OPTIMAL APPLICATION OF MORRISON'S ITERATIVE

NOISE REMOVAL FOR DECONVOLUTION

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OPTIMAL APPLICATION OF MORRISON'S ITERATIVE NOISE REMOVAL FOR DECONVOLUTION

Theses and Research Papers

Much of the research done in connection with this grant has been carried out by graduate students who have written Master's theses summarizing their results. These Master's theses are included as Appendices to this report, and will be referred to in the discussion. Since they are quite large, they are bound separately as three theses in four volumes:

Appendix A: James H. Leclere, Optimum Use of Morrison's Iterative Method of Noise Removal for Deconvolution

Appendix B: Aed M. El-saba, Effect of Input on Optimization of Morrison's Iterative Noise Removal for Deconvolution

Appendix C, Parts 1 and 2: Abolfazl M. Amini, Optimization of Convergent Iterative Noise Removal and Deconvolution and an Evaluation of Phase-Shift Migration.

Much of the grant work has been summarized in Semi-Annual Status Reports submitted at six month intervals over the grant period. Research papers related to the grant have also been given in those reports. Those papers are included as Appendix D at the end of this document, as well as more recent papers which have not been reported in any of the Status Reports. A list of these papers is given at the beginning of Appendix D. In addition to the theses suppported and/or directly a part of the grant research, two additional theses have been supervised by the Principal Investigators which are related to the subject of the grant. Title pages and abstracts of these theses appear in Appendix E.

Summary of Grant Research

In 1963 Morrison proposed an iterative technique of noise removal for deconvolution. The method has been applied to several data types. In 1967, 1968, and 1976, Ioup and Thomas and Ioup applied the method and proposed modifications to its use. Until the early 1980's, however, and the work of Wright (1980), Wright and Ioup (1981), and Ioup and Ioup (1981), the optimum use of the method was not known, and the number of iterations applied only approximated optimum use. Beginning in 1983 and continuing with the research in this grant, a systemmatic study of the optimum use of the method was made, as well as the related van Cittert iterative deconvolution and the always-convergent iterative techniques of noise removal and deconvolution of Ioup (1981). The results of the systemmatic study of Morrison's method are given in the thesis of Leclere (1984), which is included as Appendix A of this report. This thesis includes an investigation of the accuracy and reliability of inverse filtering. It employs both the L1 and L2 norms for the optimization. It includes both Gaussian noise with a constant standard deviation and Gaussian noise with an ordinate-dependent standard deviation. Since the optimizations are done statistically, the results are reported statistically, with means and standard deviations for optimum number of iterations and resulting mean squared error. These are given for Morrison noise removal alone and for Morrison noise removal combined with direct inverse filtering. The results have been reported by Leclere et al. (1985).

During and after completion of the thesis, Mr. Leclere investigated several related topics as a Research Associate. The first was a combination of constant and ordinate-dependent noise. It was found that the results fall between those of the constant and ordinate-dependent noise separately. He also made a thorough investigation of another method of noise removal, proposed by Morrison in 1963, of truncating the transform so that it does not exceed the response function transform if both are normalized to the same value at zero frequency. Ioup (1968) has shown that this procedure is strictly justified only for non-negative data. For almost all cases, the iterative approach was found to be more effective than the truncation used alone. When the truncation was used with the iterative approach, it often gave improvement but not always enough improvement to justify its application.

Another question investigated by Mr. Leclere was the effect of substituting point-successive for point-simultaneous iterations. The latter is the natural outgrowth of the initial formulation of the iterative method. For it, each iteration is complete before the data array is updated for the new iteration. In the point-successive technique, new data values are inserted into the array as they are calculated. This means that the point-successive technique should converge with fewer iterations. By doing the same statistical study for the point-successive technique, the savings in iterations have been shown, as well as the slight sacrifice in mean squared error values, which are so small as to suggest for the cases studied that the point-successive technique should be the one of choice.

Mr. Leclere also tested asymmetric Gaussian impulse response functions to examine the effect of the lack of symmetry on the optimization procedure. An asymmetric reponse function was constructed of two half Gaussians, each of different width. The results of this study were quite interesting. The amount of noise removal accomplished for deconvolution and the quality of the deconvolution were determiend primarily by the high-frequency behavior of the transform, and this was determiend mainly by the narrow Gaussian side. The number of iterations required, however, was much greater than either the wide or the narrow Gaussian. This requirement can be understood from the convergence properties of the iterative method and its dependence on the imaginary component of the impulse response transfer function. The convergence properties are being discussed in a publication now in preparation. In the same publication we will show that the optimization of Morrison's iterative noise removal prior to direct inverse filtering is equivalent to optimizing the unconstrained van Cittert iterative deconvolution applied without noise removal. This aspect is discussed in Mr. Leclere's thesis, Appendix A. In later optimization studies of van Cittert iterative deconvolution used alone, Mr. Leclere has shown the equivalence to hold in practice.

In theory the convolution performed at each iteration of the iterative noise removal expands the length of the data. If the expansion is included in the procedure, it causes an unnecessary waste of computer resources. However, some expansion of the data is known to be necessary to reduce adverse edge effects. For all the previously reported results only one expansion of the data has been allowed. Mr. Leclere has tested two, three, and four expansions, and shown that the second expansion has a slight effect on the results, while the higher order expansions have negligible effects. These results are related to the wraparound studies to be discussed.

The initial noise generation methods have been based on a folded Gaussian noise distribution. The folding was necessary to guarantee non-negative data, which are the type of data under investigation. In order to learn the sensitivity of the methods to the assumed form of the noise distribution, we have substituted a number of additional constant and ordinate-dependent noise probability density functions in place of the folded Gaussian. The optimum number of iterations is not very sensitive to the probability density function assumed. In fact, the curves of the mean optimum iteration number versus signal-to-noise ratio for each of the constant noise types were very similar, and the same was true for all the curves of the ordinate-dependent noise types. Even the separation between the curves of constant and ordinate-dependent noise types is not very large. This means our initial premise, that one could determine the optimum iteration number based only on the signal-to-noise ratio to characterize the noise, is probably true. This result greatly increases the utility of the method, since it appears that in addition to knowing the signal-to-noise ratio, at most one need only know the mix of ordinate-dependent and constant noise to determine the optimum iteration number. Not even details of the probability density function for the noise need be known, let alone a complete knowledge of the autocorrelation of the noise, such as is needed for the ordinary least-squares approach.

The thesis of Mr. Aed El-saba, Appendix B, reports the results of using a very different input function from that used in the studies of Mr. Leclere. It is clear from his work that when a very different input is used, the optimum iteration number is affected. Therefore in optimizing the method for a given instrument, consideration must be given to the input as well as the impulse response of the instrument.

The first simultaneous optimization of iterative noise removal and iterative deconvolution was accomplished by Mr. Abolfazl Amini, and is reported in his thesis, Appendix

C, Parts 1 and 2. The success was possible in part because the computational facilities available at the University of New Orleans were upgraded to include a VAX Cluster consisting of four VAX 8600's. Instead of the Morrison and van Cittert iterations, Mr. Amini used the related always-convergent technique of Ioup (1981), which does not suffer the convergence limitations of the prior methods. Not only is it possible from the results of Mr. Amini's work to determine the optimum iteration number for simultaneous use of the iterative technique for noise removal and deconvolution, but it is also possible for the first time to know for which signal-to-noise ratios it is efficacious to use iterative noise removal prior to iterative deconvolution, and for which it is not. The methodology is now in place to establish the results for any instrument. Complete details may be found in Appendix C. Results for seismic data (not grant supported work, but grant related) have been presented by Amini et al. (1986) and Amini et al. (1987a). Results for aerospace data will be given by Amini et al. (1988).

Mr. Leclere then applied the same techniques to optimize simultaneously the Morrison noise removal and van Cittert deconvolution iterations which are convergent for the Gaussian response functions employed in the grant research. The results of his work will be presented by Leclere et al. (1988).

All the work described thus far has been done with a wide and a narrow Gaussian used for the impulse response function except that which considered an asymmetric Gaussian. Mr. Leclere and Mr. Amini went on to include a sequence of Gaussian widths from narrow to wide in their respective simulations. Mr. Leclere's simulations were done with the Morrison and van Cittert iterations, while Mr. Amini's were with the always-convergent iterations. With these calculations accomplished three-dimensional surface plots are possible. An example is a surface describing the variation of the mean squared error with the independent variables of signal-to-noise ratio and Gaussian width. These surfaces can be extremely useful in understanding the effects of deconvolution for a given instrument. A number of these surfaces have been generated and will be reported by Amini et al. (1988) and Ioup et al. (1988). In the last Status Report submitted for this grant a claim was made that these surfaces could be used to optimize the output for an instrument after deconvolution if the relation of signal-to-noise ratio to resolution of the instrument was known. Ioup et al. (1983/84) suggested that the optimum operating instrumental parameters might not be those giving the highest resolution if deconvolution is to be used. Because it was felt to be a fruitful area of research, a proposal was submitted to NASA, titled "Determination of Design and Operation Parameters for Upper Atmospheric Research Instrumentation to Yield Optimum Resolution with Deconvolution." This proposal has been funded and research is continuing in this direction. Preliminary results of the study will be presented by Ioup et al. (1988).

The work of Mr. William S. Kamminga has been summarized in the most recent Status Report for the grant. The abstract of his thesis, "Gibbs Oscillations for Three Point Sources," is given in Appendix E, and a copy of the complete thesis has been given to the Technical Monitor.

One of the subject areas of study discussed in the grant proposal was the application of iterative deconvolution as a single window in the transform domain. Although such an application must be modified for the inclusion of function-domain constraints, it offers a major advantage in terms of speed. The thesis of Mr. Mark Whitehorn (1981) contains the first one-shot filter study. The important question to be investigated in this grant proposal was the effect of wraparound due to the telescoping of many iterations into one. The first investigation of wraparound was accomplished by Mr. Tahar Bensueid. His preliminary results seem to indicate that when no noise was present, wraparound error was negligible for all response function considered. Mr. Amini then performed a systemmatic study of the wraparound effect including noise over a whole domain of signal-to-noise ratios for seismic data. His work confirmed the findings of Mr. Bensueid and were reported by Amini et al. (1987b). The investigation of this effect for upper atmospheric research data has been the subject of the thesis work of Mr. Haihong Ni. Mr. Ni's thesis is not yet complete, but a copy of it will be given to the Technical Monitor when it is finished. His work is being reported by Ni et al. (1988). A side benefit of this research has been the availability of a fast method for optimization of the iterative techniques for impulse responses of low resolution, which require many iterations. That research will also be reported in Mr. Ni's thesis.

Although the application of the optimization studies to data which go positive and negative is not the subject of the grant, investigation of iterative deconvolution and noise removal for such data can nevertheless be revealing when contrasted to the results for nonnegative data and response functions. Mr. Edward J. Murphy has worked with oscillatory type data and has completed a thesis, "Always-Convergent Iterative Deconvolution for Acoustic Non-Destructive Evaluation." The abstract of his thesis appears in Appendix E, and a copy of his complete thesis has been given to the Technical Monitor. His work will be reported by Murphy et al. (1988).

In the renewal proposal to NASA, it was proposed to build a theoretical model of the noise removal in order to determine whether it might be possible to calculate analytically the optimum iteration number. Mr. Amini has built a theoretical model which includes the noise spectrum as well as the data spectrum and the transfer function. His model also includes the deconvolution. Unfortunately the theoretical result is a complicated function of these spectra and does not lend itself to any direct determination of the optimization. Therefore the simulation approach which has been used for our work is still the method of choice, and will be until a more efficient procedure can be found.

