood about the actual performance of such circuits during the deep fading situations which limit the performance . . . In this paper a model that is consistent with observed experimental data is developed for a fading circuit. The instrumentation necessary to allow laboratory simulation and testing under exactly those conditions which are most critical for satisfactory system design is discussed. . . .

APPROXIMATE DETERMINATION OF THE DISTRIBUTION FUNCTION OF FADE LENGTHS BELOW THRESHOLD LEVEL FOR THE ENVELOPE OF THE SUM OF A DETERMINISTIC SIGNAL AND GAUSSIAN STATIONARY NOISE
B. R. Levin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 20/26.

. . . compared with known experimental data as well as with Rice's approximation method. . . .

ADAPTIVE DIGITAL COMMUNICATION FOR A SLOWLY VARYING CHANNEL
G. Lieberman, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 44/51, 26 refs.

. . . Theoretical gains achievable with adaptation are calculated in terms of reductions in required mean transmitter energy as a function of a signal-fading parameter for different probabilities of unsatisfactory operation.

A NOTE ON THE COHERENT MULTICHANNEL DETECTOR
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 180/184.

An integral solution is presented which has application to the singly noncenteral F-distribution with 2 deg. of freedom for the chi-squared

variate and 1 deg. for the denominator; in terms of detection theory the integral specifies the error rate for a coherent correlation receiver which is connected to a channel that may assume one of several statistical forms.

PERFORMANCE ANALYSIS FOR THE COHERENT MULTIRECEIVER IN SPECULAR AND RANDOM MULTICHANNELS
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 154/156.

(No Title)
H. R. Machin (editor), Central Radio Propagation Lab., National Bureau of Standards, Boulder, Colo., Quarterly progress rept. no. 7, Jan-March 1963, NBS Rept. no. 7694, March 1963, 116 p., AD 419 303.

. . . In the modulation research program an analysis has been made of ionospheric-scatter transmissions using a voice signal to frequency-modulate the transmitter with maximum deviations of 1, 3, 5, and 15 kc/s. . . . an atmospheric noise tape-recording system has been developed. . . .

OPTIMUM PULSE TRANSMISSIONS FOR MULTIPATH CHANNELS
J. G. Proakis, Lincoln Lab. Mass. Inst. of Tech., Lexington, (Rept. 64G-3; AD 416 639), 16 Aug. 1963, 40 p., refs., N64-17454.

. . . performance of an incoherent M-ary communication system . . . computed under very restrictive conditions on the channel behavior, namely, that the received signal consists of resolvable, independent Rayleigh fading paths, each of which has been corrupted additively by independent gaussian noise . . . generalizations of results obtained earlier. From these expressions the optimum time duration for pulse transmissions is computed for two channels-the orbital dipole channel and the moon.

CANCELLATION OF DOPPLER FREQUENCY SHIFT
R. M. Waetjen, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 70, March 1963, 21 p., AD 404 428.

A circuit is described which is capable of cancelling first-order Doppler frequency shifts.

Section 1.86

1.860: Comparison of Modulation Systems under Special Equipment Conditions

Included: Comparison of modulation systems under certain power limitations; Peak power limited channels; Average power limited channels; Comparison of modulation systems for coherent detector operation.

Not Included: Theory of coherent detectors (2); Theory of envelope detectors (2).

Cross References: Channel models (Sect. 1.13).

Principal Publications:

COMPARISON OF REQUIRED RADIO FREQUENCY POWER IN DIFFERENT METHODS OF MULTIPLEXING AND MODULATION
Nicholas, Conv. Rec. IRE, May 1954, p. 59/65.

COMPARISON OF COHERENT AND PHASE-COMPARISON DETECTION OF A FOUR-PHASE DIGITAL SIGNAL (Correspondence)
C. R. Cahn, Proc. IRE, vol. 47, Sept. 1959, p. 1662.

. . . considered by Lawton in a previous correspondence.

MAXIMUM INTERFERENCE RESISTANCE OF SYSTEMS WITH DISCRETE SIGNALS
N. L. Teplov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 4, 1960, p. 44/60.

. . . in the presence of coherent and non-coherent reception. . . . takes into account the correlation of instantaneous value of interference. The "limiting excesses of the signal above the interference" correspond to maximum interference resistance. . . Functions are formulated for an ideal receiver which will achieve maximum interference resistance. Use is made of the simplest method of analysis, namely signal and interference amplitude envelopes (skirting). . . .

POWER-BANDWIDTH TRADE-OFFS FOR FEEDBACK FM SYSTEMS: A COMPARISON WITH PULSE-CODE MODULATION
E. Bedrosian, RAND Corp., Santa Monica, Calif., (Rept. RM-2787), Oct. 1961, 59 p., AD 264 781.

. . . For a given quality of service, power can be traded against bandwidth depending on the amount of feedback used. Large amounts of feedback in a typical system can reduce the amount of transmitter power required by as much as 8 db while roughly doubling the radio channel occupied, compared with a conventional FM system designed to minimize transmitter power. Assuming an optimum detection process, a comparable PCM system requires about 3 db less power than a conventional toll-quality FM system but about 5 db more power than a feedback FM system using 35 to 40 db of feedback.

ANALYSIS OF ANGLE MODULATION COMMUNICATIONS SYSTEMS

M. F. Easterling, et al., JPL Res. Summary, vol. 1, no. 36-10, June/July 1961, p. 30/36.

. . . the receiving system utilizes only phase-locked demodulators. . . . The consideration of the FM phase-locked demodulator is of interest because of recent work. . . on FM discriminators with negative feedback.

COHERENT SYNCHRONOUS SAMPLED DATA TELEMETRY SYSTEMS

W. V. Rusch, et al., JPL Res. Summary, no. 36-8, Feb./March 1961, p. 41/51.

. . . certain types of data sources are of of a sampled nature; i. e., commutators are employed which sample a given source periodically. Sampled data signals also afford an inherent degree of synchronization which can be used advantageously in a communication system. . . . For the evaluation and comparison of various modulation and detection systems, a generic performance criterion must first be stipulated. One of the simplest to measure and to calculate is a mean-square error criterion, which will be discussed in the next section. On this basis, a wide class of coherent synchronous communications systems will then be analyzed. . . . Conclusions. . . PAM appears to be better than PDM and PSK by a factor of three among the modulation methods which may be demodulated by linear synchronous detection, only because the average power is the criterion. If a peak power criterion were used, the three systems would behave equally. . . .

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE—A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS

E. Arthurs, et al., IRE Transactions on Communications Systems, vol. CS-10, Dec. 1962, p. 336/372, 18 refs., A63-15047.

. . . to derive the optimum detector for each of the basic data transmission systems: (1) m-level phase-shift-keyed, (2) m-level amplitude-shift-keyed, and (3) m-level frequency-shift-keyed. Corresponding probability of error curves are derived, compared, and discussed in detail.

ERROR RATES IN COHERENT COMMUNICATION SYSTEMS

A. V. Balakrishnan, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 86/89.

. . . In coherent PCM communication systems where the noise is additive and Gaussian (such as in space communication systems) two classes of nonredundant coding are of special interest. One is Regular Simplex Coding which yields the lowest possible error rate for fixed SNR. The other is Bi-orthogonal Coding because of its many desirable features from the practical point of view. . . .

THEORY OF COHERENT SYSTEMS

W. M. Brown, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 187/196.

A circuit theory model is derived for coherent radar, communication, sonar and antenna systems. The model involves linear time invariant operators and hence can be thought of as cascaded filters. The model provides insight for such systems not previously available, and it provides a unified approach to the analysis of all the above systems. . . . emphasis on the range channel of coherent radars with particular attention to pulse compression radars. Performance limitations are imposed by various random phenomena; specifically, phase errors which take into account deviations from perfect coherence are included in the analysis.

COHERENT FDM/FM TELEPHONE COMMUNICATION

J. A. Develet, Jr., Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1957/1966.

. . . telephone communication as applied to a satellite repeater system. Particular emphasis is placed on a method of coherent reception. . . new to the field of common carrier telephony. . . . for the class of signals utilized in common carrier telephony, an attempt is made to place on a quantitative footing the design of FDM/FM satellite communication systems. The interrelation among such quantities as sensitivity, bandwidth occupancy, and channel quality is presented for a simply realized second-order receiving system. In addition, the maximum sensitivity achievable with the optimum receiving system is shown. . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART I. INFORMATION EFFICIENCY OF BINARY COMMUNICATION SYSTEMS

J. C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind. Tech. rept. on Improved Information Transfer Efficiency of Wideband Systems, (ASD TDR 62-611, pt. 1), 121 p. July 1962, incl. illus., tables, 18 refs., AD 284 450.

. . . A new criterion called information efficiency is defined. . . Performance curves showing information efficiency and probability of error as functions of S/N are given. A similar analysis is given for a group of matched filter systems which includes both coherent and non-coherent matched filter detection of amplitude and frequency shift keyed signals.

ERROR PROBABILITIES FOR COHERENT MULTICHANNEL RECEPTION THROUGH

RICIAN FADING
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 159/165.

. . . On reception the observed data is assumed to be processed by an a-posteriori probability computing coherent receiver. . . .

OPTIMUM COHERENT DEMODULATION OF CONTINUOUS MODULATION SYSTEMS
A. J. Viterbi, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 50/54.

OPTIMUM COHERENT DEMODULATION FOR CONTINUOUS MODULATION SYSTEMS
A. J. Viterbi, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 498/508.

. . . Coherent demodulation refers to the recovery of the information signal by operating upon the noise-corrupted received signal with a replica of the carrier signal.

This principle applies simply to amplitude modulation wherein the information signal is multiplied by the carrier signal. Demodulation can be achieved by multiplying the received signal by a replica of the carrier signal.

CLASSIFICATION AND EVALUATION OF COHERENT SYNCHRONOUS SAMPLED-DATA TELEMETRY SYSTEMS
A. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 1, March 1962, p. 13/23.

. . . various types of continuous wave and pulse modulation. . . perturbed by white Gaussian noise. Optimal coherent synchronous detection schemes for all the different modulation methods are shown to belong to one of two general classes: linear synchronous detection and correlation detection. The figures of merit, mean-square signal-to-error ratio and bandwidth occupancy, are determined for each system and compared.

FEHLER WAHRSCHEINLICHKEIT BINARER UBERTRAGUNGEN BEI MEHRFACH-EMPFANG UND BEI FREQUENZSELEKTIVEM SCHWUND (Error Probability of Binary Transmission Systems with Diversity Reception Under Selective Fading Conditions) (In German)
P. Besslich, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 271/277.

. . . Although the error probability of non-coherent transmission methods is reduced more by diversity reception than in the case of coherent methods, the coherent systems remain decidedly superior in diversity reception. . . .

COHERENT AND NON-COHERENT DEMODULATION OF ENVELOPE-MODULATED RADIO SIGNALS
P. V. Indiresan, et al., J. Brit. Instn. Radio Engrs., vol. 25, no. 1, Jan. 1963, p. 65/71.

The ordinary "linear detector" and the coherent demodulator are briefly discussed as the two extreme cases of demodulators for envelope-modulated signals, since in the former the rectifier (or modulator) is switched by the complete input signal, while in the latter a pure local reference tone is used. The synchrodyne and enhanced-carrier systems are regarded as intermediate cases in which the switching is effected by an impure carrier derived from the incoming signal. . . .

NULL-ZONE ENVELOPE DETECTION IN BINARY SYSTEMS
J. J. Metzner, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 219/227, 12 refs.