As part of his grant investigation, Mr. Amini also analyzed the procedure invented by LaCoste (1982) for accelerating van Cittert-type iterations. Although Lacoste's method has limited utility because of certain details of its operation, Mr. Amini was able to invent new methods of accelerating the iterations which promise to be extremely important for the deconvolution of low resolution instruments. These methods are currently being tested as part of our continuing NASA grant-supported work, and the Technical Monitor will be apprised of all new developments.

Acknowledgments

It has been a pleasure working with Dr. George M. Wood, Jr., of NASA Langley Research Center, the Technical Monitor for this grant. The investigators and their students are grateful for NASA support for this work.

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Appendix D

This Appendix contains copies of abstracts and papers reporting research performed as part of the grant and closely related research, which was not performed as part of the grant. A list of all papers follows.

James H. Leclere, George E. Ioup, and Juliette W. Ioup, A Statistical Optimization Study of Iterative Noise Removal for Deconvolution, paper presented to the American Geophysical Union, San Francisco, CA, Dec 1985 and abstracted in EOS Trans. Am. Geophys. Union 66, 983 (1985)

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A Statistical Optimization Study of Iterative Noise Removal for Deconvolution

JAMES H. LECLERE, GEORGE E. IOUP, and JULIETTE W. IOUP (Department of Physics and Geophysical Research Laboratory, University of New Orleans, New Orleans, LA 70148)

Iterative noise removal for linear deconvolution is applied in a simulation study to noise-added data sets of various noise levels to determine statistically the optimum use of the method. Typical peak-type data is selected as input and is convolved with a narrow or wide Gaussian response function to produce the data sets analyzed. Both constant and ordinate-dependent standard deviation Gaussian distributed noise is added to the data. Optimization is determined by the minimization of L1 and L2 norms or by reaching a suitably defined convergence. Results include both the mean optimum iteration number and the mean error improvement versus the signal-to-noise ratio and the statistical properties of these quantities. The results also determine the optimum use of van Cittert's iterative deconvolution, when it is applied without prior noise removal.

1. 1985 fall meeting

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A COMPARISON OF CONVERGENT ITERATIVE DECONVOLUTION METHODS WITH THE LEAST SQUARES TECHNIQUE FOR SYNTHETIC SEISMIC DATA

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SUMMARY

The reblurring/mirror image iterative procedure (RB) of Kawata and Ichioka and LaCoste, and the always-convergent iterative procedure (AC) of Ioup are compared for synthetic seismic data to standard least-squares spiking deconvolution (LS). A test is constructed which accounts for the differing assumptions of the methods. These assumptions are discussed and contrasted. The fact that the iterative or any other deconvolution technique can use an approach to minimum phase wavelet estimation equivalent to that of the zero delay LS spiking deconvolution (except for noise) is discussed. Varying spike separations and heights are employed to test the resolution of the techniques for noise-free data and for data with a signal-to-noise ratio of 40. The results show that the RB deconvolves slowly as a function of iteration number and is not very sensitive to noise. The LS and AC deconvolutions for the noise-free data are very similar. For the noisy data the LS gives slightly more resolution and slightly less noise than the 50 iteration result selected for the AC. Finally, techniques for improving the results are summarized.

The development of the reblurring/mirror image iterative procedure (RB) of Kawata and Ichioka (1980) and LaCoste (1982) and the always-convergent iterative technique (AC) of Ioup (1981) enhances the applicability of iterative methods to spiking and shaping deconvolution of seismic data. It is important to compare these methods to the standard least-squares approach (LS) (Robinson, 1980; Robinson and Treitel, 1980). This comparison is made difficult by the fact that the assumptions for the LS can differ significantly from those of the iterative techniques. The former often assumes that the autocorrelation of the wavelet may be calculated from that of the data, for non-noisy data, if the input spike series is white. It assumes the phase of the wavelet to be minimum for zero-delay spiking, or it assumes that the wavelet is known so that the optimum delay or shape for the desired output may be selected. It is possible to use sideways recursion to determine the optimum delay for deconvolution, again with knowledge of the wavelet (Wiggins and Robinson, 1965; Simpson et al., 1963). The iterative techniques assume the wavelet is known. Although the LS in general requires the power spectrum of the noise, this does not present a difficulty if it may be assumed that the signal and noise are uncorrelated. This is because the filter calculation requires the autocorrelation of the wavelet plus the autocorrelation of the noise as a single factor, and this autocorrelation may be taken to be the autocorrelation of the seismic data, provided the signal and noise are uncorrelated and the white input assumption holds. For automatic application, the iterative techniques require a general characterization of the noise, e.g., by the signal-to-noise ratio (S/N) of the data, to guide the determination of the optimum number of iterations for deconvolution (Leclere, 1984).

The differences in these approaches to the data are not as great as they might seem. For example, in the zero delay spiking for the LS, Wold decomposition (Wold, 1954) and an intrinsic miminum delay (minimum phase) assumption are used to incorporate the wavelet. But Wold decomposition may be used to find the autocorrelation of the wavelet from the data prior to any method of deconvolution with the same assumption of a white input. A standard calculation (Oppenheim and Schafer, 1975; Claerbout, 1976) may then be made to find the corresponding minimum phase wavelet, independent of the least-squares approach. A difficulty is that the noise will be a contaminant in the autocorrelation and so must be accounted for. As the techniques of wavelet estimation become more successful for seismic data, this problem may be overcome, and it is possible with further developments that neither the minimum nor any other phase assumption will be necessary. It is also possible that making the noise a part of the wavelet autocorrelation will be beneficial to the iterative techniques as it is to the least-squares method.

Since we are adding noise to synthetic data, we can construct a test which we feel is fair to all three methods and still meaningful. The wavelet is taken to be minimum phase so that it is the appropriate wavelet for zero-delay spiking deconvolution. Since the noise-free data are known, the autocorrelation of the noise can be calculated for the purpose of achieving an optimum LS filter without the assumption of a white input spike series. The S/N for the data is also available to guide in the selection of the number of iterations to be used in the iterative techniques. It should be emphasized that this paper is concerned with deconvolution performance for noise-free and noisy data, and not with comparisons of computer economics, since the present iterative techniques have not been optimized for speed. To examine the limits of resolution for the techniques, an input spike series was created with systematically increasing separations for the spikes for two equal spikes and for second spikes having heights of 0.5 and 0.25 of the first. This was done both for spikes of the same polarity and for two spikes with opposite polarity. The separations of the spikes were successively increased by one from two sample intervals to seven sample intervals.

The results of the deconvolution for the same polarity data are given in Fig. 1, and those of opposite polarity in Fig. 2. In each figure the top three tests are for the noise-free data and the bottom three are for the same data with noise added for a S/N of 40. Each trace in a set of three corresponds to a different deconvolution technique. The order from top to bottom in these sets is (1) RB, (2) zero delay spiking LS, and (3) AC. For the RB, 400 iterations were used in all applications. For the LS a 100 length filter was applied. For the AC, the noise-free result is that of 200 iterations, while the noisy result is that of 50 iterations.

The RB is a slow function of iteration number compared to other iterative techniques, and this is apparent in all cases. The resolution even after 400 iterations is significantly less than that of the other two methods. As expected, however, the sensitivity to noise is also much less. The performance of the LS and the AC are similar for the noise-free data. Comparison for the noisy data shows slightly less resolution and slightly more noise for the AC result of fifty iterations. A good idea of the resolution performance may be obtained from the figures; however, no firm conclusions should be drawn for the noisy data until a study is done over many cases.

There are important improvements for all three methods which are not a part of the basic test results shown in these figures. The RB may be accelerated as a function of iteration number using the procedure given by LaCoste (1982). For the noisy data the LS spiking filter can be replaced by a shaping filter (using the known wavelet in the filter design) which would be less sensitive to noise. An additional white noise term may be added to the noise autocorrelation in the filter design, again to reduce the sensitivity to noise. Both of these changes would reduce the resolution in the result. A longer filter can also be used to improve the result. The AC is less sensitive to noise if preceeded by an always-convergent iterative noise removal technique which has not been used for this basic test (Ioup, 1981; Ioup and Ioup, 1983; Ioup et al., 1983/1984).

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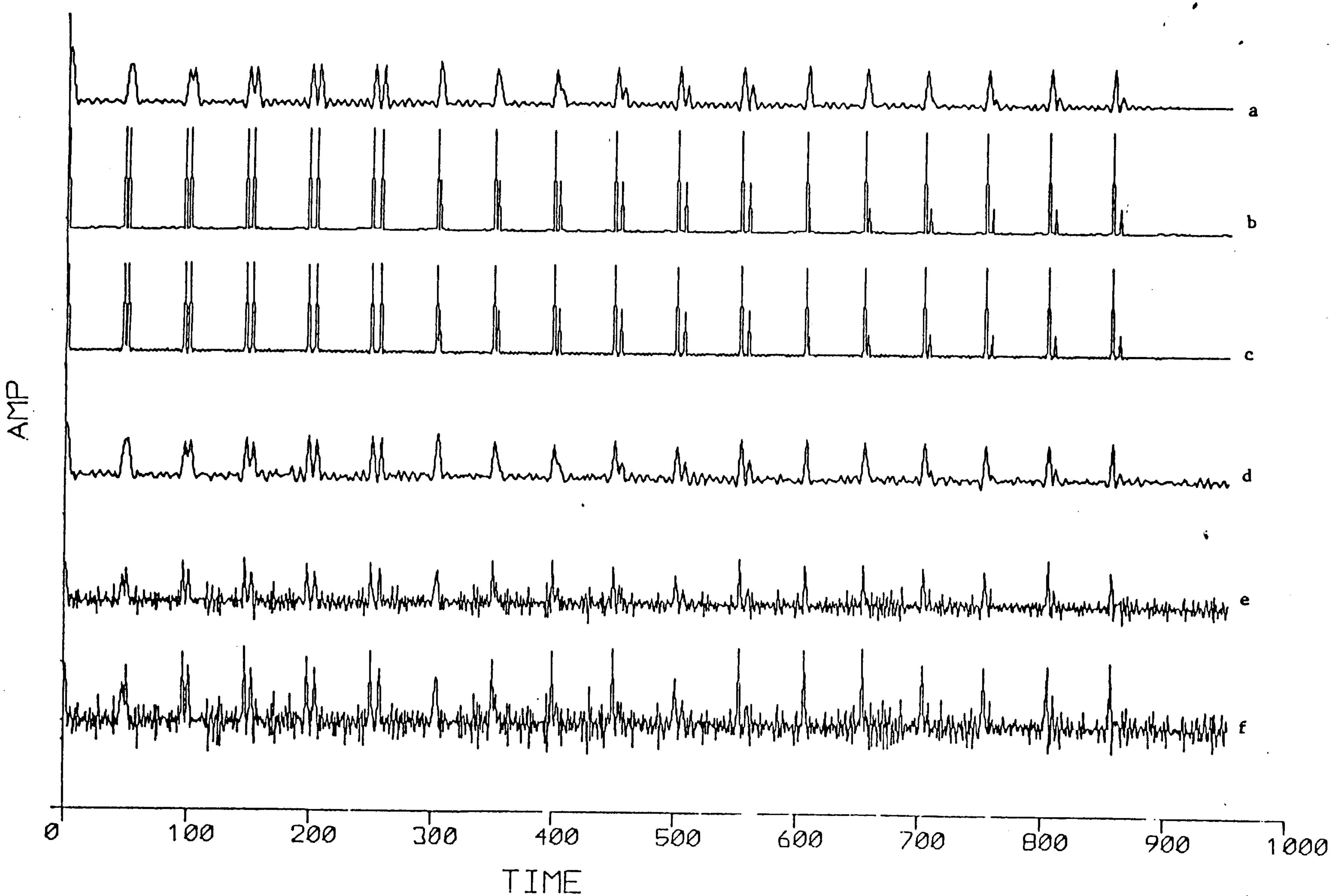

Fig. 1. Same polarity test case. (a), (b), and (c) no noise; (d), (e), and (f) 40 S/N. (a) and (d) reblurring procedure; (b) and (e) least squares procedure; (c) and (f) always convergent iterative procedure.