. . . The effects of applying the null-zone decision mechanism to two types of envelope-detection systems are investigated, and comparisons are made with previous results for synchronous-detection systems. It is demonstrated conclusively that, just as for the synchronous system, null-zone reception offers a means of improving the information rate of a uni-directional system.

ERROR PROBABILITIES FOR SOME GENERAL CLASSES OF NON-ORTHOGONAL M-ARY SIGNALS UNDER PHASE-COHERENT RECEPTION
A. H. Nuttall, Litton Systems Inc., Waltham, Mass., Rept. no. TR 63 7 BF, 1 Sept. 1963, 16 p., AD 419 991.

PERFORMANCE OF COHERENT DETECTION SYSTEMS USING DECISION DIRECTED CHANNEL MEASUREMENT
J. G. Proakis, et al., Lincoln Lab., Mass. Inst. of Tech., Rept. no. 64G1, AFESD TDR 63 80, 27 June 1963, AD 409 819.

A NOTE ON POWER REQUIREMENTS FOR DIGITALIZED VOICE TRANSMISSION
B. Reiffen, Lincoln Lab., Mass. Inst. of Tech., Lexington, AFESD TDR 63 60, 6 May 1963, 7 p., AD 405 622.

A digital communication system is analyzed under the following assumptions: (1) equal energy orthogonal signals are used; (2) the channel adds white gaussian noise; and (3) the receiver uses band-pass correlation followed by envelope detection.

UNIFIED ANALYSIS OF CERTAIN COHERENT AND NONCOHERENT BINARY COMMUNICATIONS SYSTEMS
S. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 43/51.

. . . including all possible conditions of nonorthogonality of signal, and correlations in the noise processes. These forms include frequency-shift keying with noncoherent detection, generalized to all noncoherent

detection systems utilizing two basic waveforms, and phase-shift keying with a noisy reference signal, generalized to all coherent detection systems utilizing a single basic waveform.

The unified result is achieved by exploiting a fundamental relationship between noncoherent and coherent operation. Also, some useful and not widely-known mathematical techniques involving the Q function are presented and utilized in the derivations. . . .

OPTIMUM PULSE SHAPES FOR TRANSMITTERS WHICH ARE BOTH PEAK POWER LIMITED AND AVERAGE POWER LIMITED
D. W. Tufts, et al., Cruft Lab., Harvard U., Cambridge, Mass., TR428, 12 Nov. 1963, 16 p., AD 434 875.

. . . an explicity formula is derived for the input waveform p(t) which maximizes the output waveform amplitude at a prescribed time instant. The problem and the results are closely related to the matched filter problem of radar theory and the bang-bang problem of optimal control theory. . . .

Related Publications:

DETECTION OF ASYMMETRIC SIDEBAND SIGNALS IN THE PRESENCE OF NOISE
T. Murakami, et al., RCA Rev., vol. 19, no. 3, Sept. 1958, p. 388/417, 19 refs.

The first part of this paper analyzes three methods of detection of signals contaminated by fluctuation noise:

(1) Linear Envelope Detectors
(2) Product Detectors
(3) Exalted Carrier Detectors

. . .

INCREASING THE RELIABILITY OF DIGITAL COMMUNICATIONS SYSTEMS UNDER POOR SIGNAL CONDITIONS
N. Levine, et al., Air Force Cambridge Research Center, Bedford, Mass., (Rept. no. AFCRC TR 59 158), June 1959, 31 p., AD 228 773.

Synchronous communication using phase modulation . . . Amplitude modulation using an autocorrelation receiver . . .

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

. . . It is shown that product or synchronous detectors can eliminate the effects of cross modulation. . . . if two signals are present at the detector, a sudden change in one of them causes a spurious change in the amplitude and phase of the other. This type of distortion will be called transient cross talk distortion to differentiate it from the normal cross talk between two or more steady carriers. A later section shows that the transient cross talk distortion can be many times the steady-state cross talk. . . .

FM RECEPTION UNDER CONDITIONS OF STRONG INTERFERENCE
J. van Slooten, Philips Technical Review, vol. 22, no. 11, July 1961, p. 352/360.

AN AM VESTIGIAL SIDEBAND DATA TRANSMISSION SET USING SYNCHRONOUS DETECTION FOR SERIAL TRANSMISSION UP TO 3,000 BITS PER SECOND
F. K. Becker, et al., Commun. Electronics, vol. 81, no. 60, May 1962, p. 97/101.

. . . Carrier recovery and synchronous detection are performed in the receiver. The system is asynchronous and will operate at any bit speed up to its maximum. Satisfactory operation has been achieved at 2,000 bits per second over the switched telephone network, and at 3,000 bits per second over equalized voice band circuits. . . . appears to be economically advantageous when compared with other systems of the same speed capability. . . .

DEMODULATION AND DETECTION EFFECIENCY OF AN UNCODED, COHERENT, BIORTHOGONAL DIGITAL CHANNEL IN GAUSSIAN NOISE
G. L. Fultz, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 204/210.

In uncoded, coherent subcarrier communication systems, data is usually demodulated from the subcarrier with a locally generated reference and then detecting the data with a matched filter . . . From the results of the . . . discussion, the data demodulation and detection efficiency of the Mariner 2 demodulator was questioned and subsequently analyzed. The results of the investigation are presented . . .

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Rev., vol. 23, no. 3, Sept. 1962, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given. . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantiles of error probability as well as the mean probability of error.

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 19, 1963, 51 p., 9 refs., N63-23350.

. . . optimum way to divide the available energy between the channel measurement and information transfer functions. Specifically considered is a binary symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise. . . Under a wide variety of conditions, the best strategy is to devote all the available power to modulation, and to obtain the synchronizing information by performing some operation on the incoming signal which removes its dependence on the data.

ERROR PROBABILITY FOR A PARTIALLY COHERENT BINARY COMMUNICATION SYSTEM

A. J. Viterbi, JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 171.

. . . The carrier phase, however, is never known exactly. Typically, it is obtained from a phase-locked loop which is tracking an auxiliary carrier or subcarrier. The error in the phase estimate is a random variable . . . expression is exact for a first-order loop and is a close approximation for higher order loops . . .

DIVISION 1.9
WIDEBAND AND MULTIPLEX MODULATION METHODS

Space communications systems require support in two additional areas of modulation techniques, which so far have not been considered in their entirety in this bibliography.

One of these areas is known under a variety of names, such as wideband modulation methods, spread spectrum modulation systems, pulse compression encoding systems or pseudo noise communication methods. These names designate slightly different techniques, only some of which have to date found application in space. However, electronic techniques which offer any noise reduction advantage for a given transmitter power and information transmission rate will be under very close scrutiny by space communications engineers in the near future. We attempted to assemble all references to this speciality in subdivision 1.920, though many of them are also included under digital modulation techniques. The cross references will make any such interconnections clear.

The second area of particular concern to space communications designers is multiplex modulation methods. Multiplexing as a form of information encoding will be discussed in volume 2 of this series. However we believe that the problems of modulating a carrier at two or more modulation levels should be a part of this volume on modulation methods. The reader will therefore find in section 1.93 multiplex modulation methods which use FM as the last modulation level and any other modulation method on the subcarrier level. Section 1.94 contains references to such multiple modulation methods with phase modulation as the main carrier modulation. Section 1.95 is similarly devoted to AM for modulating the composite multiplex signal on the transmission carrier.

Section 1.90
General Section on Multiplex Modulation Methods

1.902: Comparison of Multiplex Modulation Methods

Included: Comparison of modulation methods for radio relay links; Comparison of multiplex modulation methods for telemetry.

Not Included: Fundamentals of multiplex methods (2); Diversity reception techniques (2); Practical design of radio relay links; Telemetering system design.

Cross References: Comparison of simplex modulation methods (Div. 1.8).

Principal Publications:

THEORETICAL ANALYSIS OF VARIOUS SYSTEMS OF MULTIPLEX TRANSMISSION
Landon, RCA Rev., vol. 9, June 1948, p. 287/351; vol. 9, Sept. 1948, p. 433/482.

COMPARISON OF REQUIRED RADIO FREQUENCY POWER IN DIFFERENT METHODS OF MULTIPLEXING AND MODULATION
Nicholas, IRE Conv. Rec., vol. 5, 1954, p. 59/65.

COMPARISON OF PSK VS FSK AND PSK-AM BINARY-CODED TRANSMISSION SYSTEMS
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 87/100.

. . . in the presence of additive white Gaussian noise . . . based on the relative probablity of error, operating range, required system bandwidth, and system frequency instability. The important subjects of improvement thresholds, some aspects of statistical decision theory, and channel characterization are briefly discussed.

(Correction)
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 272.

. . . "Comparison of PSK vs FSK and PSK-AM vs FSK-AM Binary-coded Transmission Systems," which appeared on pages 87-100 of the June 1960, issue.

THE CASE OF FM-AM VERSUS FM-FM TELEMETRY
L. L. Rauch, Proc. Nat. Aeron. Electronics Conf., vol. 8, May 1960, p. 450/452.

DESIGN STUDY OF AN INTEGRATED AIRBORNE TELEMETRY SYSTEM
Telemetering Corp. of America, Sepulveda, Calif., Dec. 1959, AD 235 349.

. . . analysis of system performance . . . (1) FM/FM system . . . most applicable to a short term development program, (2) PCM/FM . . . offer . . . theoretical advantages, (3) PDM, PPM, do not offer advantages over FM/-FM or PCM/FM . . . (See also AD 235 661; AD 232 133, AD 233 527).

BINARY ERROR RATES IN FADING FDM-FM COMMUNICATIONS
D. E. Johansen, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 206/214.

. . . in a fading environment FDM-FM . . . it is shown that an FDM-FM data system does not perform as well as does the equivalent FDM-SSB system by an amount in the order of 10 db.

INTERFERENCE-IMMUNITY OF A COMMUNICATION SYSTEM WITH TONAL MANIPULATION DURING IDEAL RECEPTION
P. A. Konstantinov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 11, 1961, p. 16/24.

. . ."manipulation" for completely known signals with two different values. Optimal receiver circuits are determined. The criterion of an ideal observer and the apparatus of detection theory are used for the analysis. . . . 2. FM-AM Type Communication System. In such a communication system, frequency manipulation of the subcarrier oscillations and amplitude modulation of the carrier-frequency oscillations are accomplished . . . 3. PM-AM Type Communication System . . . 4. FM-FM Type Communication System . . . 5. PM-FM Type Communication System . . .

SELECTION OF MODULATION TECHNIQUE FOR SPACE-VEHICLE TELEMETRY
E. J. Baghdady, Rec. Nat. Symp. Space Electronics, Telemetry, Oct. 1962.

. . . The case of FM/AM vs FM/FM telemetry, and the case of negatively correlated (e. g., phase-reversal keying) vs uncorrelated (e. g., frequency-shift keying) binary signaling. . . .

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
D. G. Childers, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 267/283.

. . . In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM telemetry systems and PACM-FM. . . .

POTENTIAL AND REAL NOISE IMMUNITY OF A MULTICHANNEL RADIOTELEMETERING SYSTEM OF PAM-FM TYPE IN THE PRESENCE OF WEAK FLUCTUATION NOISE
A. F. Fomin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 8, Aug. 1962, p. 8/12.

The article determines the potential noise immunity of a radiotelemetering system of PAM-FM-FM type. It compares the potential noise immunity of PAM-FM-FM, PAM-FM and FM-FM systems. . . .

A CRITERION FOR THE STATISTICAL COMPARISON OF COMMUNICATION SYSTEMS
T. L. Grettenberg, Lockheed Aircraft Corp., Sunnyvale, Calif., (Rept. no. 6-90-62-22), Feb. 1962, 153 p., incl. illus., 25 refs., AD 275 467.

The methods of comparing statistical experiments are investigated as possible criteria for comparing communication systems. It is found that one method of comparison (the divergence criterion) is implied by each of the comparison criteria considered. . . . may be used to select an optimum communication system from a class of communication systems to be compared. This procedure is illustrated in four signal-selection problems.

EXPERIMENTAL OPTIMIZATION AND EVALUATION OF TELEMETRY SYSTEMS
W. F. Link, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 239/246.

. . . A careful laboratory program to experimentally optimize and evaluate four telemetry systems in wide use (FM-FM, PAM-FM, PDM-FM and PCM-FM) has been concluded . . . Each of the four systems was implemented in the laboratory and the system under test was modulated by random signal sources typifying actual data. . . .

ATTAINABLE ERROR PROBABILITIES IN DEMODULATION OF RANDOM BINARY PCM/FM WAVEFORMS
E. F. Smith, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p, 290/297.

. . . Comparison is also made between theoretically attainable bit-error probabilities for PCM/AM, PCM/PSK, conventional PCM/-FM (i. e. frequency modulating a single oscillator) and "switched PCM/FM" (i. e. switching between two oscillators of different frequencies). . . .

Related Publications:

PRACTICAL CONSIDERATIONS IN THE DESIGN OF MINIMUM BANDWIDTH DIGITAL FREQUENCY MODULATION SYSTEMS USING GAUSSIAN FILTERING
W. L. Glomb, IRE Trans. Commun. Syst., vol. CS-7, no. 4, Dec. 1959, p. 284/290.

. . . The relationship between peak deviation and system threshold is explored and an optimum deviation established. The location of the Gaussian filters in the system is discussed . . . These results have been applied to a 2000-mc communication equipment.

. . . The system under discussion will be assumed to be a PTM-FM or a PCM-FM system.

REQUIRED SIGNAL-TO-NOISE RATIOS, RF SIGNAL POWER, AND BANDWIDTH FOR MULTICHANNEL RADIO COMMUNICATIONS SYSTEMS
E. F. Florman, et al., National Bureau of Standards, Boulder, Colo., (Technical note. no. 100), July 1960, ref., Jan. 1962, 182 p., incl. illus., tables, 52 refs., AD 288 285.

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART II. BINARY COMMUNICATIONS SYSTEMS USING WIDEBAND SIGNALS
J. C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind., Final tech. rept. June 1961 - June 1962 on improved Information Transfer Efficiency of Wideband Systems., July 1962, 151 p., incl. illus., 16 refs., (ASD TDR 62-611, pt. 2), AD 284 451.

Contents: The analysis of binary systems (using a signal-space concept) Linear receivers The application of linear receivers Nonlinear receivers Applications of nonlinear receivers Time compression methods Adaptive receivers.

TELEMETRY CONSIDERATIONS FOR LARGE SPACE VEHICLES
J. E. Rorex, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 135/138.

. . . Some significant characteristics of specific telemetry multiplexing and modulation techniques are pointed out. The contributions to real-time data requirements such as vehicle prelaunch monitoring and checkout that can be made by telemetry techniques are described. . . .

(No Title)
J. J. Tsimbidis, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 3, 11 March - 10 June 1962, 10 June 1962, lv, incl. illus. tables, AD 282 947.

Results obtained in back-to-back white noise testing of the various modems . . . Problems of crosstalk and transmission levels encountered in the AN/TCC-7 white noise tests are . . . discussed. . . . The amplitude and delay characteristics of the AN/VRC-12 radio set are presented in graphical form. . . . Noise quieting curves of the AN/TRC-24 radio set are discussed and the performance of the various modems over the radio set operating near and on the FM threshold is reported. The results of field cable testing of the modems are presented in tabulated form with a more detailed discussion of hits and drop outs in this transmission link.

PAM, PDM, AND PCM TECHNIQUES IN APPLICATION TO DIGITAL TELEMETRY ON VOICE BANDWIDTH FACILITIES
C. Yanis, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 139/151.

. . . The requirements of these telemetry modes in terms of link conditions, tone equipment, and terminal equipment is examined. Conclusions are reached regarding adapatability to high speed, multiplexing, and hardware requirements.

Section 1.92

1.920: Wideband Modulation Methods

Included: Pulse compression transmission systems; Swept frequency modulation techniques; Pulse stretching techniques; Linear FM radar pulse compression techniques; Spread spectrum transmission systems; Data systems with high time-bandwidth products; Bandwidth expanding modulation methods; Systems using PN sequences as wideband signals; Chirped transmission signals; FSM (=frequency slope modulation) wide band signals; Frequency spreading techniques.

Not Included: Detection and decision theory (2); Multiple access systems (2); RADA = random access discrete address systems (2); PN codes (2).

Cross References: Spread spectrum waveforms (1.316); Digital sequences as data transmissions waveforms (1.314); Matched filter extractors (1.372); Correlation receivers for data transmissions (1.373); Pulse slope modulation (1.482).

Principal Publications:

A COMPARISION BETWEEN PULSE AND FREQUENCY-MODULATION ECHO-RANGING SYSTEMS
L. Kay, J. Brit. Instn. Radio Engrs., vol. 19, Feb. 1959, p. 105/117.

A general theory of the operation of frequency-modulation systems has been developed which can be applied to either Asdic or Radar, and the information obtained from such a system is compared with that from a conventional pulse system and a multipulse system.

PULSE COMPRESSION - KEY TO MORE EFFICIENT RADAR TRANSMISSION
C. E. Cook, Proc. IRE, vol. 48, no. 3, March 1960, p. 310/316.

THE CORRELATION FUNCTIONS AND ENERGY SPECTRA OF FM RADAR SIGNALS
S. E. Fal'kovich, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 16/24.

. . . assumption that the duration T of the signal is the same as the duration of . . . the modulation period . . . it is supposed that the signal can be regarded as a frequency-modulated oscillation . . .

THE THEORY AND DESIGN OF CHIRP RADARS
J. R. Klauder, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 745/808.

. . . A long high-duty factor transmitted pulse, with suitable modulation (linear frequency modulation in the case of Chirp), which covers a frequency interval many times the inherent bandwidth of the envelope, is employed. . . .

WIDE-BAND CARRIER COMMUNICATIONS. VOL I. AMPLITUDE MODULATION
J. J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., (Rept. no. LMSD-704011), vol. 1, Oct. 1960, lv., AD 253 281.

. . . Wide bandwidth carriers are defined as time functions with unmodulated bandwidths much wider than that of the intelligence to be transmitted. Both predictable and random carriers are considered in some detail. . . .

WIDE-BAND CARRIER COMMUNICATIONS. VOLUME II. FREQUENCY MODULATION OF RANDOM CARRIERS
J. J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., 1 Jan.- 18 March 1960, (Rept. no. LMSD-704016, vol. 2), Oct. 1960, lv., AD 253 282.

. . . transmitting a frequency band of random energy in two forms; a reference carrier is transmitted on one frequency band, and a frequency-shift modulated version of the reference carrier is transmitted on a second band not overlapping the first. . . .

CORRELATIONAL AND SPECTRAL TECHNIQUES IN MODERN COMMUNICATION AND CONTROL SYSTEMS
N. D. Diamantides, Elect. Engng., vol. 80, no. 11, Nov. 1961, p. 860/865.

. . . the general and/or special purpose computer is an indispensable tool. . . .

CORRELATION RADAR USING PSEUDO-RANDOM MODULATION
W. Fishbein, et al., IRE Internat. Conv. Rec., vol. 5, March 1961, p. 259/277.

. . . operating with continuous transmission and provides unambiguous range and velocity information. The range and velocity information is obtained by phase modulating the transmitter with a pseudo-random waveform and correlating returned echoes with a delayed replica of the modulating signal . . . a radar operating at a frequency of 10,000 MC and having an 18" diameter antenna would require only 100 microwatts of transmitter power in order to detect a one square meter target at a range of 1000 meters.

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P. H. Haas, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, (Rept. no. GE/EE/61-6), Aug. 1961, 68 p., AD 270 272.

Master's thesis . . . A survey . . . as applicable to the statistical analysis of communications is presented . . . Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

WIDE-BAND CARRIER COMMUNICATIONS. VOLUME III. BINARY COMMUNICATION BY MEANS OF NOISE SAMPLES
R. L. Luedtke, et al., Lockheed Aircraft Corp., Sunnyvale, Calif., (Rept. no. LMSD-704048, vol. 3), Nov. 1961, lv., AD 253 283.

A novel and easily instrumented technique of binary communications is described . . . A short elaboration is given on the low detectability of the signal by an unfriendly observer while operating at low signal-to-noise ratios . . .

CHANNEL CAPACITY AND INTEGRATION TIME IN TELEMETRY
E. C. Posner, et al., JPL Res. Summary, no. 36-11, Aug. - Sept. 1961, p. 27/29.

. . . Suppose it is desired to transmit information over this channel by sending binary digits of equal length t . . . The length t is chosen so as to maximize the channel capacity in bits per second of the resulting binary symmetric channel. . . . if near error-free transmission is desired, the capabilities of usable codes must be taken into account. . . . t should be chosen . . . so as to maximize the near error-free transmission rate obtainable with usable codes. This is a complicated optimization problem.

POWER SPECTRA OF SIGNALS MODULATED BY RANDOM AND PSEUDORANDOM SEQUENCES
R. C. Titsworth, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, (Rept. 32-140), Oct. 1961, 45 p., AD 268 119.

. . . concerned with the spectral distribution of signals coherently modulated by discrete random and randomlike sequences which change state only at integral multiples of some basic time division t sub 0. In general, a sequence may modulate signals randomly or in some fixed deterministic fashion. Furthermore, deterministic processes may be constructed to possess certain randomlike qualities. Special attention is directed to Markov chains and linear pseudorandom sequences; the signals selected by the modulation process are not restricted to any one class, and examples are given for sinusoids and square waves. Specifically, the effects of carrier-signal waveform and type of sequence upon the over-all power spectrum are considered. In the case of sinusoidal modulation, the effect of phase shift is investigated.

SPECTRUM CONSERVATION THROUGH FREQUENCY SPREADING
H. Wamboldt, Proc. Nat. Aerospace Electronics, Conf., vol. 9, May 1961, p. 319/324.

In general there are three possible ways (other than FM) in which r-f energy may be spread out. One . . . whereby . . . sidebands . . . spread out over a relatively broad band . . . Another method . . . by so-called correlation techniques. The other, which will be discussed more fully hereafter, will be referred to as frequency-hopping . . .

A STUDY IN DEMODULATION TECHNIQUES
J.A. Webb, Proc. Nat. Telemetering Conf., May 1961, p. 10-45/10-58.

. . . to explore spread-spectrum techniques, and to discuss the use of these techniques for secure communication purposes. Receiver characteristics and lock-on criteria for signal recovery are also discussed. . . .

THE EFFECT OF FREQUENCY-COMPRESSIVE FEEDBACK UPON ADDITIVE DISTURBANCES IN WIDEBAND-FM SYSTEMS
E.J. Baghdady, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 110.

. . . theoretical analysis . . . of particular relevance to communications via earth satellites are the various aspects of the performance in the presence of random-fluctuation noise. It is shown, for example, that the performance in the presence of noise of frequency-compressive feedback loop depends primarily upon the convolution of the envelope of the impulse response of the IF filter and the impulse response of the low-pass filter within the loop. . . .