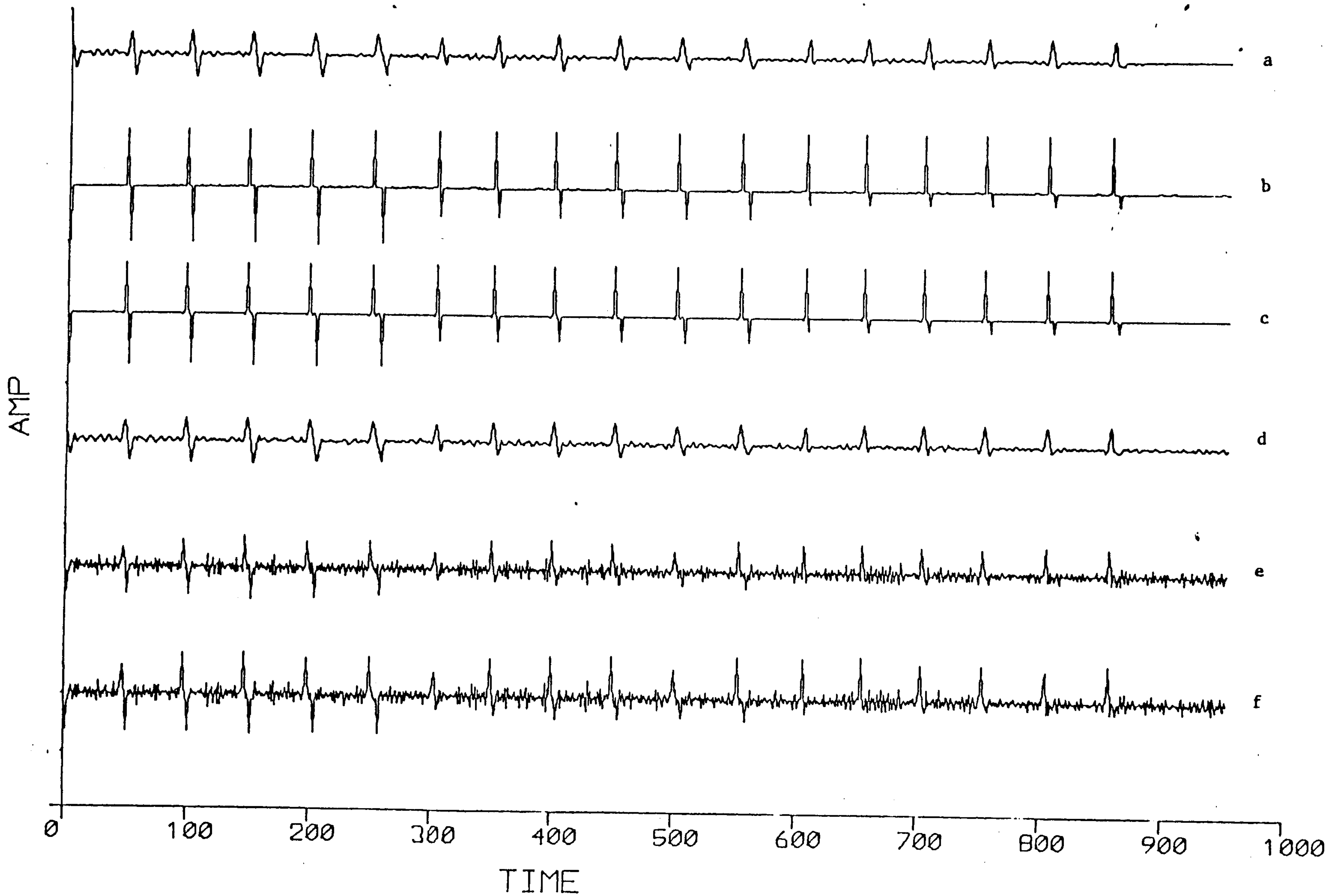

Fig. 2. Opposite polarity test case. (a), (b), and (c) no noise; (d), (e), and (f) 40 S/N. (a) and (d) reblurring procedure; (b) and (e) least squares procedure; (c) and (f) always convergent iterative procedure.

OPTIMUM USE OF MORRISON'S ITERATIVE METHOD OF NOISE REMOVAL FOR DECONVOLUTION

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TABLE OF CONTENTS

		PAGE
CHAPTER I:	INTRODUCTION	1
CHAPTER II:	INVERSE FILTER	4
CHAPTER III:	MORRISON'S METHOD FOR NOISE REMOVAL ALONE	69
CHAPTER IV:	MORRISON'S METHOD PRIOR TO DECONVOLUTION	186
CHAPTER V:	CONCLUSION	286
REFERENCES		291
APPENDIX		292
VITA		332

LIST OF TABLES

Table			Page
(2.1)	:	Narrow Gaussian Error	20
(2.2)	:	Wide Gaussian Error	21
(2.3)	:	Difference Gaussian Error	22
(3.1)	:	Narrow Ordinate SNR	96
(3.2)	:	Narrow Ordinate SNR	97
(3.3)	:	Narrow Constant SNR	98
(3.4)	:	Narrow Constant SNR	99
(3.5)	:	Wide Ordinate SNR	100
(3.6)	:	Wide Ordinate SNR	101
(3.7)	:	Wide Constant SNR	102
(3.8)	:	Wide Constant SNR	103
(3.9)	:	Narrow Ordinate Iteration	104
(3.10)	:	Narrow Ordinate Iteration	105
(3.11)	:	Narrow Constant Iteration	106
(3.12)	:	Narrow Constant Iteration	107
(3.13)	:	Wide Ordinate Iteration	108
(3.14)	:	Wide Ordinate Iteration	109
(3.15)	:	Wide Constant Iteration	110
(3.16)	:	Wide Constant Iteration	111
(3.17)	:	Narrow Ordinate Error	112
(3.18)	:	Narrow Ordinate Error	113
(3.19)	:	Narrow Constant Error	114
(3.20)	:	Narrow Constant Error	115
(3.21)	:	Wide Ordinate Error	116
(3.22)	:	Wide Ordinate Error	117

Table			Page
(3.23)	:	Wide Constant Error	118
(3.24)	:	Wide Constant Error	119
(4.1)	:	Narrow Ordinate Iteration	205
(4.2)	:	Narrow Ordinate Iteration	206
(4.3)	:	Narrow Constant Iteration	207
(4.4)	:	Narrow Constant Iteration	208
(4.5)	:	Narrow Ordinate Error	209
(4.6)	:	Narrow Ordinate Error	210
(4.7)	:	Narrow Constant Error	211
(4.8)	:	Narrow Constant Error	212
(4.9)	:	Wide Ordinate Iteration	213
(4.10)	:	Wide Ordinate Iteration	214
(4.11)	:	Wide Constant Iteration	215
(4.12)	:	Wide Constant Iteration	216
(4.13)	:	Wide Ordinate Error	217
(4.14)	:	Wide Ordinate Error	218
(4.15)	:	Wide Constant Error	219
(4.16)	:	Wide Constant Error	220

LIST OF FIGURES - CHAPTER II

Figure			Page
(2.1)	:	System	4
(2.2)	:	Narrow Gaussian	23
(2.3)	:	Wide Gaussian	24
(2.4)	:	Input	25
(2.5)	:	Narrow Output	26
(2.6)	:	Wide Output	27
(2.7)	:	Wide 1/G(s), NT=32	28
(2.8)	:	Wide Filter, NT=32	29
(2.9)	:	Wide 1/G(s), NT=64	30
(2.10)	:	Wide Filter, NT=64	31
(2.11)	:	Wraparound Overlay	32
(2.12)	:	Narrow 1/G(s), NT=64	33
(2.13)	:	Narrow Filter, NT=64	34
(2.14)	:	Prepared g	35
(2.15)	:	Transform	36
(2.16)	:	Magnitude	37
(2.17)	:	Filter	38
(2.18)	:	Narrow Filter, NT=32	39
(2.19)	:	Narrow Filter, NT=4096	40
(2.20)	:	Wide Filter, NT=32	41
(2.21)	:	Wide Filter, NT=128	42
(2.22)	:	Wide Filter, NT=4096	43
(2.23)	:	Narrow Deconvolution, NT=32	44
(2.24)	:	Narrow Deconvolution, NT=64	45
(2.25)	:	Narrow Deconvolution, NT=4096	46

Figure			Page
(2.26)	:	Wide Deconvolution, NT=32	47
(2.27)	:	Wide Deconvolution, NT=64	48
(2.28)	:	Wide Deconvolution, NT=128	49
(2.29)	:	Wide Deconvolution, NT=250	50
(2.30)	:	Wide Deconvolution, NT=4096	51
(2.31)	:	Narrow SMABER/L	52
(2.32)	:	Narrow SMSQER/L	53
(2.33)	:	Narrow SMABER/M	54
(2.34)	:	Narrow SMSQER/M	55
(2.35)	:	Narrow SMSQER/(NT+M)	56
(2.36)	:	Wide SMABER/L	57
(2.37)	:	Wide SMSQER/L	58
(2.38)	:	Wide SMABER/M	59
(2.39)	:	Wide SMSQER/M	60
(2.40)	:	Wide SMSQER/(NT+M)	61
(2.41)	:	Narrow SMABDF/M	62
(2.42)	:	Narrow SMSQDF/M	63
(2.43)	:	Narrow SMABDF/(NT+M)	64
(2.44)	:	Narrow SMSQDF/(NT+M)	65
(2.45)	:	Wide SMABDF/(NT+M)	66
(2.46)	:	Wide SMSQDF/(NT+M)	67
(2.47)	:	Narrow Single Precision	68

LIST OF FIGURES - CHAPTER III

Figure			Page
(3.1)	:	Narrow Constant, SNR=2	120
(3.2)	:	Narrow Ordinate, SNR=2	121
(3.3)	:	Narrow Ordinate NSF	122
(3.4)	:	Narrow Constant NSF	123
(3.5)	:	Wide Ordinate NSF	124
(3.6)	:	Wide Constant NSF	125
(3.7)	:	Narrow Ordinate L1 AVITNM	126
(3.8)	:	Narrow Ordinate L1 AVITNM	127
(3.9)	:	Narrow Ordinate L2 AVITNM	128
(3.10)	:	Narrow Ordinate L2 AVITNM	129
(3.11)	:	Narrow Constant L1 AVITNM	130
(3.12)	:	Narrow Constant L1 AVITNM	131
(3.13)	:	Narrow Constant L2 AVITNM	132
(3.14)	:	Narrow Constant L2 AVITNM	133
(3.15)	:	Wide Ordinate L1 AVITNM	134
(3.16)	:	Wide Ordinate L1 AVITNM	135
(3.17)	:	Wide Ordinate L2 AVITNM	136
(3.18)	:	Wide Ordinate L2 AVITNM	137
(3.19)	:	Wide Constant L1 AVITNM	138
(3.20)	:	Wide Constant L1 AVITNM	139
(3.21)	:	Wide Constant L2 AVITNM	140
(3.22)	:	Wide Constant L2 AVITNM	141
(3.23)	:	Narrow Ordinate L1 AVERNM	142
(3.24)	:	Narrow Ordinate L1 AVERNM	143
(3.25)	:	Narrow Ordinate L2 AVERNM	144

Figure			Page
(3.26)	:	Narrow Ordinate L2 AVERNM	145
(3.27)	:	Narrow Constant L1 AVERNM	146
(3.28)	:	Narrow Constant L1 AVERNM	147
(3.29)	:	Narrow Constant L2 AVERNM	148
(3.30)	:	Narrow Constant L2 AVERNM	149
(3.31)	:	Wide Ordinate L1 AVERNM	150
(3.32)	:	Wide Ordinate L1 AVERNM	151
(3.33)	:	Wide Ordinate L2 AVERNM	152
(3.34)	:	Wide Ordinate L2 AVERNM	153
(3.35)	:	Wide Constant L1 AVERNM	154
(3.36)	:	Wide Constant L1 AVERNM	155
(3.37)	:	Wide Constant L2 AVERNM	156
(3.38)	:	Wide Constant L2 AVERNM	157
(3.39)	:	Noise Overlay	158
(3.40)	:	Narrow Ordinate Before, SNR=2	159
(3.41)	:	Narrow Ordinate After, SNR=2	160
(3.42)	:	Narrow Ordinate Before, SNR=47	161
(3.43)	:	Narrow Ordinate After, SNR=47	162
(3.44)	:	Narrow Ordinate L1 After, SNR=264	163
(3.45)	:	Narrow Ordinate L2 After, SNR=264	164
(3.46)	:	Narrow Ordinate L1 After, SNR=1075	165
(3.47)	:	Narrow Ordinate L2 After, SNR=1075	166
(3.48)	:	Narrow Constant Before, SNR=2	167
(3.49)	:	Narrow Constant After, SNR=2	168
(3.50)	:	Narrow Constant Before, SNR=46	169
(3.51)	:	Narrow Constant L2 After, SNR=46	170

Figure			Page
(3.52)	:	Narrow Constant L2 After, SNR=262	171
(3.53)	:	Narrow Constant L2 After, SNR=1043	172
(3.54)	:	Wide Ordinate Before, SNR=2	173
(3.55)	:	Wide Ordinate After, SNR=2	174
(3.56)	:	Wide Ordinate Before, SNR=47	175
(3.57)	:	Wide Ordinate L2 After, SNR=47	176
(3.58)	:	Wide Ordinate L2 After, SNR=260	177
(3.59)	:	Wide Ordinate Before, SNR=1080	178
(3.60)	:	Wide Ordinate L2 After, SNR=1080	179
(3.61)	:	Wide Constant Before, SNR=2	180
(3.62)	:	Wide Constant After, SNR=2	181
(3.63)	:	Wide Constant Before, SNR=47	182
(3.64)	:	Wide Constant L2 After, SNR=47	183
(3.65)	:	Wide Constant L2 After, SNR=267	184
(3.66)	:	Wide Constant L2 After, SNR=1084	185

LIST OF FIGURES - CHAPTER IV

Figure			Page
(4.1)	:	Narrow Ordinate AVITNM L1	221
(4.2)	:	Narrow Ordinate AVITNM L1	222
(4.3)	:	Narrow Ordinate AVITNM L2	223
(4.4)	:	Narrow Ordinate AVITNM L2	224
(4.5)	:	Narrow Constant AVITNM L1	225
(4.6)	:	Narrow Constant AVITNM L1	226
(4.7)	:	Narrow Constant AVITNM L2	227
(4.8)	:	Narrow Constant AVITNM L2	228
(4.9)	:	Narrow Ordinate AVERNM L1	229
(4.10)	:	Narrow Ordinate AVERNM L1	230
(4.11)	:	Narrow Ordinate AVERNM L2	231
(4.12)	:	Narrow Ordinate AVERNM L2	232
(4.13)	:	Narrow Constant AVERNM L1	233
(4.14)	:	Narrow Constant AVERNM L1	234
(4.15)	:	Narrow Constant AVERNM L2	235
(4.16)	:	Narrow Constant AVERNM L2	236
(4.17)	:	Narrow Ordinate Before, SNR=2	237
(4.18)	:	Narrow Ordinate After, SNR=2	238
(4.19)	:	Narrow Ordinate Before, SNR=49	239
(4.20)	:	Narrow Ordinate After, SNR=49	240
(4.21)	:	Narrow Ordinate Before, SNR=270	241
(4.22)	:	Narrow Ordinate L1 After, SNR=270	242
(4.23)	:	Narrow Ordinate L2 After, SNR=270	243
(4.24)	:	Narrow Ordinate Before, SNR=1017	244
(4.25)	:	Narrow Ordinate L2 After, SNR=1017	245

Figure			Page

(4.26) : Narrow Constant Before, SNR=2 246

(4.27) : Narrow Constant After L2, SNR=2 247

(4.28) : Narrow Constant Before, SNR=46 248

(4.29) : Narrow Constant After L2, SNR=46 249

(4.30) : Narrow Constant Before, SNR=260 250

(4.31) : Narrow Constant After L1, SNR=260 251

(4.32) : Narrow Constant After L2, SNR=260 252

(4.33) : Narrow Constant Before, SNR=1050 253

(4.34) : Narrow Constant After L2, SNR=1050 254

(4.35) : Wide Ordinate L1 AVITNM 255

(4.36) : Wide Ordinate L2 AVITNM 256

(4.37) : Wide Constant L1 AVITNM 257

(4.38) : Wide Constant L2 AVITNM 258

(4.39) : Wide Ordinate After L1, SNR=262 259

(4.40) : Wide Ordinate After L2, SNR=262 260

(4.41) : Wide Ordinate L2 AVITNM 261

(4.42) : Wide Constant L2 AVITNM 262

(4.43) : Wide Ordinate L2 AVERNM 263

(4.44) : Wide Ordinate L2 AVERNM 264

(4.45) : Wide Constant L2 AVERNM 265

(4.46) : Wide Constant L2 AVERNM 266

(4.47) : Wide Ordinate Before, SNR=2 267

(4.48) : Wide Ordinate L2 After, SNR=2 268

(4.49) : Wide Ordinate Before, SNR=47 269

(4.50) : Wide Ordinate L1 After, SNR=47 270

(4.51) : Wide Ordinate L2 After, SNR=47 271

Figure			Page
(4.52)	:	Wide Ordinate Before, SNR=262	272
(4.53)	:	Wide Ordinate L2 After, SNR=262	273
(4.54)	:	Wide Ordinate Before, SNR=1035	274
(4.55)	:	Wide Ordinate L2 After, SNR=1035	275
(4.56)	:	Wide Constant Before, SNR=2	276
(4.57)	:	Wide Constant L2 After, SNR=2	277
(4.58)	:	Wide Constant Before, SNR=47	278
(4.59)	:	Wide Constant L1 After, SNR=47	279
(4.60)	:	Wide Constant L2 After, SNR=47	280
(4.61)	:	Wide Constant Before, SNR=263	281
(4.62)	:	Wide Constant L2 After, SNR=263	282
(4.63)	:	Wide Constant Before, SNR=1042	283
(4.64)	:	Wide Constant L2 After, SNR=1042	284
(4.65)	:	Weighted Error Measure	285

ABSTRACT

Morrison's iterative method of noise removal, or Morrison's smoothing, is applied in a simulation to noise-added data sets of various noise levels to determine the optimum use of the method. Morrison's smoothing is applied for noise removal alone, and for noise removal prior to deconvolution.

For the latter calculation, an accurate method of deconvolution is analyzed to provide confidence in the optimization. The method of deconvolution consists of convolving the data with an inverse filter calculated by taking the inverse discrete Fourier transform of the reciprocal of the transform of the response of the system. Various length filters are calculated for the narrow and wide gaussian response fuctions used. Deconvolution of non-noisy data is performed, and the error in each deconvolution calculated. Plots are produced of error versus filter length; and from these plots the most accurate length filters are determined.

The statistical methodologies employed in the optimizations of Morrison's method are similar. A typical peak-type input is selected and convolved with the two response fuctions to produce the data sets to be analyzed. Both constant and ordinate-dependent gaussian distributed

noise is added to the data, where the noise levels of the data are characterized by their signal-to-noise ratios. The error measures employed in the optimizations are the L1 and L2 norms. Results of the optimizations for both gaussians, both noise types, and both norms include figures of optimum iteration number and error improvement versus signal-to-noise ratio, and tables of results. The statistical variation of all quantities considered is also given.

The computer codes employed are included in the appendix; and the correspondence with an optimization of van Cittert's iterative deconvolution and suggestions for future research are also given.

CHAPTER I

INTRODUCTION

Morrison's noise removal (Morrison, 1963), or Morrison's smoothing, is an iterative technique in which the first iteration smoothes the data to which it is applied, and which with each subsequent iteration restores the data to the original, except for incompatable noise, upon convergence of the method It has been shown by Ioup(1968), Wright(1980), Ioup et al (1983/1984), and others, that the iterations may be terminated before convergence of the method and a reasonable approximation to the noise free signal obtained. Indeed, this approximation can be better than that obtained on convergence. This work concerns the optimum use of Morrison's noise removal for noise removal alone, and for noise removal prior to deconvolution. It should be noted that the primary use of Morrison's method is for noise removal prior to deconvolution, and the reader may be familiar with more effective methods for noise removal alone.

Before a study can be undertaken to determine the optimum use of Morrison's noise removal prior to deconvolution, some determination of the accuracy of the operation of the deconvolution itself must be made. Chapter II outlines the method for choosing the most accurate length inverse filter, calculated from the response of the system, to be used for deconvolution. Included is the procedure for calculating the filter, along with the testing methodology for determining accuracy. Also given is a detailed discussion of the theoretical and experimental errors which most affect the reliability of the filter and the accuracy of the deconvolution.

Chapter III is a study of the optimum use of Morrison's smoothing for noise removal alone. A statistical study is performed in which the optimum use of Morrison's noise removal is determined when applied to data sets of varying noise levels. A discussion of the types of noise added to the data is provided and the statistical methodology employed for optimization is outlined. Plots of optimization results. i e optimum iteration number versus noise level are provided, as are tables listing numerical results. A detailed analysis of the results obtained is also given, including tables and plots showing the improvement at the optimum iteration number. The statistical variation of all results is also given.

The study of the optimum use of Morrison's smoothing prior to deconvolution is dicussed in Chapter IV. Here Morrison's smoothing is applied to data sets having approximately the same noise levels as those of Chapter III, and deconvolution is performed after each of Morrison's iterations by applying the most accurate length filter calculated in Chapter II. The optimization, i.e., the choice of optimum iteration number, is based on the deconvolved result. The statistical method of optimization is provided, along with an analysis of results. Plots of optimum iteration number and the corresponding noise reduction versus noise level are produced.

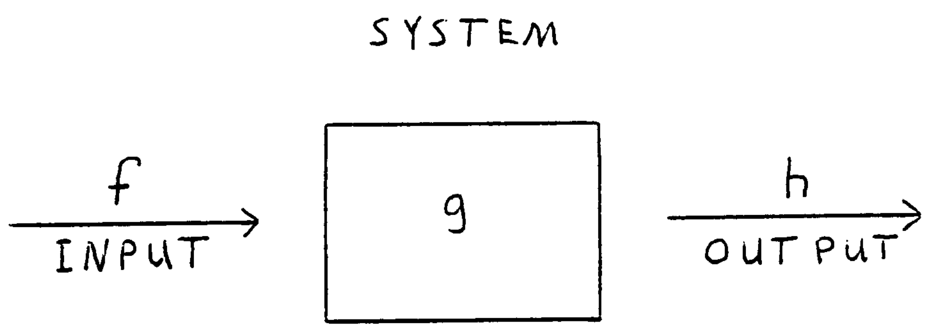
A comparison of the optimum use of Morrison's smoothing for noise removal alone and prior to deconvolution is given in the conclusion section. Guidelines are given which a user may follow in the application of the results obtained in the preceeding chapters. Also, the correspondence of Morrison's method with van Cittert's iterative method of deconvolution is given, as are suggestions for further research. The appendix lists all of the computer programs used to calculate the results of this study, and contains brief computer documentation for each program.

CHAPTER II

INVERSE FILTER

Input to any linear, shift-invariant system is distorted by the system itself, where the effect on the input is determined by the impulse response of the system. The output of the system is the distorted input. This effect of the impulse response on the input is represented mathematically by the convolution of the input and the impulse response, or discretely by their serial product, convolution sum, or discrete convolution (Bracewell, 1978).