SYSTEM PERFORMANCE IN THE PRESENCE OF STOCHASTIC DELAYS
W.M. Brown, et al., IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. 206/214.

. . . With the advent of sophisticated data-processing systems using high time bandwidth products, it becomes necessary to consider the effects of stochastic delays. Depending on the particular application, the mathematical process to be considered is either a stochastic process of a stochastic process or a function of a stochastic process. . . .

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS
C.E. Cook, IRE Internat. Conv. Rec., Pt. 4, vol. 10, no. 5, March 1962, p. 174/184.

. . . Paired-echo theory has been used to describe the effects of network and time-function distortions (both amplitude, and phase) of pulsed signals. The advent of coded-waveform techniques (e.g., pulse compression) that generate waveforms having sidelobes extending in time has led to the application of paired echo theory in the establishment of design criteria for modern radar techniques. This paper introduces somewhat more general conditions into the paired echo analysis as a basis for conducting experimental work on the effects of phase-error modulation of the time signal in a pulse compression system. . . .

RF PULSE-COMPRESSION STUDY
J.G. Ferguson, Lockheed Electronics Co., Plainfield, N.J., 1 July - 31 Dec. 1962, 10 p., AD 407 986.

This study of r-f pulse compression is an experimental one aimed at realization of a wideband pulse expansion/compression capability at microwave frequencies. . . . feasibility of using all-pass networks employing distributed-circuit strip transmission lines, hybrid networks, and printed-circuit resonators at a frequency of about 3,000 mc with a bandwidth approaching 400 mc . . .

ON THE USE OF PULSE COMPRESSION FOR THE ENHANCEMENT OF RADAR ECHOES FROM DIFFUSE TARGETS (Correspondence)
D. Fryberger, Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1993/1994.

A diffuse radar target is one which is made up of a large number of discrete targets each of which is quite small. The specific example is a weather cloud which is composed of myriads of water droplets. . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATION SYSTEMS. PART II. BINARY COMMUNICATIONS SYSTEMS USING WIDEBAND SIGNALS
J.C. Hancock, et al., Purdue U. School of Electrical Engineering, Lafayette, Ind., Final tech. rept., (ASD TDR 62-611, pt. 2), June 1961 - June 1962 on Improved Information

Transfer Efficiency of Wideband Systems, July 1962, 151 p., incl. illus. 16 refs., AD 284 451.

Contents: The analysis of binary systems (using a signal-space concept). Linear receivers. The application of linear receivers. Nonlinear receivers. Applications of nonlinear receivers. Time compression methods. Adaptive receivers.

WEIGHTED STATISTICAL AVERAGES AS A MEANS OF CALCULATING MULTIPLIER OUTPUTS AND CARRIER POWERS FOR NOISE MODULATED CARRIERS

C. E. Gilchriest, JPL Space Progr. Summ. vol. 4, no. 37-16, June - July 1962, p. 87/92.

Weighted mean averages have proved to be a very convenient tool in the analysis of correlation detectors when the reference signal has noise modulation in phase, or equivalently, modulation in time. In particular, the first moment is capable of yielding the average correlator output or, equivalently, the amount of power remaining in the carrier under the noisy phase modulation process.

THE THRESHOLD EFFECT IN MODULATION SYSTEMS THAT EXPAND BANDWIDTH

D. Slepian, IRE Trans. Inform. Th. (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. S122/127.

. . . presents curves which are believed to represent the best thresholds obtainable with practical modulators that expand bandwidth and operate instantaneously on the baseband signal. The model from which the curves are obtained is described in detail.

STUDY OF SAC BASE NON-TACTICAL RADIO SYSTEMS

ITT Communications Systems, Inc., Paramus, N. J., Rept. no. 62TR72, ESD TDR 63 688, 31 Aug. 1962, 18 p., AD 429 829.

. . . A discussion of the new spread spectrum systems is also presented. . . . existing systems and conventional equipment, with one exception, meet the present operating requirements. . . . Random access discrete address type systems are not recommended for this application.

PULSE COMPRESSION TECHNIQUES (Correspondence)

M. Bernfield, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1261.

. . . This communication presents a theoretical comparison of . . . pulse compression techniques. . . .

A DISCUSSION OF SPREAD SPECTRUM COMPOSITE CODES

D. J. Braverman, Aerospace Corp., El Segundo, Calif., Communications Systems Technical Report No. 3, 1 Dec. 1963, 49 p. refs., AD 425 862, N64-13890.

. . . a technique known as composite code synchronization in which individual element codes of the composite can be synchronized individually . . . The detectability of the elements decreases as the square root of the number of elements. Optimum strategies for communication and jamming imply the use of the majority Boolean function of the elements which are in synchrony. Time averages are computed on an ensemble assumption by using a truth table in which each entry is equally probable.

OPTIMUM POWER ESTIMATES WITH SMALL SAMPLES

I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-25, Dec. - Jan. 1963, p. 200/205.

Consider the problem of detecting a narrow-band Gaussian signal embedded in independent wide-band white Gaussian noise. Suppose that the shape of the spectrum of the signal is known, but not the amplitude, and that the spectral density of the noise is known (it is flat, of known amplitude). Suppose a short sample of the signal-plus-noise is received. What is the optimum way to measure the power in the signal? For long samples of signal-plus-noise, the answer is known-matched filtering, matched to the signal spectral shape. This note discusses the case of short samples, where it can not be assumed that the response of filters which would be used is the steady-state response.

RF PULSE-COMPRESSION STUDY

J. G. Ferguson, Lockheed Aircraft Corp., Burbank, Calif., Quarterly progress rept. no. 4 for period ending 1 April 1963. 1 April 1963, 10 p., AD 412 508.

. . . to determine the feasibility of using all-pass networks employing distributed-circuit strip transmission lines, hybrid networks, and printed-circuit resonators at a frequency of about 3000 Mc with a bandwidth approaching 400 Mc. . . . The design and construction was completed of a time-domain test set for demonstration pulse expansion/compression by the use of the delay line.

A PULSE COMPRESSION SYSTEM EMPLOYING A LINEAR FM GAUSSIAN SIGNAL

E. N. Fowle, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 304/312.

. . . A signal of Gaussian envelope and linear frequency modulation is shown to have an auto-correlation function of Gaussian shape. . . . design and construction of equipment used to generate and receive the signal. . .

A CLASS OF NOISE RADAR SYSTEMS
M. P. Grant, et al., Proc. IEEE, vol. 51, no. 7, July 1963, p. 1060/1061.

. . . The ambiguity diagram, which is a graphical presentation of the time and frequency autocorrelation of the transmitted signal, displays the expected ambiguities in range and Doppler determinations made by the system. Techniques such as chirp radar and use of pseudorandom pulsing decrease the ambiguities. It is apparent that the continuous transmission of true wide-band noise would eliminate all ambiguities. This has not been exploited because of the difficulties of transmitting such noise in an efficient manner. Several mitigating possibilities remain open, however: 1) Signal processing . . . 2) The use of naturally occurring noise. . . .

TAPPED DELAY LINE SYNTHESIS OF LARGE TIME BANDWIDTH SIGNALS
R. D. Haggarty, MITRE Corp., Bedford, Mass., Rept. no. TM3535, ESD TDR 63 180, June 1963, 19 p., AD 409 295.

A method is presented for linearly generating large time-bandwidth signals by tapped delay line filter synthesis techniques . . . The technique does not make use of many elements which are found in most conventional pulse compression systems. In particular, dispersive networks, mixers, frequency synthesizers, and precision bandpass filters are not required. Consequently, the total number of components is small, even for time-bandwidth products of a few thousand, thereby making it feasible to obtain good peak signal to "hash" sidelobe levels at the matched filter output.

A DIGITAL WIDE-BAND NONLINEAR RECEIVER CAPABLE OF NEAR OPTIMUM RECEPTION IN THE PRESENCE OF NARROW-BAND INTERFERENCE
J. C. Hancock, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 272/279.

In a wide-band communication system the additive disturbances in the channel are less likely to be white Gaussian noise than in narrow-band links. . . . illustrates how linear receivers can be made more optimum by incorporating a nonlinear transformation which precedes detection. Narrow-band AM stations are assumed to be the only additive disturbance in the channel. Adaptive techniques are also suggested . . .

APPLICATION OF SWEPT-FREQUENCY MODULATION TECHNIQUES TO PCM TELEMETRY
E. K. Holland-Moritz, et al., Institute of Science and Tech., U. of Michigan, Ann Arbor, Final rept., May 1962 - Aug. 1963, Rept. no. 5097 17F, Jan. 1964, 122 p., AD 432 244.

. . . It compares optical, acoustic, and electrical techniques for generating and processing SFM signals, and it discusses the effects of doppler shift and multipath propagation on PCM/SFM signals. . . .

OPTIMUM USE OF SPACE-TIME SIGNALS
A. A. Kuriksha, (Radiotekhnika i Elektronika, vol. 8, April 1963, p. 552/563.) (In Russian) Radio Engineering and Electronic Physics, vol. 8, April 1963, p. 595/605, 8 refs., Translation, A64-15213.

A WIDEBAND COMMUNICATION SYSTEM USING FREQUENCY SLOPE MODULATION (FSM)
H. G. Lafuse, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 346/357.

. . . Experimental data from an FSM system operating at C-band with a bandwidth of approximately 60 megacycles is presented . . . serves to establish the feasibility of wideband communication systems.

THE DETECTION OF CHIRPED RADAR SIGNALS BY MEANS OF ELECTRON SPIN ECHOES
W. B. Mims, Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1127/1134.

. . . In a typical system the transmitted pulse is subjected to a linear frequency sweep and extends over a considerable period of time. When this waveform returns from the scattering object, a device in the receiver delays the earlier portions in such a way that all the received energy is concentrated into a short pulse . . . One way of obtaining the differential delay of frequency components is by passing the received signal through a dispersive network. An alternative scheme involving the generation of electron spin echoes is suggested here. It is readily adaptable to waveforms having a variety of frequency sweeping functions, and it offers the possibility of operating with exceptionally high time compression factors. . . .

STRETCHING PULSES WITH THE LINK STRUCTURE
D. Mitchell, Cornell U. School of Electrical Engineering, Ithaca, N.Y., Rept. no. TR 78, Jan. 1964, 53 p., AD 432 967.

A theoretical and experimental study of a pulse-stretching network using the link structure is presented. The Bessel filter has a good low-pass approximation of the ideal transmission line for use in the link structure. . . . used in taking photographs of a 5-ns input pulse and the resulting output pulse . . .

SIGNAL-TO-NOISE RATIO ANALYSIS OF A SYSTEM CONTAINING A SQUARE LAW DETECTOR AND A LIMITER
T. Nishimura, JPL Space Progr. Summ., vol. 4, no. 37-21, April - May 1963, p. 161/167.

In the system to be analyzed, a PN sequence on-off modulates an RF carrier, and the resulting signal is then contaminated by additive white Gaussian noise before it is demodulated by a square law detector followed by a limiter.

CODED PULSE RADAR (CORRELATION RADAR USING RANDOMLY CODED PULSE)
T. Sakamoto, et al., In: International Symposium on Space Technology and Science, Tokyo, Japan, August 27-31, 1962, 4th Proceedings, Edited by Tamiya Nomura, Tokyo, Japan and Rutland, Vt., Japan Publications Trading Co., 1963, p. 586/591, A64-15039.

. . . improving the performance of long-range-radar systems . . . the product of signal bandwidth and duration, namely, the radar response function, should be sharply defined and possess a low side-lobe . . . laboratory experiments were carried out . . . High range resolution is accomplished by modulating the phase of the carrier of transmitted pulse. Pseudo-random sequence generated by using a feedback shift register is utilized as a modulating signal.