Figure (2.1)



The convolution integral is:

$$h(x) = \int_{-\infty}^{+\infty} f(u)\; g(x-u)\; du$$

where f is the input, g the impulse response of the system, and h the distorted output.

To remove the effect of the response, the output is deconvolved. One approach is that a function domain inverse filter is calculated from the response of the system, which when convolved with the output results in a good approximation of the original input. There are several methods used for the calculation of an inverse filter. The technique used in this work is to take the inverse transform of the Discrete Fourier Transform (DFT) of the impulse response:

$$f(x) * \quad (x) = h(x)$$

$$F(s)\ G(s) = H(s)$$

$$F(s) = H(s)\ (1/G(s))$$

$$f(x) = h(x) * (\text{inverse filter}(x)) \ ,$$

$$\text{inverse filter}(x) = 1/NT \sum_{s=1}^{NT} (1/\ G(s)\ )\ e^{+i2\pi sx/NT}$$

where capital letters denote the Fourier transform representations of the corresponding functions, and the Fourier transform of the convolution of f and g is the product of their transforms by the Convolution Theorem (Bracewell, 1978). NT is the number of discrete frequency components contained in 1/G(s) , and x and s are the function and transform domain variables, respectively.

Before deconvolution, it is desired to know something about the accuracy of the inverse filter calculated. As will be shown, the accuracy of the filter is very dependent on the length of the filter, and this chapter concerns the calculation and test procedure used in determining the optimum length filter for the technique employed.

In a previous work Wright(1980) constructed the gaussian impulse response functions of two widths and the realistic input to the system which are used for this study.

The gaussian responses are discrete real valued functions of nine and twenty-one points, both with unit area. Both re ponses are represented by g, and their number of points by N. They are referred to as the narrow and wide gaussians and are shown in figures (2.2) and (2.3), respectively.

The input consists of three gaussians representing approximate impulses input to the system, where the peaks are close enough to have overlap after convolution with g. The string of approximate impulses is twenty-four points in length, with zeroes on the ends and in between the peaks. The input is represented by f, the number of points by L, and f is shown in figure (2.4).

As mentioned above, the output of the system, represented by h, is the convolution of the input with the response of the system. The length of the output is N+L-1 points (Bracewell, 1978), where the lengths for the outputs of the narrow and wide gaussian responses are thirty-two and forty-four points, respectively. These lengths are represented by M, and figures (2.5) and (2.6) are plots of these outputs.

Wraparound Error

Since the system considered is entirely discrete we assume there is no error due to sampling (Bracewell, 1978). Thus theoretically the most significant effect on the accuracy of the inverse filter is wraparound error in the function domain (Oppenheim and Schafer, 1975). The wraparound is significant because the filter is calculated from a sampled transform domain function with frequency components of large magnitude at the edges of the window. A procedure to reduce this effect is to reduce the sampling interval in the transform domain, or correspondingly, to add zeroes in the function domain. This results in widening the function domain window of the filter, thus reducing the error introduced by wraparound. In this study filters of increasing length are calculated, with the purpose being to choose the most accurate length filter applicable.

Figures (2.7) through (2.11) show how too coarse a sampling interval in the transform domain causes significant wraparound in the calculation of the filter, and how sampling at a finer rate can reduce this effect greatly.

Figure (2.7) is the coarsely sampled function 1/G(s), and figure (8) is the inverse filter calculated from 1/G(s). The transform domain function has NT=32 points and the inverse filter has NT+1=33 points. More will be said later as to why the filter is one point longer. There is significant wraparound with the 33 point filter as overlap from the replicated windows interferes with the window of intrest.

Figures (2.9) and (2.10) show 1/G(s) sampled at a finer interval, NT=64. and the corresponding 65 point inverse filter, respectively. Note that increasing the number of points in the transform increases the length of the filter, thus reducing the wraparound significantly. A portion of both length filters is overlayed in figure (2.11), where the effect from wraparound can be observed in the 32 point filter.

It should be noted that a filter calculated from the narrow gaussian has less wraparound than a wide gaussian filter of the same length and sampling interval. The transform of the narrow gaussian, G(s), is wider and has larger values at the edges of it's window. When the filter is calculated from the reciprocal of the transform, 1/G(s), the filter has less oscillations and dies off more rapidly since the narrow case 1/G(s) has smaller values at the window edges. Observe the 64 point reciprocal, 1/G(s) , and the 65 point narrow gaussian filter shown in figures (2.12) and (2.13), respectively.

It is noted, and it will be discussed in more detail later, that the precision with which the calculations are carried out has an effect in determining the optimum length filter, as round-off error in the calculations can cause inconsistency and erroneous results in the test procedure.

Inverse Filter Calculation

To calculate an inverse filter from one of the two response functions (the calculation for the wide gaussian 65 point filter is shown here) the function is first prepared so that it´s transform can be calculated with the Fast Fourier Transform (FFT) subroutine used (Higgins, 1976).

The FFT subroutine requires that input data have real and imaginary components and that the number of points input, NT, be a power of two greater than two (Higgins, 1976). To meet these requirements, and to increase the length of the filter to reduce wraparound zeroes are added to the end of the data so that the length is NT. Then zeroes representing the imaginary part of the data are added between successive real points, and on the end, until the total length is 2NT. For this study NT will have values 32,64.... 4096. Figure (2.14) is the prepared wide gaussian with NT=64, where the zero imaginary component is not shown.

As the peak of the response is not centered on the origin, the response is shifted in the function domain. When the Fourier transform of the shifted gaussian is calculated, the phase will be effected thusly (Bracewell, 1978):

$$g(x-a) \supset \exp(-i2\pi sa)G(s)$$

where G(s) is the transform of g(x), "a" represents the amount that g is shifted from the origin, and $i2\pi sa$ represents the delay in phase. Figure (2.15) is the transform of the shifted function, where the real component is denoted by "o", and the imaginary part by "x".

The magnitude of the transform is then calculated eliminating the delay in phase:

$$G(s) = \left([Re(G(s))]^2 + [Im(G(s))]^2 \right)^{1/2} = G_o(s)$$

The 64 point G(s) is shown in figure (2.16), where the high positive and negative frequencies are located at the center of the window. It is the small magnitude high frequencies which increase the wraparound.

The reciprocal of G(s) is calculated, figure (2.9), and zeroes are then added between successive real points, and at the 2NT´th point, in preperation for applying the inverse FFT to calculate the inverse filter. The 64 point inverse filter is shown in figure (2.17).

For the deconvolution calculations that follow, the peak is shifted to the center of the window and the filter made symmetric by dividing the first point of the shifted filter by two and adding a sixty-fifth point (NT+1) equal to the first point. The result is a real, symmetric, NT+1 length inverse filter. Figure (2.10) shows the 65 point symmetric inverse filter.

Optimum Length Test Procedure

The methodology employed in determining the optimum length filter to use for deconvolution is to calculate inverse filters of lengths 33,65,...,4097, as just described, for each of the two response functions. Noise free data h are then deconvolved by applying each of the various length symmetric filters. The results of the deconvolutions are compared to the known input f, and also with the result of the deconvolution performed with the longest length filter, with suitable error measures. In the latter instance this deconvolution is assumed to be the most accurate, as might be done if f is not known. There are some minor problems with this assumption as will be discussed.

The error measures used in the comparisons with f are the sum of the absolute error, and the sum of the squared error, or variance, per point. These measures are calculated over the input window L, the data window M, and the full range of the deconvolution NT+M. The notations used for the two measures for the window L are SMABER/L and SMSQER/L, respectively. For the window M the expressions are:

$$\text{SMABER/M} = (1/M) \sum_{I=1}^{M} \text{HN}(I) - f(I)$$

and

$$\text{SMSQER/M} = (1/M) \sum_{I=1}^{M} (\text{HN}(I) - f(I))^2$$

where HN(I) is the deconvolved result.

For comparison to the longest length filter, the sum of the absolute difference and sum of the squared difference per point, SMABDF/(NT+M) and SMSQDF/(NT+M), respectively, are calculated. f(I) is replaced by the longest filter result in the above expressions.

Plots are produced of the various length inverse filters and the deconvolution results, figures (2.10), (2.13), and (2.18)-(2.30), and of the error versus the number of points of the filter, figures (2.31)-(2.46).

From the error plots it is possible to choose the most accurate length filter to apply in deconvolution for the width response under consideration. The sensitivity of deconvolution to small error in the inverse filter can be seen by observing the plots of the filter and deconvolution for the wide gaussian 65 point case, figures (2.10) and (2.27). Comparing the 65 point filter with the 4097 point filter, figure (2.22), no apparent wraparound is noticed in the 65 point case, yet in the deconvolved result the error is readily observable. This effect is most easily understood in the transform domain. At frequencies where G(s) is small, small changes in G(s) can be large percentage changes in G(s) , 1/ G(s) , and the deconvolved result, F(s)=H(s)/G(s).

Test Results

For all length filter plots, figures (2.18)-(2.22), of both narrow and wide gaussian cases, only the 33 point wide gaussian case filter shows evidence of wraparound. Plots of the deconvolutions, figures (2.23)-(2.30), show wraparound only in the 65 and 129 point wide cases. Yet, the error results, figures (2.35) and (2.40), for both the narrow and wide gaussians, when calculated over the full range of the deconvolution, show a monotonic decrease in error as the filter length increases.

It should be noted, that doing all computer calculations in double (or even a higher) precision is esential for consistent results in both the narrow and wide gaussian cases because of the sensitivity of the calculations to round-off error. No attempt to reduce this sensitivity by alteration of calculations is made. For routine calculations this would be important. All results given here are double precision results unless otherwise specified. Doing calculations in single precision was originally attempted and there was little consistency in the results; many of the results were simply wrong.

The deconvolution is especially sensitive to the precision of the calculation as there are many additions and subtractions of very small numbers in the inverse filter with relatively large values in the data. The inverse filter calculation also contributes greatly to round-off error, perhaps even more so than the deconvolution calculation (this was not determined) because of the large magnitude of 1/G(s) at high frequencies. In both cases the round-off error could be reduced significantly by adding all of the subtraction amounts and doing a subtraction just once for each case.

As mentioned above, the inverse filter calculated from the narrow gaussian has less oscillations and dies off more rapidly than the filter for the wide gaussian case, so that there are less small negative values affecting the result. For this reason, as well as 1/ G(s) having smaller magnitude high frequencies, the narrow case is less affected by round-off error.

The results calculated in double precision are somewhat affected by round-off error, but the results are much more consistent and correct than the single precision results.

Figures (2.47) and (2.32) are plots of the sum of the square error per point calculated over the L length window for the narrow gaussian versus filter length, for single and double precision calculations, respectively. As is evident, the double precision plot exhibits the type of theoretical behavior expected, i.e., decreasing error as filter length increases, while the error in the single precision plot does not at all increase monotonically nor smoothly as the filter length increases.

Plots of the error versus filter length for both the narrow and wide gaussian cases are shown in figures (2.31)-(2.40). The numerical results given to seven significant figures are listed in tables (2.1) and (2.2). A discussion of the plot behavior is now detailed, along with the criterion by which the optimum length filter for deconvoluion is selected.

Examination of the results of the narrow gaussian case, figures (2.31)-(2.35), shows that in all measures calculated the error increases monotonically as the filter length decreases. The results of the two error measures of the deconvolution compared to the known input calculated over L and M length windows, show that there is relatively large error due to wraparound for the 33 point filter. Increasing the filter length to 65 points greatly reduces the error, and in all but one case, the sum of the absolute error calculated over M points, SMABER/M, the decrease in error esentially levels off by the 257 point filter. The large relative decrease in error for the 4097 point filter is thought to be a consequence of the type error measure used, as the sum of the square error calculated over the M window, SMSQER/M, and the two measures calculated over the L window do not show this decrease. The sum of the square error calculated over the full length of the deconvolution, SMSQER/(NT+M), decreases significantly and monotonically as the filter length increases.

From the theoretically consistent behavior or the results of the narrow gaussian case, it is believed that the major contribution to the error is from wraparound, and that round-off error is insignificant.

In the comparison of the deconvolution to f for the wide gaussian case, figures (2.36)-(2.40), the error introduced from wraparound is too large to be considered when applying the 33 point filter. Increasing the length to 65 points again greatly reduces the error, but with the error measures calculated over the M length window, the errors are still relatively large when compared to the results of the longer length filters. The error is actually a minimum for the 65 point filter with the error calculated over the L length window, and the 129 point filter shows the best results for the M length measures.

Three of the four measures calculated over the L and M windows show a slight increase in error as the filter length increases from 129 points for all greater length filters. It is believed that this departure from expected theoretical behavior is due to round-off error. Evidently the increase in round-off error as filter length increases is greater than the improvement in wraparound. The SMABER/M shows a significant decrease in error for the 4097 point filter. As for the narrow case, this is thought to be a consequence of the type measure employed for very small numbers. The measures taken over (NT+M) points exhibit the theoretical behavior of decreasing error as filter length is increased.

The results of comparing the deconvolutions to the longest length deconvolution are only shown for the result calculated over the NT+M window for the wide gaussian case, figures (2.45) and (2.46). For the narrow case the result are shown calculated over the M and NT+M windows, figures (2.41)-(2.44). The numerical results are listed in table

(2.3). For the wide case this is because round-off affected the shorter length window results enough that, in general for these windows, the deconvolutions performed with the shorter length filters are more accurate.

In the selection of the the optimum length filter to apply in deconvolution for both the narrow and wide cases, it was decided to make the selection from the L and M length error results, with the M length results being weighted more heavily in the decision. This is because the shorter length windows are usuallv the regions of most interest experimentally. In the work of Chapter IV we will only be concerned with the result calculated over the M window. The results calculated by comparing to the longest length filter are not considered in the selection.

For the narrow case the 257 point filter is chosen as the most accurate. The error had esentially leveled off by the 257 length result for most cases, and the small increase in accuracy gained by using a longer length filter will not compensate for the increased computer time needed for the longer length calculations. The reduction in computation time is especially important for the work of Chapter IV. The optimum length filter for the wide case is 129 points, as round-off in general caused an increase in error for longer length filters. For the SMABER/M where there was a large relative decrease in error, this was roughly only a 3% decrease for both narrow and wide cases, and the error magnitude is small enough that the decrease is insignificant.

It is of interest that a longer length filter is chosen as optimum for the narrow case. This selection goes against theory as the wide case should require a longer filter. As mentioned previously, the departure from expected results is due to round-off error, and doing the calculations in a higher precision, or revising the calculations would result in a longer length wide filter. Also, examination of the L and M window error results for both gaussians show that the error magnitudes for the 129 through 4097 length filters are all very close. Using even a 65 point filter in the narrow case, or a longer length filter than 129 points in the wide case, where round-off affects the accuracy, will not affect the deconvolution too severely. For this study the selection of optimum filter length is based most importantly on error reduction, unless there is a considerable increase in computation time, as is the case for the 4097 point filter. Another user of these results may decide he requires more or less accuracy corresponding to his needs and computer time available. The computer program used in calculating all results of this chapter are listed in the appendix.

Table (2.1)

NARROW GAUSSIAN

FILTER LENGTH	SMABER/L	SMSQER/L
3.300000E+01	4.970879E-05	9.528120E-09
6.500000E+01	1.068407E-05	1.945857E-10
1.290000E+02	1.068390E-05	1.945715E-10
2.570000E+02	1.068386E-05	1.945680E-10
5.130000E+02	1.068385E-05	1.945672E-10
1.025000E+03	1.068385E-05	1.945669E-10
2.049000E+03	1.068385E-05	1.945669E-10
4.097000E+03	1.068385E-05	1.945669E-10

FILTER LENGTH	SMABER/M	SMSQER/M
3.300000E+01	5.708786E-05	1.237392E-08
6.500000E+01	8.411077E-06	1.460660E-10
1.290000E+02	8.410643E-06	1.460555E-10
2.570000E+02	8.410541E-06	1.460529E-10
5.130000E+02	8.410508E-06	1.460523E-10
1.025000E+03	8.410253E-06	1.460521E-10
2.049000E+03	8.402295E-06	1.460521E-10
4.097000E+03	8.147680E-06	1.460521E-10

FILTER LENGTH	SMSQER/(NT+M)
3.300000E+01	1.216599E-08
6.500000E+01	4.868889E-11
1.290000E+02	2.921147E-11
2.570000E+02	1.622845E-11
5.130000E+02	8.591554E-12
1.025000E+03	4.425974E-12
2.049000E+03	2.247045E-12
4.097000E+03	1.132238E-12

Table (2.2)

WIDE GAUSSIAN

FILTER LENGTH	SMABER/L	SMSQER/L
3.300000E+01	7.054848E+03	9.392609E+07
6.500000E+01	2.094336E-01	6.822844E-02
1.290000E+02	2.094349E-01	6.823538E-02
2.570000E+02	2.094352E-01	6.823715E-02
5.130000E+02	2.094353E-01	6.823761E-02
1.025000E+03	2.094353E-01	6.823773E-02
2.049000E+03	2.094353E-01	6.823777E-02
4.097000E+03	2.094353E-01	6.823778E-02
1.025000E+03	1.321833E-01	3.801159E-02
2.049000E+03	1.321174E-01	3.801164E-02
4.097000E+03	1.291816E-01	3.801165E-02

FILTER LENGTH	SMABER/M	SMSQER/M
3.300000E+01	8.606430E+03	1.198460E+08
6.500000E+01	3.211137E+00	9.266671E+01
1.290000E+02	1.321193E-01	3.800783E-02
2.570000E+02	1.321695E-01	3.801067E-02
5.130000E+02	1.321818E-01	3.801140E-02
1.025000E+03	1.321833E-01	3.801159E-02
2.049000E+03	1.321174E-01	3.801164E-02
4.097000E+03	1.291816E-01	3.801165E-02

FILTER LENGTH	SMSQER/(NT+M)
3.300000E+01	8.827930E+07
6.500000E+01	6.071961E+02
1.290000E+02	1.420265E-02
2.570000E+02	5.649545E-03
5.130000E+02	3.011642E-03
1.025000E+03	1.567809E-03
2.049000E+03	8.004685E-04
4.097000E+03	4.045085E-04

Table (2.3)

NARROW GAUSSIAN

FILTER LENGTH	SMABDF/M	SMSQDF/M
3.300000E+01	5.238886E-05	5.238886E-05
6.500000E+01	4.990104E-09	4.990104E-09
1.290000E+02	1.207103E-09	1.207103E-09
2.570000E+02	2.986158E-10	2.986158E-10
5.130000E+02	7.363779E-11	7.363779E-11
1.025000E+03	1.752466E-11	1.752466E-11
2.049000E+03	3.504542E-12	3.504542E-12

FILTER LENGTH	SMABDF/(NT+M)	SMSQDF/(NT+M)
3.300000E+01	5.239288E-05	1.195982E-08
6.500000E+01	1.534156E-08	4.379296E-16
1.290000E+02	8.677523E-09	1.950363E-16
2.570000E+02	4.773366E-09	8.856593E-17
5.130000E+02	2.576831E-09	4.074210E-17
1.025000E+03	1.336576E-09	1.803191E-17
2.049000E+03	5.884715E-10	6.013890E-18

WIDE GAUSSIAN

FILTER LENGTH	SMABDF/(NT+M)	SMSQDF/(NT+M)
3.300000E+01	6.508820E+03	8.827931E+07
6.500000E+01	1.431675E+01	6.071861E+02
1.290000E+02	3.133485E-02	4.466132E-03
2 570000E+02	3.288296E-03	6.986873E-05
5.130000E+02	4.180027E-04	6.927578E-07
1.025000E+03	1.592667E-04	9.967352E-08
2.049000E+03	7.187993E-05	3.949944E-08

ORIGINAL PAGE IS
OF POOR QUALITY

Figure (2.2)