WIDE-BANDWIDTH COMMUNICATIONS
L.S. Schwartz, Space/Aeronautics, vol. 40, Dec. 1963, p. 84/89, A64-12905.

Discussion of the ability of wide-bandwidth systems to solve practical situations, problems of traffic density, of operation in the face of jamming, and of channel availability . . . communications satellite systems sooner or later will require wide spectrum width. . . .

A STUDY OF CORRELATOR BEHAVIOR USING "NON STATIONARY" SIGNALS, PART I
W. G. Shesnut, G. C. Dewey, and Co., Inc., New York, Rept. no. R127 1, 17 June 1963, 54 p., AD 411 249.

. . . developing the expected correlation behavior of analog and clipper correlators processing non-stationary signals . . . Non-stationary noise may degrade analog processing gain whereas it appears to improve the processing by the clipper correlator. The development is restricted to the case of small signals buried in noise . . .

POWER REQUIRED TO JAM A SATELLITE REPEATER
F.F. Yates, Aerospace Corp., El Segundo, Calif., Materials Science Lab., (SSD-TDR-63-203; TDR-269(4111)-3; AD428375, Dec. 1963, 18 p., refs., N64-14344, AD 436 812.

A general expression is derived for the ratio of interference power to signal power required at the terminals of the receiving antenna of a communication satellite (in the bandpass of a communication channel) to reduce the performance of the channel to any specified minimum condition. The expression may be applied to the analysis of spread-spectrum multiple access systems as well as to the analysis of jamming vulnerability.

COMPARISON OF SIGNALLING EFFICIENCY IN WIDEBAND COMMUNICATION SYSTEMS
J.W. Ye, Mitre Corp., Bedford, Mass., Rept. no. TM3851, ESD TDR63 437, Oct. 1963, 15 p., AD 422 599.

. . . comparing the system performance improvement in a coded correlation communication system under heavy jamming environment for the following forms of message encoder and decoder: (1) simple reduction of the transmission rate, (2) simple reduction of the same symbol, and (3) application of error-correcting codes. The error-correcting codes were found to perform uniformly better than the other two schemes. . . .

A LINEAR-FM RADAR PULSE COMPRESSION SYSTEM EMPLOYING THICKNESS-TAPERED DISPERSIVE DELAY LINES
R.C. Yost, Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 321; ESD TDR63 551, 11 July 1963, 20 p., AD 417 528.

. . . employs a linear-FM signal. At the option of the operator, the shape of the signal envelope can be made rectangular, Butterworth, or Gaussian. Ultrasonic dispersive delay lines that are thickness-tapered to provide a linear group time delay characteristic over a frequency band of 2 mc are used as the signal expansion and compression devices. For the poorest care, the time sidelobes in the receiver output waveforms are shown to be 35 db below the peak response.

WEAK SIGNAL COMMUNICATION TECHNIQUES
Bell Telephone Labs., Inc., Whippany, N.J., Final rept., May 1961 - April 1963, ASD TDR63 525, July 1963, 96 p., AD 417 037.

. . . a two-year study . . . The theoretical results . . . are documented more fully in the interim report (AD 299 219) dated April 1962. That report included . . . threshold performance of FMFB demodulators, analysis of FSK systems with noise-like signals, and determination of group code performance. The present report contains . . . threshold bounds for analog communication systems . . . use of binary group codes on the gaussian noise channel; and a more complete analysis of the performance of multilevel FSK systems which employ noise-like signals. An octary system, a breadboard version implemented under this program, is described in detail.

Related Publications:

MEANS FOR COUNTING "EFFECTIVE" NUMBERS OF OBJECTS OR DURATION OF SIGNALS (Correspondence)
R. Lerner, Proc. IRE, vol. 47, Sept. 1959, p. 1653.

. . . if a signal has approximate duration T and approximate bandwidth W, it can be specified by approximately 2 TW numbers or coefficients. In dealing with signals of large time-bandwidth product, it is customary to speak of the "effective" number of degrees of freedom as the number of these coefficients that are "sufficiently" large. Except in the case of band limited signals, however, no means of computing the "effective" number of degrees of freedom has been suggested.

A METHOD OF OBTAINING ARBITRARY PHASES OF AN M-SEQUENCE
R.C. Curry, Rochester U., N.Y., Nov. 1960, 44 p., AD 248 455.

. . . If an m-sequence is generated by an N-stage shift register which has been modified by the addition of logical feedback, a sequence delayed by up to a maximum of ((2 to the power N)-1) digits can be obtained by adding modulo 2 the outputs of various stages of the shift-resister generator. A method is given for determining from which stages the outputs should be added to obtain any specified delay . . . Also described is the network of modulo 2 adders which are used to obtain the delayed sequence. A program is given in the appendix for generating the phase-table with a digital computer (IBM 650).

GENERATION OF A SAMPLED GAUSSIAN TIME SERIES HAVING A SPECIFIED CORRELATION FUNCTION
M.J. Levin, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 545/548.

A computationally convenient method is presented for simulating a sequence of sampled values of a stationary Gaussian process having a specified correlation function or power spectrum. Z-transform theory is applied to provide a simple recursive formula for generating the values from a set of independent Gaussian random variables.

A STUDY OF NANOSECOND PULSE TECHNIQUES IN RADAR TRANSMISSION
C.G. Bachman, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., (Rept. no. UB-1426-2-1), (RADC TR 61-247), 27 Feb. 1961, 299 p., AD 268 880.

DEMODULATION OF A PHASE-MODULATED NOISE CARRIER
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 19/27.

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P.H. Haas, Air Force Inst. of Tech., Wright-Patterson Air Force Base, Ohio, Master's thesis, (Rept. no. GE/EE/61-6), Aug. 1961, 68 p., 13 refs., AD 270 272.

A survey . . . as applicable to the statistical analysis of communication is presented. Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

THE OUTPUT SPECTRAL DENSITY OF A DETECTOR OPERATING ON A F.M.C.W RADAR SIGNAL IN THE PRESENCE OF BAND-LIMITED WHITE NOISE
J. Lait, et al., Proc. Instn. Elect. Engrs., Part C, vol. 108, no. 13, March 1961, p. 197/207.

. . . Expressions for spectral density are derived separately for both quadratic and linear detectors, and the question of optimum pre-detector bandwidth is examined. Finally, the authors consider how signal/noise ratio will be affected by choice of bandwidth in stages which follow the detector. . . .

SOME RESULTS OF NEW CLASSES OF MATCHED FILTERS
D. Middleton, Rand Corp., Santa Monica, Calif., (Rept. no. RM-2625) 12 July 1961, 34 p., AD 261 027.

. . . the design criterion is the automatic decision process that occurs when the signals are detected or measured in noise. . . . conceived theoretically, and the approach is indicated to their design and construction for actual use.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A.B. Glenn, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 168/173.

. . . The first system employs large bandwidth signal duration product (WT) orthogonal signals with quadrature detection. . . .

THE GENERATION OF IMPULSE-EQUIVALENT PULSE TRAINS
D.A. Huffman, IRE Trans. Inform. Th., (Intern. Symp. Brussels 1962), vol. IT-8, no. 5, Sept. 1962, p. S10/16.

The necessary and sufficient conditions for a function to be the autocorrelation function of a waveform consisting of a finite length train of pulses of various amplitudes is derived. The number of pulse trains having a given realizable autocorrelation function is determined. An "impulse-equivalent" pulse train is defined as one that yields, as closely as is theoretically possible, the same autocorrelation function that a single pulse gives. . . .

It is demonstrated that all impulse-equivalent pulse trains can be generated by exciting a linear digital filter with two input pulses that correspond in time to the initiation and to the termination of the desired output sequence. . . .

ANTI-MULTIPATH TESTS OF A RANDOM NOISE CARRIER SYSTEM
M.A. Messineo, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., Final rept., AD 273 196.

. . . utilizing the transmitted reference technique . . . Test results over a several thousand mile, high-frequency circuit are presented and discussed. Recommendations are made for future applications . . .

THE EFFECTS OF DOPPLER DISPERSION ON MATCHED FILTER PERFORMANCE (Correspondence)
W.L. Rubin, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2127/2128.

. . . linear FM-pulse compression falls within the broader domain of matched filtering . . . modifying previous expressions for the "matched filter uncertainty function," in which Doppler has been approximated by a simple frequency translation. . . .

DETECTION OF A SIGNAL MODULATING A RANDOM NOISE CARRIER (In French)
C. Ducot, Onde Electr., vol. 43, no. 433, April 1963, p. 452/455.

PERFORMANCE OF DIGITAL COMMUNICATIONS SYSTEMS IN AN ARBITRARY FADING RATE AND JAMMING ENVIRONMENTS
A.B. Glenn, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 57/68.

. . . The results . . . apply only for a nonselective fading environment . . . The first system, called the quadrature detection system, employs large-bandwidth signal duration product (WT) . . . The next two systems employ a WT product approximately equal to one. . . .

A TRACTABLE BERNOULLI-SEQUENCE GENERATOR
C.C. Hoopes, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 282/294.

. . . implementation and evaluation of a random-pulse-train generator. The technique is of special interest and advantage for those testing or working with digital equipment. The generator is a reliable, reproducible, and stable source of Bernoulli sequences with p in the range 10^{-3} to 10^{-1}.
The Bernoulli sequence is generated by means of a noise source in conjunction with a shift-register generator . . .

USE OF RECIRCULATORS FOR COMPRESSING FREQUENCY-MODULATED PULSES
V.V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 60/68.

The possibility of using circulating memory devices (recirculators) for the optimum extraction of a frequency-modulated pulse in noise is considered. A comparision with the usual filters using dispersive delay lines is carried out. . . .

200 MBIT/S PSEUDO RANDOM SEQUENCE GENERATORS FOR VERY WIDE BAND SECURE COMMUNICATION SYSTEMS
R.A. Marolf, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 183/187.

. . . The generators are of the re-fed shift register type, whereby the shift register can easily be expanded by regular transmission lines to generate extremely long sequences. The Pumped Tunnel Diode Transistor Logic (PTDTL) circuit is used in the shift register and feedback logic circuit. Stable operation is ensured by wide tolerances on dc bias and "pump" voltages.

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO FM SIGNALS AND NOISE
D.L. Schilling, Proc. IEEE, vol. 51, no. 10, Oct. 1963, p. 1306/1316.

. . . to determine its response to frequency modulated signals, and narrow-band Gaussian noise. Emphasis is placed on the system's response to signals having "ramp" type FM. The response . . . is obtained using a perturbation and piecewise linear technique. The response of the system to noise is obtained using an iteration technique. The complete response . . . is then discussed.

THE RESPONSE OF AN AUTOMATIC PHASE CONTROL SYSTEM TO AN FM SIGNAL IN THE PRESENCE OF GAUSSIAN NOISE
D.L. Schilling, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 242/246.

. . . An Automatic Phase Control (APC) System is analyzed to determine its response to an FM signal and additive narrowband gaussian noise. Emphasis is placed on the system's response to a "ramp" type FM signal when the input S/N ratio is less than unity. . . . portion of a Doctoral Dissertation . . .

SYNCHRONIZATION OF COHERENT DETECTORS
I. Selin, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 100/109.

The estimation of carrier frequency and subcarrier epoch in a coded - "noise" communication system is discussed. . . .