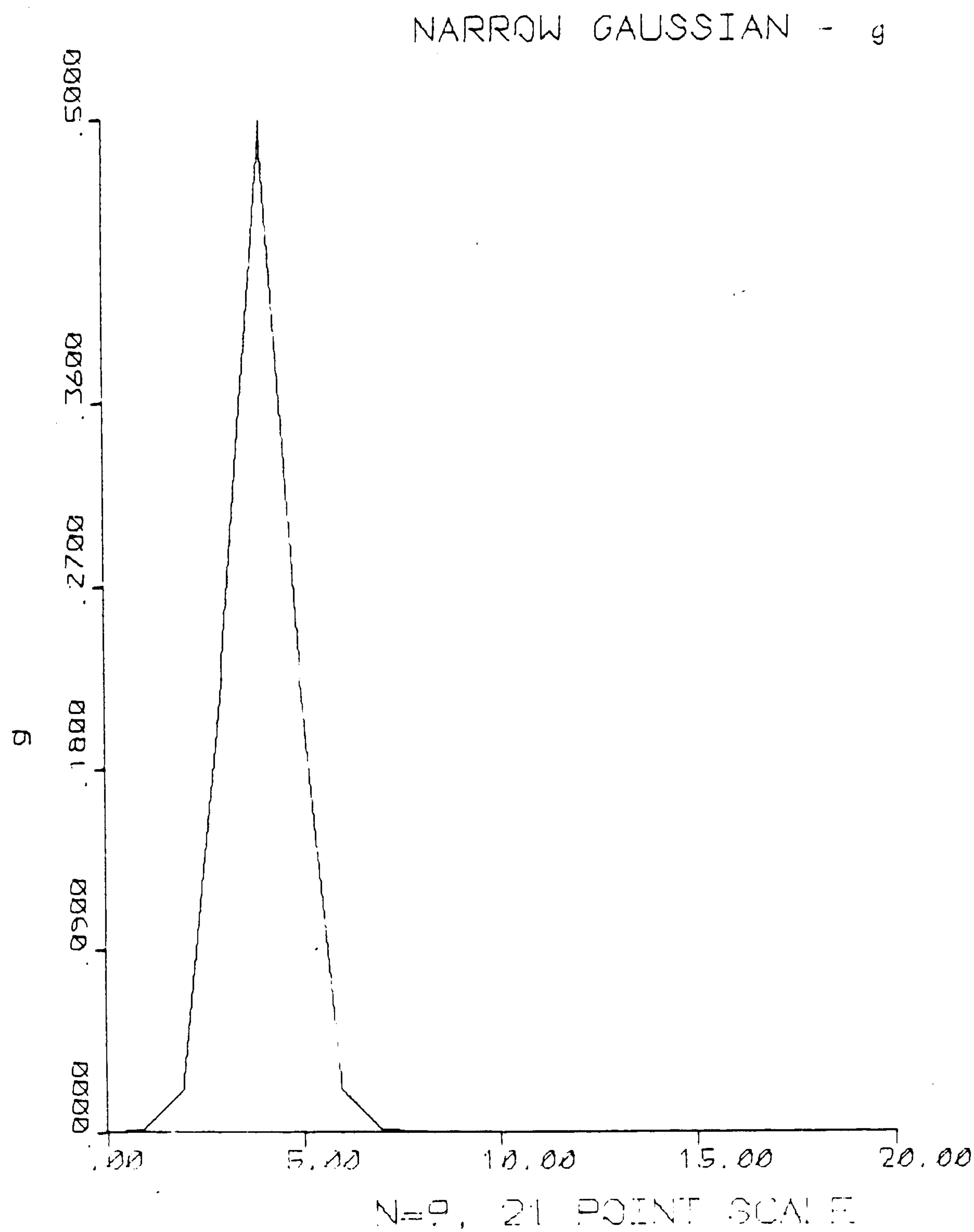
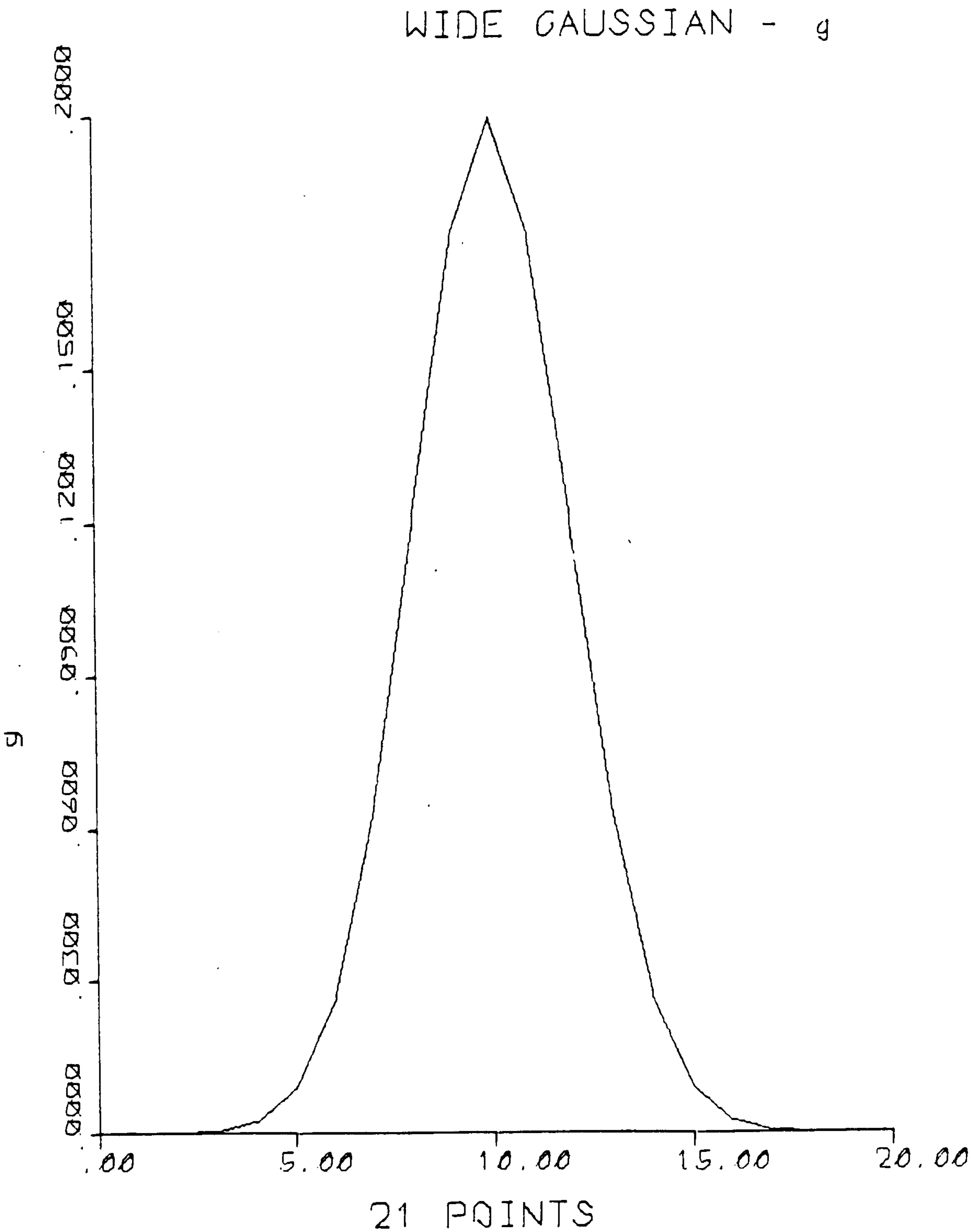


Figure (2.3)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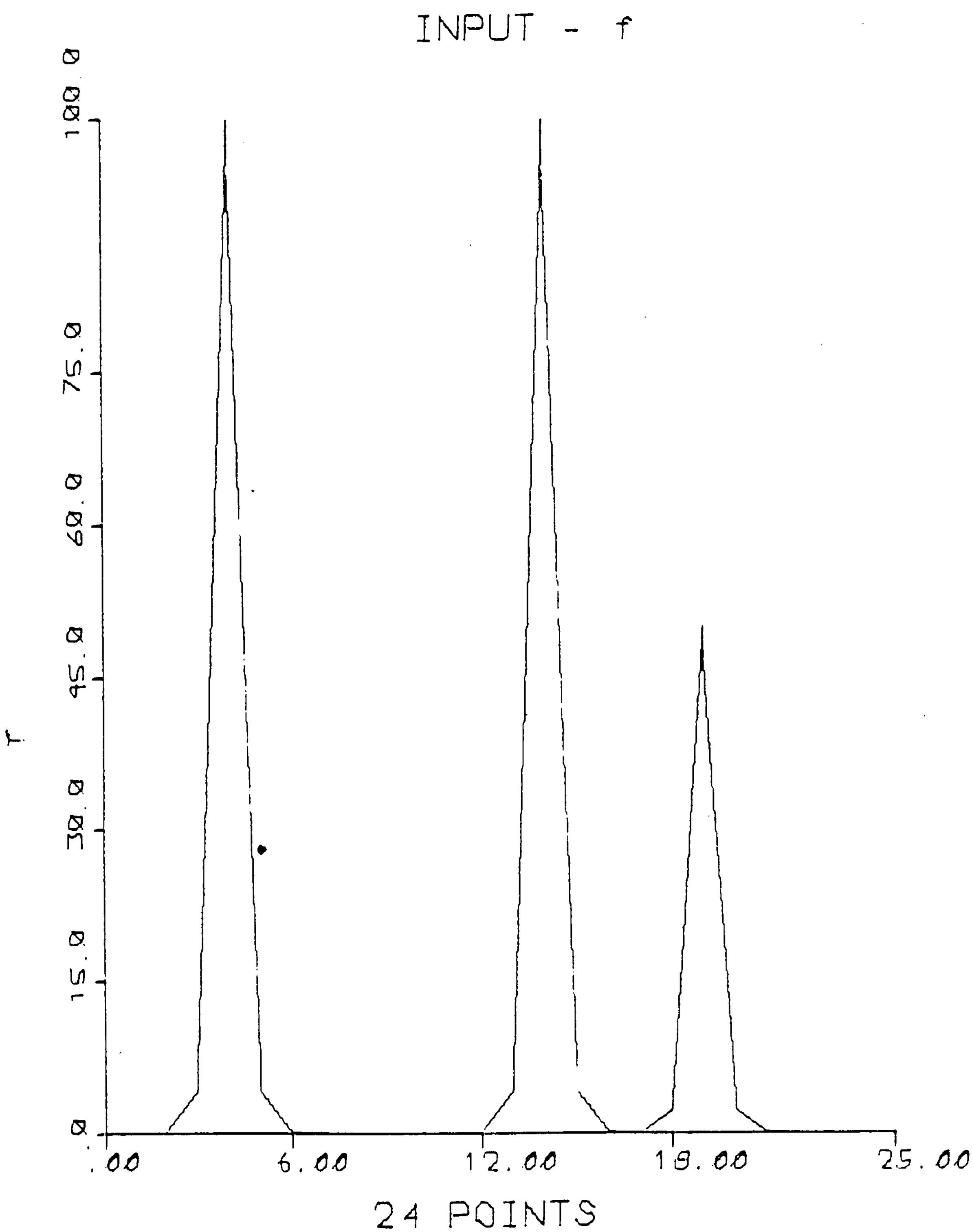
.1200
.0900
.0600
.0300
.0000
g
.00
5.00
10.00
15.00
20.00
21 POINTS

Figure (2.4)


INPUT - f
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0
f
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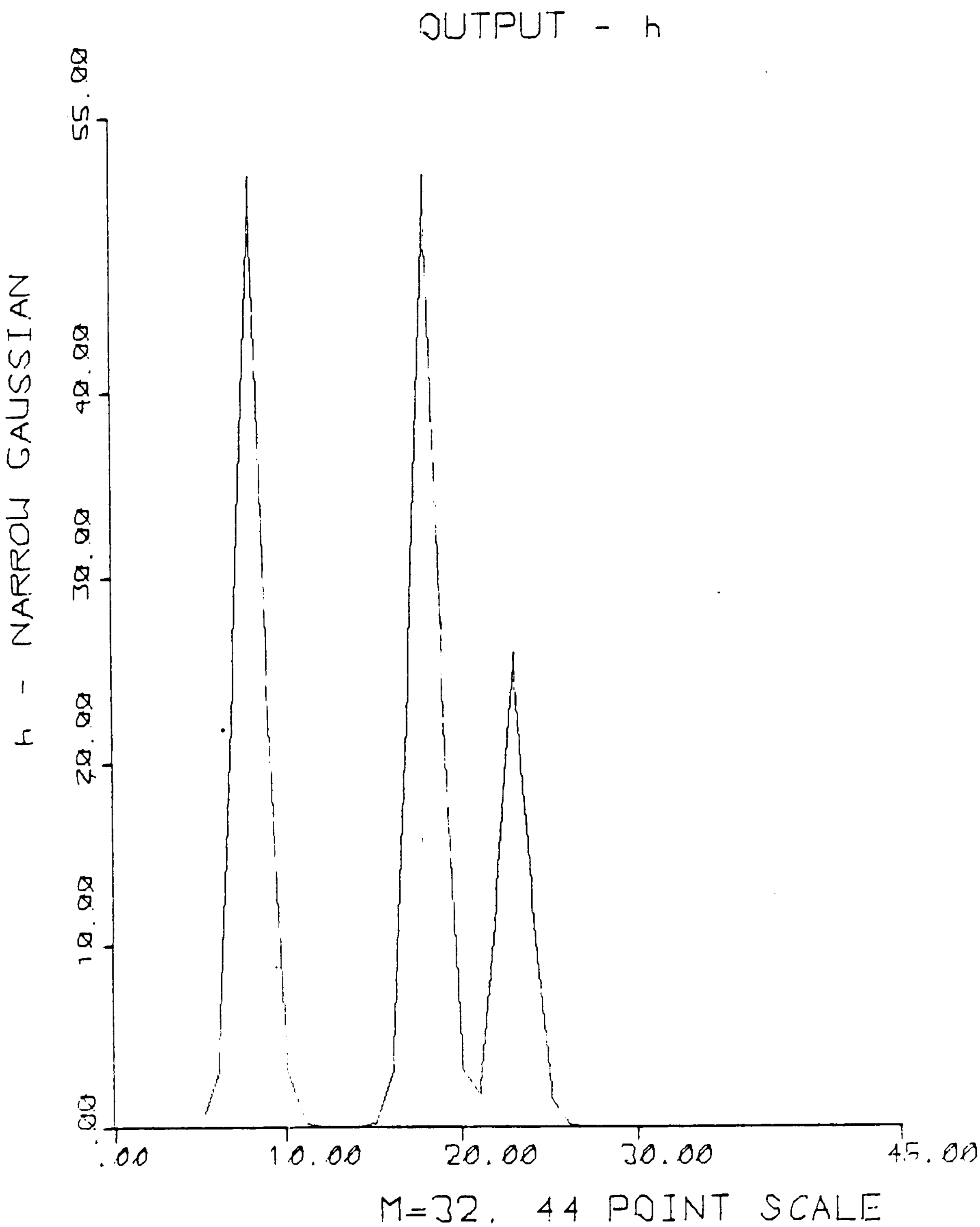
6.00
12.00
18.00
25.00
24 POINTS

Figure (2.5)