Section 1.93
Multiplex Modulation Methods with FM Carrier Modulation

1.932: Analog Multiplex Modulation Methods with FM Carrier

Included: FM/FM modulation; SS/FM modulation; FDM/FM multiplex modulation methods; FM/FM/FM multiplex modulation method; Triple FM modulation.

Not Included: Frequency division multiplex fundamentals (2); Design of telemetry systems.

Cross References: Analog simplex modulation methods (Div. 1.2); Fundamentals of frequency modulation (1.232); PAM/FM multiplex modulation methods (1.933); PAM/FM/FM modulation (1.933).

Principal Publications:

A TRANSISTORIZED FM/FM TELEMETERING SYSTEM
R. E. Colander, et al., IRE Trans. Telemetry Remote Contr., vol. TRC-1, no. 2, May 1955, p. 20/24.

A NOTE ON THE FREQUENCY DISTRIBUTION OF AN FM/FM SIGNAL
P. B. Arnstein, IRE Trans. Telemetry Remote Contr., vol. TRC-3, no. 2, May 1957, p. 13/16.

THE APPLICATION OF PHASE-LOCKED LOOP DISCRIMINATORS FOR THRESHOLD IMPROVEMENT AND ERROR REDUCTION IN FM-FM TELEMETRY
C. E. Gilchriest, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, 7 Jan. 1957, 10 p., AD 252 556.

. . . solution to the threshold problem which accomplishes 18-db improvement over commonly used discriminators so that FM-FM systems can again compete closely with any other system. . . .

EXTENSION OF FM/FM CAPABILITIES
H. O. Jeske, IRE Trans. Telemetry Remote Contr., vol. TRC-3, no. 1, April 1957, no. 2.4, 10 p.

PROGRESS REPORT ON A SOLID STATE FM-FM TELEMETERING SYSTEM
E. Y. Politi, IRE Trans. Telemetry Remote Contr., vol. TRC-3, no. 1, April 1957, 19 p.

NOISE AND BANDWIDTH IN FM/FM RADIO TELEMETERING
K. M. Uglow, IRE Trans. Telemetry Remote Contr., vol. TRC-3, no. 2, May 1957, p. 19/22.

. . . This paper discusses the derivation, limitations, and use of system equations relating input and output signal/noise ratios in fm detection with band-pass and with low-pass output filters and in fm/fm multiplex transmission. . . .

COMPARISON OF THE PERFORMANCE OF PAM-FM AND FM-FM TELEMETRY SYSTEMS
D. Hochman, Proc. Nat. Symp. Telem., Sept. 1958, no. 8.2, p. 1/6.

TRIPLE-FM—A PRACTICAL METHOD FOR INCREASING THE CAPACITY OF TELEMETERING SYSTEMS
W. F. Janeway, Proc. Nat. Symp. Telem., Sept. 1958, no. 8.5, p. 1/7.

. . . In an FM/FM telemetering system, time-division multiplexing is often applied to individual subcarrier bands in order to get more data channels. An alternative method is to employ frequency-division multiplexing of subcarriers. . . .

MULTICHANNEL FM/FM TELEMETERING SYSTEM
L. Katz, et al., Proc. Nat. Symp. Telem., Sept. 1958, no. 9.2, p. 1/14.

TELEMETRY SYSTEMS FM/FM
F. H. Reynolds, Electro-Mechanical Research, Inc., Sarasota, Florida, Final Engineering Rept., Report no. AFMTC TR 58-12, April 1958, 4 p., AD 134 285.

DISTORTION IN FM-FM SYSTEMS AND ITS EFFECT ON SYSTEM ACCURACY
W. O. Frost, Proc. Nat. Telem. Conf., May 1959, p. 45/52.

SS-FM: A FREQUENCY DIVISION TELEMETRY SYSTEM WITH HIGH DATA CAPACITY
W. O. Frost, et al., Nat. Symp. Space Electronics Telem., Sept. 1959, no. 7.2, p. 1/14.

. . . results of a theoretical study . . . preliminary design . . . single sideband AM subcarriers on an FM carrier . . . An analytical comparison with FM-FM is made of the S/N performance of a 15 channel SS-FM system. . . .

THE DESIGN AND USE OF COMMUTATED FM/FM TELEMETRY SYSTEM USING THE STANDARD IRIG CHANNELS
B. M. Hadfield, Research and Advanced Development Div., AVCO Corp., Wilmington, Mass., Rept. no. TR 759 13., 23 April 1959, 45 p., AD 421 696.

A NEW PRACTICAL APPROACH TO SUB-CARRIER PRE-EMPHASIS
W. E. Hane, Proc. Nat. Telem. Conf., May 1959, p. 151/160.

New designs for fm/fm telemetry often lack a method of obtaining optimum subcarrier pre-emphasis. . . . The use of an optimum pre-emphasis curve rather than a "standard" curve significantly increases the effective range of a given telemetry system. However, when the system has more than six to eight subcarrier oscillators, the data distortion often becomes intolerable. . . .

ANALYSIS OF MULTIPLEX ERROR IN FM/FM AND PAM/FM/FM TELEMETRY
J. Schenck, et al., IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 3, Sept. 1959, p. 138/147.

. . . frequency division multiplex of FM subcarriers where commutation, or pulse amplitude modulation time division multiplexing, is used on one or more of the FM subcarrier channels . . .

THE CASE OF FM-AM VS FM-FM TELEMETRY
L. L. Rauch, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 2, June 1960, p. 81/84.

IMPROVED BANDWIDTH UTILIZATION FOR FM/FM SYSTEMS USING TONE CODE MODULATION ON BINARY MEASUREMENTS
A. A. Tyer, et al., Proc. Nat. Telemetering Conf., May 1960, p. 489/500.

EFFECTS OF AMPLITUDE AND PHASE FLUCTUATIONS ON THE PERFORMANCE OF DIGITAL DATA SYSTEMS IN FADING FDM-FM AND FDM-SSB SYSTEMS
H. D. Becker, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 93/100.

. . . Emphasis is placed on theoretical performance of differentially coherent phase-shift keyed (DCPSK) systems in which DCPSK data is transmitted on subcarriers over a frequency-division multiplex single-sideband (FDM-SSB) or an FDM-FM transmission system, such as employed in typical tropospheric scatter links. . . .

COHERENT FDM/FM TELEPHONE COMMUNICATION
J. A. Develet, Jr., Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1957/1966.

. . . telephone communication as applied to a satellite repeater system. Particular emphasis is placed on a method of coherent reception . . . new to the field of common carrier telephony. . . . for the class of signals utilized in common carrier telephony, an attempt is made to place on a quantitative footing the design of FDM/FM satellite communication systems. The interrelation among such quantities as sensitivity, bandwidth occupancy, and channel quality is presented for a simply realized second-order receiving system. In addition, the maximum sensitivity achievable with the optimum receiving system is shown. . . .

POTENTIAL AND REAL NOISE IMMUNITY OF A MULTICHANNEL RADIOTELEMETERING SYSTEM OF PAM-FM-FM TYPE IN THE PRESENCE OF WEAK FLUCTUATION NOISE
A. F. Fomin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 8, Aug. 1962, p. 8/12.

The article determines the potential noise of a radiotelemetering system of PAM-FM-FM type. It compares the potential noise immunity of PAM-FM-FM, PAM-FM and FM-FM systems. . . .

SS-FM: A TELEMETRY TECHNIQUE FOR WIDE-BAND DATA
W. O. Frost, IRE Trans. Space Electronics, Telemetry, Vol. SET-8, no. 4, Dec. 1962, p. 283/289.

. . . The data channels are stacked in the frequency spectrum as single-sideband subcarriers which frequency-modulate the RF carrier. The system design utilizes to advantage the statistical properties of vibration data to achieve maximum data transmission efficiency from the available RF carrier deviation. However, in contrast to proposed statical predigestion techniques, the data is transmitted in raw form. . . . general description of the SS-FM vehicle and ground telemetry equipment utilized in the Saturn vehicle program and a summary of system characteristics and performance. . . .

THE AJAX FRENCH RADIO-TELEMETRY SYSTEM (In French)
G. Greneche, Onde Electr., vol. 43, no. 432, March 1963, p. 286/297.

. . . a French telemetry system using subcarriers of the FM/FM type based on the recommendations of the American organization IRIG (Intermediate-Range-Instrumentation-Group). . . . has been developed on a national basis. All the operating items making it up are manufactured in France.

PARAMETER OPTIMIZATION OF AN FM/FM MULTICHANNEL TELEMETRY SYSTEM
D. H. Sapp, RCA Rev., vol. 24, no. 3, Sept. 1963, p. 381/390.

. . . discusses the r-f equipment parameters and parameter optimization of the r-f portion of a wideband telemetry system containing a combination PCM and FM/FM multiplex. The various sources of distortion in FM systems are discussed and graphs are given to show typical saddle points by means of which parameters can be selected to maximize the channel signal-to-noise rations. Empirical methods are presented that give a systematic approach to the selection of the parameters that maximize the amount of data transmitted over a telemetry link of a given bandwidth of minimize the bandwidth for a given amount of transmitted data.

Related Publications:

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE vol. 48, Sept. 1961, p. 1613/1629.

BANDWIDTH LIMITING EFFECTS OF FREQUENCY SELECTIVE FADING OVER TROPOSPHERIC SCATTER PATHS
P. D. Shaft, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y. Master's thesis, (Research rept. no. PIBMRI-976-61), 12 Dec. 1961, 105 p., incl. illus., tables, 28 refs., AD 281 967.

A set of design curves of intermodulation distortion due to frequency selective fading was derived for tropospheric scatter systems. . . . applicable to systems frequency modulated with frequency division multiplexed telephone and telegraph channels. . . .

EXPERIMENTAL OPTIMIZATION AND EVALUATION OF TELEMETRY SYSTEMS
W. F. Link, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 239/246.

. . . A careful laboratory program to experimentally optimize and evaluate four telemetry systems in wide use (FM-FM, PAM-FM, PDM-FM and PCM-FM) has been concluded . . . Each of the four systems was implemented in the laboratory and the system under test was modulated by random signal sources typifying actual data. . . .

1.933: Sampling Multiplex Modulation Methods with FM Carrier

Included: PAM/FM modulation; PAM/FM/FM modulation; PDM/FM modulation; PDM/FM/FM modulation method; PPM/FM modulation.

Not Included: Design of telemetry systems (2); Multiplex systems (2).

Cross References: FM/FM multiplex modulation methods (1.932); Fundamentals of sampling modulation methods (Div. 1.4); PACM/FM modulation method (1.934).

Principal Publications:

NOISE AND BANDWIDTH IN PDM/FM RADIO TELEMETERING
K. M. Uglow, IRE Trans. Telemetry Remote Contr., vol. TRC-3, no. 1, April 1957, no. 7.5, 10 p.

THE GROUND STATION OF A PAM-FM TELEMETRY SYSTEM
F. F. Fulton, Jr., et al., Proc. Nat. Symp. Telem., Sept. 1958, no. 8.4, p. 1/10.

COMPARISON OF THE PERFORMANCE OF PAM-FM AND FM-FM TELEMETRY SYSTEMS
D. Hochman, Proc. Nat. Symp. Telem., Sept. 1958, no. 8.2, p. 1/6.

PDM/FM/FM ON LOWER SUB-CARRIER FREQUENCIES
F. E. Rock, Proc. Nat. Symp. Telemetering, Sept. 1958, no. 12.2, p. 1/7.

A HIGH CAPACITY PAM-FM-FM TELEMETERING SYSTEM FOR THE SATURN BOOSTER
O. B. King, Nat. Symp. Space Electronics Telemetry, Sept. 1959, no. 7.1, p. 1/10

. . . 216 channel . . . specific problems in connection with booster telemetering are discussed. . . . requirements for a new telemeter system are set forth . . . emphasis on the multiplexer portions. . . .

ANALYSIS OF MULTIPLEX ERROR IN FM/FM AND PAM/FM/FM TELEMETRY
J. Schenck, et al., IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 3, Sept. 1959, p. 138/147.

. . . frequency division multiplex of FM subcarriers where commutation, or pulse amplitude modulation time division multiplexing, is used on one or more of the FM subcarrier channels . . .

THE EFFECT OF DIFFERENT TYPES OF VIDEO FILTERS ON PDM-FM AND PCM-FM RADIO TELEMETRY
M. H. Nichola, et al., IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 2, June 1960, p. 85/92.

A S/N IMPROVEMENT FACTOR ON PAM-FM WHOSE RECEIVED PULSE IS COSINE-SQUARED (Correspondence)
A. Watanabe, Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 257/258.

PDM/FM STANDARDS
Instrum. Control Syst., vol. 33, no. 3, March 1960, p. 410.

POTENTIAL AND REAL NOISE IMMUNITY OF A MULTICHANNEL RADIOTELEMETERING SYSTEM OF PAM-FM-FM TYPE IN THE PRESENCE OF WEAK FLUCTUATION NOISE
A. F. Fomin, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 8, Aug. 1962, p. 8/12.

The article determines the potential noise immunity of a radiotelemetering system of PAM-FM-FM type. It compares the potential noise immunity of PAM-FM-FM, PAM-FM and FM-FM systems. . . .

INTERPRETING THE IRIG STANDARDS FOR PAM/FM TELEMETRY
R. C. Barto, Proc. Nat. Telem. Conf., May 1963, p. 2/1

. . . Also available are AD 410 320

DATA TRANSMISSION AND TRAJECTORY DETERMINING DEVICES FOR RESEARCH ROCKETS AND SATELLITES, VOLUME I
J. S. Rochefort, et al., Northeastern U., Boston, Mass., Electronics Research Lab., Final Report, (AFCRL-63-821 (1)), June 30, 1963, 76 p., 7 refs., N63 21719.

. . . a dual triggered parallel-read commutator for an aspect system; the development of a PAM/FM system; a reentry physics program concerned with using Trailblazer vehicles to measure the effects of the plasma sheath on communications . . . program for the evaluation of commercial airborne telemetry system equipments . . . test procedures and equipment tested.

PAM, PDM, AND PCM TECHNIQUES IN APPLICATION TO DIGITAL TELEMETRY ON VOICE BANDWIDTH FACILITIES
C. Yanis, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 139/151.

. . . The requirements of these telemetry modes in terms of link conditions, tone equipment, and terminal equipment is examined. Conclusions are reached regarding adaptability to high speed, multiplexing, and hardware requirements.

Related Publications:

AN EXPERIMENTAL AIRBORNE PAM-FM TELEMETER PACKAGE FOR MISSILE APPLICATIONS
T. D. Lusk, Proc. Nat. Symp. Telemetering, Sept. 1958, no. 8.3, p. 1/4.

EXPERIMENTAL OPTIMIZATION AND EVALUATION OF TELEMETRY SYSTEMS
W. F. Link, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 239/246.

THE ORTHOMATCH DATA TRANSMISSION SYSTEM
B. G. Kuhn, et al., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 3, Sept. 1963, p. 63/66.

. . . Calculated and measured comparison of Orthomatch and typical PAM-FM system shows an 11.5 db power advantage for Orthomatch. . . .

A PAM-FM TELEMETRY EQUIPMENT WITH DIGITAL OUTPUT FOR IN OIL PROSPECTING (In French)
J. Ringot, Onde Electr., vol. 43, no. 440, Nov. 1963, p. 1183/1188.

1.934: Digital Multiplex Modulation Methods with FM Carrier

Included: PCM/FM modulation; PAM/PCM-FM modulation; PACM/FM modulation.

Not Included: Time division multiplex systems (2).

Cross References: Digital modulation methods (Div. 1.3); Pulse code modulation methods (Div. 1.5); PAM/FM modulation (1.933); PAM/FM/FM modulation (1.933).

Principal Publications:

STUDY OF PCM-FM TRANSMISSION OVER TROPOSPHERIC SCATTER SYSTEMS
F. Assadourian, RCA Defense Electronic Products, N. Y., Final rept. on Task 4, Sept. 1959, AD 230 426.

. . . transmission of PCM-FM signals. . . . preliminary in the sense that it is devoted primarily to a detailed survey of necessary background topics such as binary digital error rates for various types of PCM-FM signals and for correlation or non-correlation detection. . . .

A HIGH-SPEED, AIRBORNE DIGITAL DATA ACQUISITION SYSTEM
S. Cogan, et al., IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 3, Sept. 1959, p. 117/122.

. . . PCM/FM data acquisition system . . . part of a larger system designed to provide an accurate and reliable means of collecting information from a large number of transducers during aircraft flight testing, and to transfer this information in the most efficient manner to a digital computer for final data reduction . . .

MICROWAVE RADIO RELAY SYSTEMS STUDY
A. A. Meyerhoff, et al., RCA Defense Electronics Products, N. Y., Final rept. no. Task 2, Aug. 1959, AD 230 425.

Several methods of detection of PCM-FM are analysed to determine means of lowering the received carrier threshold. . . . There is an ideal curve of error probability vs. a normalized parameter, the ratio of energy in a signal element and noise power per cycle of bandwidth. The various detection methods are compared with this ideal curve. A large part of the study is devoted to the derivation of the error probability relationships for discriminator reception with an IF filter so narrow that the modulating pulses are shaped thereby. The results show that with proper choice of parameters this system requires only about 2 db more received carrier power than the ideal. Other detection methods considered, namely feedback to the local oscillator, carrier insertion, and narrow mark or space filters do not appear so promising. . . . (See also AD 230 426).

THE EFFECT OF DIFFERENT TYPES OF VIDEO FILTERS ON PDM-FM AND PCM-FM RADIO TELEMETRY
M. H. Nichols, et al., IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 2, June 1960, p. 85/92.

PCM/FM TELEMETRY SIGNAL ANALYSIS AND BANDWIDTH EFFECTS
J. F. Ornsby, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 3/4, Sept./Dec. p. 130/138.

ERROR PROBABILITIES FOR TELEGRAPH SIGNALS TRANSMITTED ON A FADING FM CARRIER
B. B. Barrow, Proc. IRE, vol. 48, Sept. 1961, p. 1613/1629.

. . . Frequency-shift keying, amplitude keying, and phase-shift keying are considered. . . . The analysis pertains most directly to troposcatter systems, but the general conclusions regarding the effect of FM theshold should be relevant also for fading transmission paths such as those met in line-of-sight and telemetry . . .

EXPERIMENTAL DETECTOR STUDY
A. Tepfer, RCA Defense Electronics Products, N. Y., (Rept. no. CR-61-419-13), Final rept. on Task 3, 28 April 1961, 17 p., AD 259 558.

A laboratory study of error-rate performance of a PCM-FM system and an investigation of some experimental detector techniques were conducted. The variation of the error rate as a function of the signal strength was determined as the frequency deviation was varied and as the carrier frequency was displaced from its normal position in the middle of the IF amplifier. The effects of carrier reinsertion in the receiver and of a time-varying IF filter synchronous with the received signal were investigated.

PACM-FM TELEMETRY EVALUATION
D. E. Gilcrest, et al., Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 103/111.

TRENDS IN MISSILE AND SPACE RADIO TELEMETRY
J. W. Muehlner, Lockheed Aircraft Corp., Sunnyvale, Calif., 1962, 45 p., AD 407 379.

Various modualtion methods and concepts are presented. . . . PAM/PCM-FM system is well suited because of its adaptability, economy of bandwidth and power and ability to handle some high-accuracy data. . . . it becomes progressively more important to combat the flood of data descending on us from outer space. This compression scheme is based on elimination of redundancy. Techniques such as are presently under development lead to compression factors of the order of 30, referenced to the indiscriminate data-transmission practices of today.

ATTAINABLE ERROR PROBABILITIES IN DEMODULATION OF RANDOM BINARY PCM/FM WAVEFORMS
E. F. Smith, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 290/297.

The deviation ratio required for minimum obtainable bit-error probability for random binary PCM/FM waveforms is derived. The resulting minimum obtainable bit-error probabilities are calculated and compared with those obtained experimentally and independently in two different laboratories using conventional demodulation equipment. The amplitude distribution of video noise in conventional FM receivers is investigated theoretically and experimentally in an attempt to interpret the effect (or lack of effect) of video filtering on error probability. Comparison is also made between theoretically attainable bit-error probabilities for PCM/AM, PCM/PSK, conventional PCM/FM (i.e. frequency modulating a single oscillator) and "switched PCM/FM" (i.e. switching between two oscillators of different frequencies). . . .

FEASIBILITY INVESTIGATION OF A PACM-FM TELEMETRY SYSTEM
Aeronutronics, Newport Beach, Calif., Final rept., (ASD TDR 62-637), June 1961 - May 1962., Oct. 1962, 86 p., incl. illus., tables, 5 refs., AD 289 886.

. . . design and construction of a PACM/FM ground station . . . design and construction of a vehicleborne data converter to generate PAM, PCM, and PACM formats . . . Laboratory test with various formats and data rates to establish system performance, and the capabilities of the equipment developed . . . analysis and evaluation of the PACM-FM system to predict equipment electrical and operational charateristics . . . preparation of recommended procurement specifications based on tests, analysis, and evaluation. The tests and analysis disclose that the performance obtainable for PAM and PCM in the PACM format is the same as in the pure PAM and PCM formats. . . .

THE MINUTEMAN PCM/FM TELEMETRY SYSTEM
E. P. Donnelly, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 509/514.

. . . The system provides for real-time read-out of any one analog channel by Nixie display plus velocity and gimbal postions. Quick-look or real-time provisions are furnished for oscillograph strip-out of data, and format conversion allows data to be reduced by IBM 704 or 7090 computers. . . .

ERROR RATE OF PCM-FM USING DISCRIMINATOR DETECTION
P. D. Shaft, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 4, Dec. 1963, p. 131/137.

. . . It is shown that discriminator performance is approximately 1 db poorer than optimum detection of a PCM-FM signal. The results compare favorably with experimental measurements conducted elsewhere. . . .

BAND LIMITATION AND ERROR RATE IN DIGITAL UHF-FM TRANSMISSION
H. J. von Baeyer, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 110/117.

The literature on systems design for the transmission of high speed digital data in the "megabits per second" range over UHF links is scarce and somewhat contradictory. . . . problem of finding the best compromise between radiated bandwidth, power balance, and output SNR, the latter being directly related ot the error rate. Confining the analysis to frequency modulation . . . optimization is analyzed. The effects of intersymbol interference, FM transient characteristics, and FM improvement threshold are discussed . . .

Related Publications:

EXPERIMENTAL OPTIMIZATION AND EVALUATION OF TELEMETRY SYSTEMS
W. F. Link, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 239/246.

. . . A careful laboratory program to experimentally optimize and evaluate four telemetry systems in wide use (FM-FM, PAM-FM, PDM-FM and PCM-FM) has been concluded . . . Each of the four systems was implemented in the laboratory and the system under test was modulated by random signal sources typifying actual data. . . .

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS-COMMUNICATION TYPE
C. W. Stuckey, et al., Georgia Inst. of Tech. Engineering Experiment Station, Atlanta, Quarterly rept. no. 3, 15 Aug. - 15 Nov. 1963, Rept. no. 24, 15 Nov. 1963, 56 p., AD 433 705.

The effects of multipath interference on the intelligibility of speech transmitted over an FM system employing time division multiplexing are reported. Prediction intelligibility measurements based on audio output S/N ratios indicate that significant degradation in intelligibility will exist for the FM/TDM system tested when multipath signals of equal strength are received over paths which differ in length by as little as 0.15 mile. . . .

PAM, PDM, AND PCM TECHNIQUES IN APPLICATION TO DIGITAL TELEMETRY ON VOICE BANDWIDTH FACILITIES
C. Yanis, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 139/151.

. . . The requirements of these telemetry modes in terms of link conditions, tone equipment, and terminal equipment is examined. Conclusions are reached regarding adaptability to high speed, multiplexing, and hardware requirements.

Section 1.94

1.940: Multiplex Modulation Methods with Phase Modulation on the Output Carrier

Included: FSK/PM modulation method; FM/PM multiplex modulation method; PCM/PS modulation; PCM-PC-PM telemetry signals.

Not Included: Telemetry system design; Time division multiplex systems (2).

Cross References: Frequency shift keying modulation (1.332); Digital phase modulation systems (Sect. 1.34).

Principal Publications:

THE PCM-PS TELEMETRY SYSTEM
H. N. Putschi, et al., Proc. Nat. Telemetering Conf., May 1959, p. 143/150.

. . . The transmitter power required in this system is equal to or less than that of an ideal conventional PCM-FM system. . . .

SYNCHRONOUS RECEPTION IN A PCM/PS TELEMETRY SYSTEM
H. Raillard, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 163/172.

. . . for space vehicles and missiles; space and weight requirements must be kept at a minimum. The considerations leading to the choice of a PCM/PS system . . . are presented. . . . the noise threshold of an AM detector limits the system performance. Therefore, synchronous detection incorporating a threshold-free product detector is used. A carrier-locked local oscillator capable of tracking the doppler shifts inherent in missile systems is used. . . .

THE PIONEER IV LUNAR PROBE: A MINIMUM-POWER FM/PM SYSTEM DESIGN
B. D. Martin, JPL, Calif. Inst. of Tech., Pasadena, Calif., (Tech. rept. no. 32-215), 15 March 1962, 76 p., incl. illus., tables, refs., AD 274 664.

. . . Use of phase-coherent techniques in both the carrier and subcarrier channels produced a system capable of threshold performance at two Moon distances, one-half million miles, with only 180 mw of transmitted power. . . . A discussion of the phase-coherent (phase-lock) technique is presented . . . The use of a carrier-tracking loop as a phase demodulator is examined, and expressions for the usable carrier and subcarrier sideband powers are developed. A useful channel design equation is then described, and 2 typical FM/PM system design calculations are presented to illustrate the application of the previously derived techniques.

FSK/PM THRESHOLD IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif. Technical documentary rept., (Rept. no. WDL-TR1870), 15 Aug. 1962, lv. incl. illus., 6 refs., AD 284 800.

An experimental study . . . to determine means of improving the threshold of the Advent FSK/PM command link. . . . construction . . . of a . . . command link simulator . . . considerable supporting data were obtained in the form of time waveform photographs, spectrum photographs and plots, and system response curves. The results indicate the desirability of using coherent tones and pre-modulation filtering in the transmitter as well as the obvious need for an optimum detector. Theoretical investigations of the bit sync problem in the receiver emphasize the need for additional work to investigate a number of interesting detection schemes.

A TELEMETRY IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif. Technical documentray rept., (Rept. no. WDL-TR 1909), 1 Oct. 1962, lv., incl. illus., tables, ref., AD 289 875.

An abbreviated derivation is given for a tapped delay-line Wiener filter. An attempt is made to apply filtering of this type to a PCM-PC-PM telemetry signal. Both i-f filtering and post-detection filtering are considered. . . . Results show that such filtering is of marginal value for the particular telemetry signal investigated.

THE ERROR RATES IN MULTIPLE FSK SYSTEMS AND THE SIGNAL-TO-NOISE CHARACTERISTICS OF FM AND PCM-FS SYSTEMS
H. Akima, Central Radio Propagation Lab., National Bureau of Standards, Colorado Springs, Colo., Technical note no. 167, 25 March 1963, 55 p., 35 refs., AD 402 243.

. . . evaluated for wide ranges of system parameters, assuming . . . a fading-free signal and an additive white Gaussian noise. It is shown that the required intrinsic SNR for an assigned value of symbol error rate in multiple FSK systems can be reduced by increasing the number of frequencies in the keying. Comparison of the threshold in band-dividing FM systems with that in PCM-PS systems shows the latter cannot be lower than the former . . . Brief discussions on the threshold effects in frequency-lock and phase lock FM demodulators suggest that the threshold of these feedback FM demodulators can not be improved beyond that of a band-dividing one.

MODULATION CONSIDERATIONS FOR THE TRANSMISSION OF REAL-TIME SPACE TELEVISION
J. A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., SSD TDR63 117, 13 May 1963, 13 p., AD 406 315.

. . . the baseband signal was assumed: (1) digitally encoded and modulated on a carrier as binary PCM/PM; and (2) analogue modulated as wideband FM . . . The performance and complexity of these two approaches were then reviewed with parameters typical of a moon mission. In comparing the digital to the analogue approach, it was found that the analogue system was superior in all respects, e. g., simplicity, reliability, and spacecraft power. Identical comparisons as the foregoing were necessary to establish the modulation techniques for Telstar and Relay, the world's first wideband communication satellites. It is not surprising, therefore, that these satellites utilize analogue wideband FM with frequency-following receivers.

Section 1.95

1.950: Multiplex Modulation Methods with AM on the Output Carrier

Included: FSK/AM modulation; FM/AM multiplex modulation methods; FM/PDM-AM telemetry signals; PSK-AM modulation; PAM/FM/AM multiplex modulation method; PDM/AM modulation; PCM/SSB modulation.

Not Included: Telemetry systems design; Design of multiplex systems (2).

Cross References: Fundementals of amplitude modulation (Sect. 1.22); Digital amplitude modulation systems (Sect. 1.32); Pulse amplitude modulation methods (Sect. 1.42).

Principal Publications:

PERFORMANCE ANALYSIS OF A DATA LINK SYSTEM
A. B. Glenn, IRE Trans. Commun. Syst., vol. CS-7, no. 1, May 1959, p. 14/24.

. . . the present air-traffic-control (ATC) system must be improved by a far more efficient and partially automatic system . . . As a result of both analytical and experimental work, two prefered modulation types have been chosen for further investigation . . . (FSK-AM) . . . and FSK . . . RCA is developing both systems . . .

COMPARISON OF PSK VS FSK AND PSK-AM VS FSK-AM BINARY CODED TRANSMISSION SYSTEM
A. B. Glenn, IRE Trans. Commun. Systems, vol. CS-8, no. 2, June 1960, p. 87/100.

THE CASE OF FM-AM VS FM-FM TELEMETRY
L. L. Rauch, IRE Trans. Space Electronics Telemetry, vol. SET-6, no. 2, June 1960, p. 81/84.

SIGNAL-TO-NOISE CONSIDERATIONS FOR A SPACE TELEMETRY SYSTEM
R. W. Rochelle, Proc. IRE, vol. 48, no. 4, April 1960, p. 691/693.

. . . comparison is given between the pulse-frequency channels and the pulse-width channels for the FM/PDM-AM telemetry system. It is shown that the pulse-frequency channels have either a higher signal-to-noise ratio or greater information rate capability than the pulse-width channels.

PROJECT RELAY DIGITAL COMMAND SYSTEM
S. H. Roth, et al., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 100/103.

. . . (NASA) has developed a coded message sequence consisting of discrete, pulse-duration-modulated (PDM) tone bursts for commanding satellites. The message consists of a sync pulse followed by some combination of six pulses, three each of zeros and ones. This code allows for 20 commands (the combination of six things taken three at a time). . . . equipment developed for the Relay satellite program which demodulates the tone bursts, converts the pulse-duration modualtion into a binary code, and then decodes the message into twenty discrete commands. . . .

The subcarrier tone amplitude-modulates a VHF carrier for transmision to the vehicle.

APPLICATION OF 465 TELEMETRY SYSTEM TO EVENT MARKING
A. H. Ellis, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 362/368.

. . . time division multiplex . . . telemetry transmitter. . . . p.a.m./f.m./a.m. system . . .

AN ANALYSIS OF PCM TRANSMISSION VIA SINGLE SIDEBAND
R. Gardner, et al., RCA Defense Electronic Products, New York., 1 May 1963, 191 p., AD 406 700.

. . . to determine the relative merits of single-sideband transmission as against FM transmission of multichannel (e. g. 12-channel) PCM signals, for tactical radio relay

equipment in the lower portion of the UHF range and to recommend immediate and long-range development plans . . .

Related Publications:

SYNCHRONIZATION OF SINGLE-SIDEBAND CARRIER SYSTEMS FOR HIGH-SPEED DATA TRANSMISSION
T. Combellick, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 110/114.

. . . requirements for synchronization of single-sideband carrier systems and the method of accomplishing absolute synchronization. The problems of application to existing systems and alternative solutions are discussed.

FAA DEVELOPMENT IN AIRCRAFT DATA COMMUNICATIONS
W. R. Deal, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 79/84.

. . . development and evaluation of an experimental "Automatic Ground-Air Communication System" referred to as AGACS. This two-way time division multiplex system was designed primarily for operation at 750 bits per second, and provided both frequency-shift keyed carrier (FSK) and tone-shifted amplitude-modulation (FSK-AM) options. . . .

AN ACCURATE DISCRIMINATOR FOR DEMODULATING NOISY PFM TELEMETRY SIGNALS
B. Harris, Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 3.3.

PULSE-FREQUENCY MODULATION
R. W. Rochelle, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 107/111.

Pulse-frequency modulation (PFM) has been successfully employed as the encoding technique in a number of small U. S. Earth satellites where reduction power and weight are prime considerations. This paper is concerned with the introduction of some of the more basic principles of PFM. Rather than presenting a rigorous proof on the orthogonality of this type of modulation, a comparison is made to the better-known characteristics of coded binary sequences. It is shown that PFM with quantized frequencies has the same communication efficiency in the presence of additive white Gaussian noise as a corresponding set of coded binary sequences with an equal number of quantized levels. . . . Vanguard III . . . carrying a combination of pulse-duration modulation and PFM. Similar systems were carried by Explorer X . . . Explorer XII carried the first truly PFM system into a highly elliptical orbit with an apogee of 50,000 miles. . . .

SUBJECT INDEX

The terms in the following index were taken directly from the subject contents of the individual subdivisions in the volume. The terms listed under "Included," as well as selected section and subdivision titles, were considered for inclusion in the index.

Multi-noun terms are presented in two ways: 1) the full term is listed in alphabetical order of the first noun, e.g., "aliasing error"; and 2) the full expressions are permuted or separated so as to provide multiple listings of a single expression, e.g., "error, aliasing". General usage of the technical terms is followed in the permuting process; combinations of words which fail to make technical sense are not included.

In instances where a particular term is not located in the index, the user should refer to the table of contents. When used in conjunction, the table of contents and index will enable the user to locate the proper section or subdivision and, in turn, the pertinent citations.

As a general rule, if a proper name, e.g., Fourier, identifies a theory, process, etc., the name has been included in the index. Words and expressions that denote general concepts, e.g., systems, problems, technologies and techniques, methods, etc., have not been included in the index.

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