OUTPUT - h
h - NARROW GAUSSIAN
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30.00
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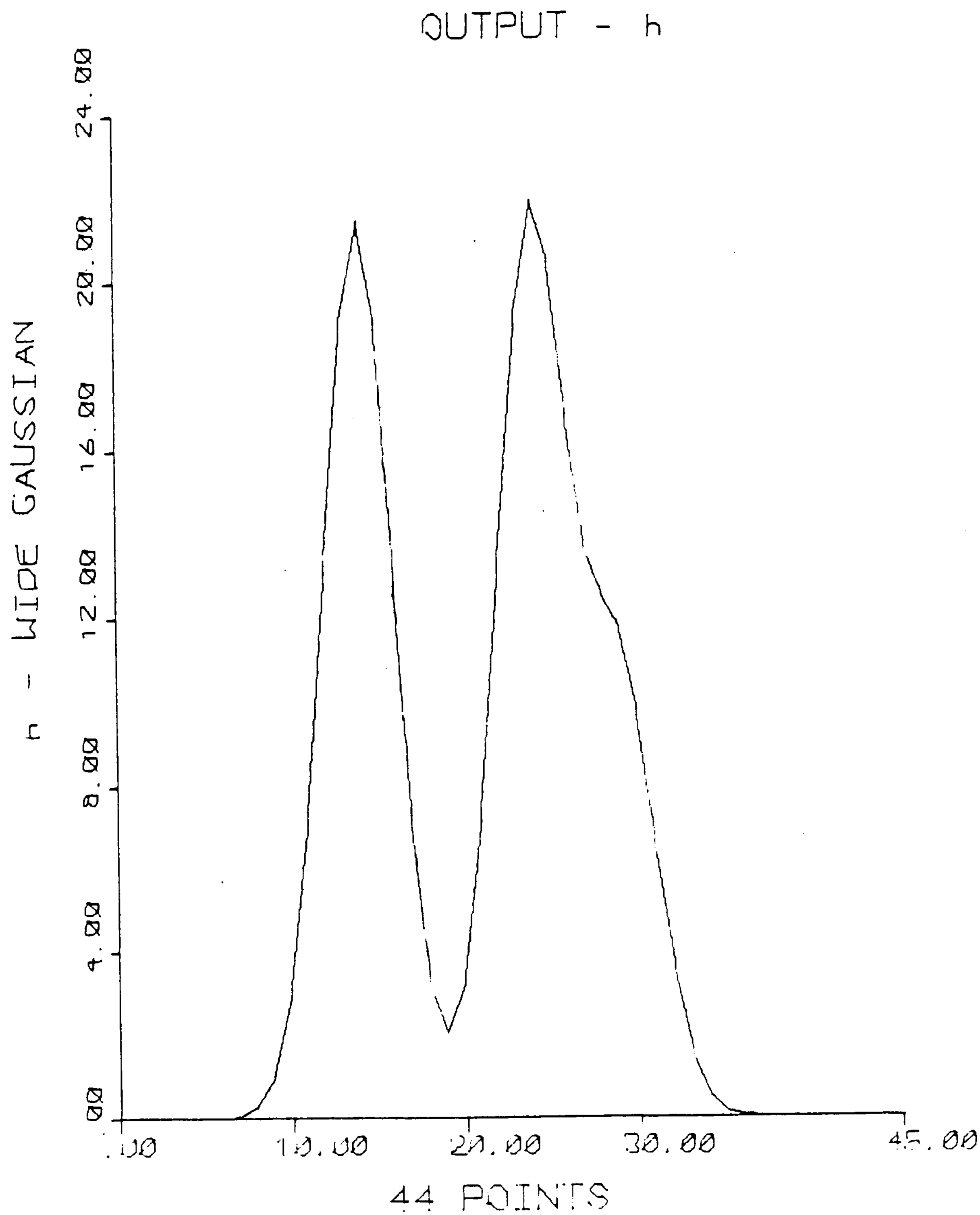
.00
10.00
20.00
30.00
45.00
M=32, 44 POINT SCALE

Figure (2.6)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h - WIDE GAUSSIAN
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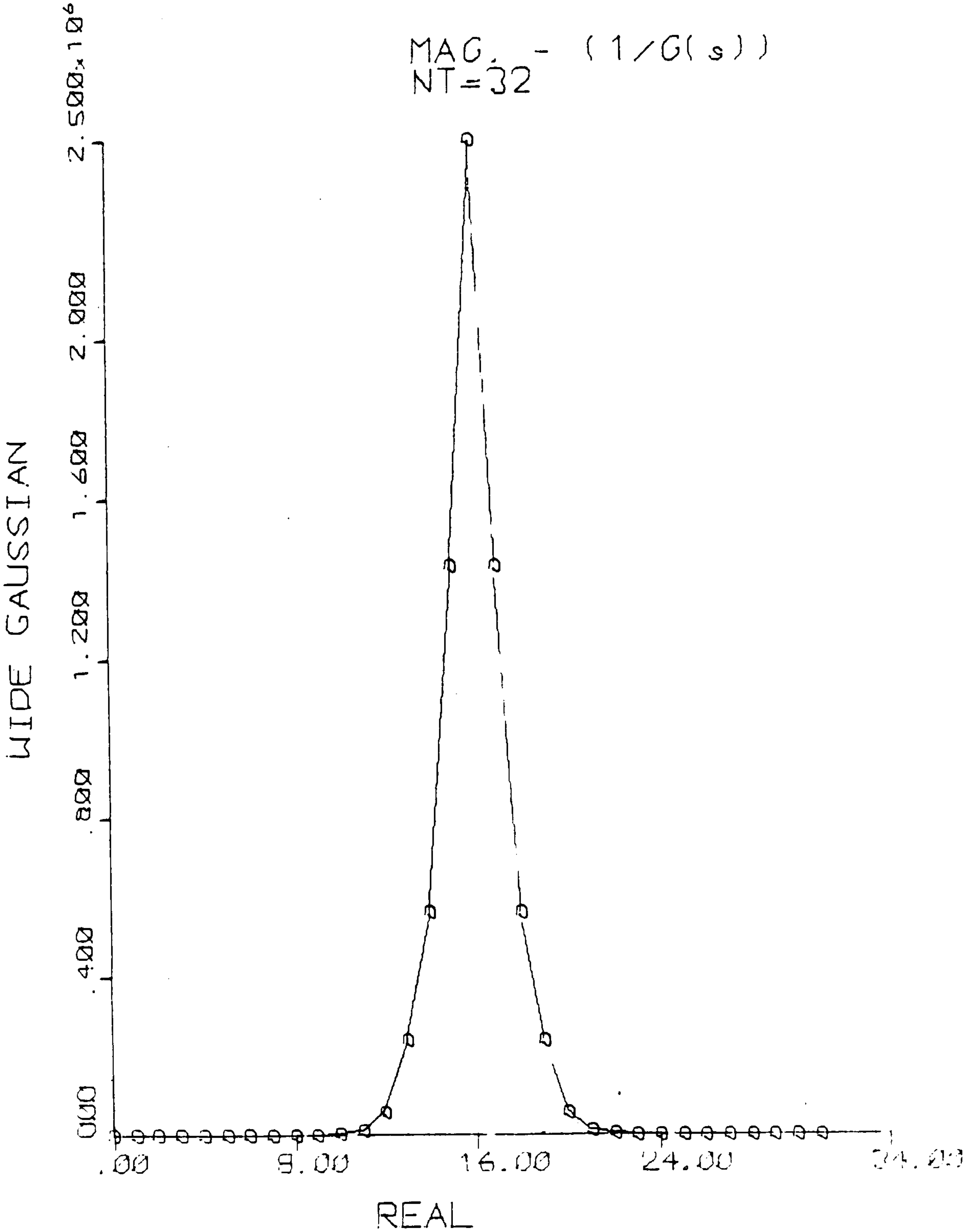
.00
.00
10.00
20.00
30.00
45.00
44 POINTS

Figure (2.7)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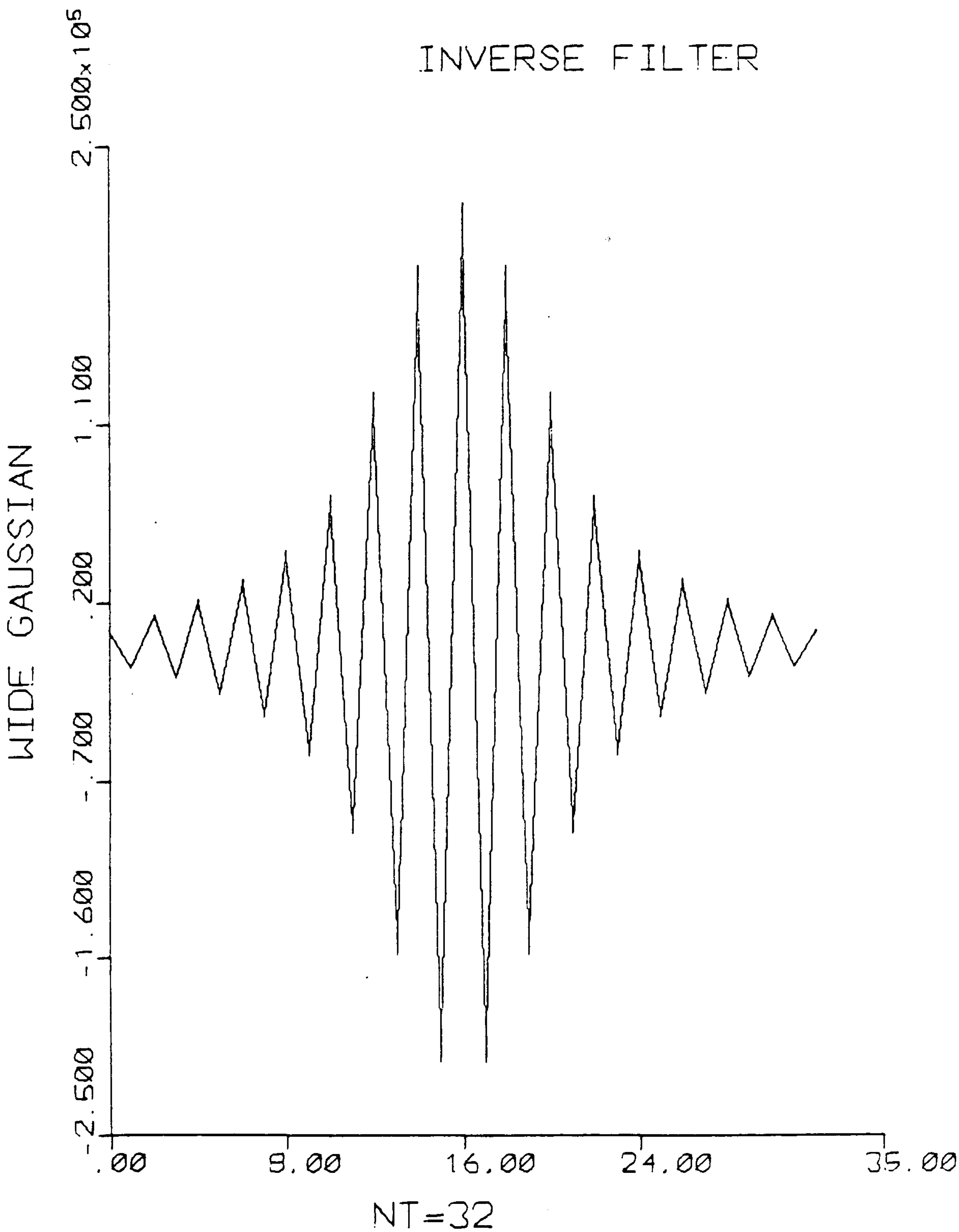
1.600
1.200
.800
.400
.000
.00
9.00
16.00
24.00
REAL

Figure (2.8)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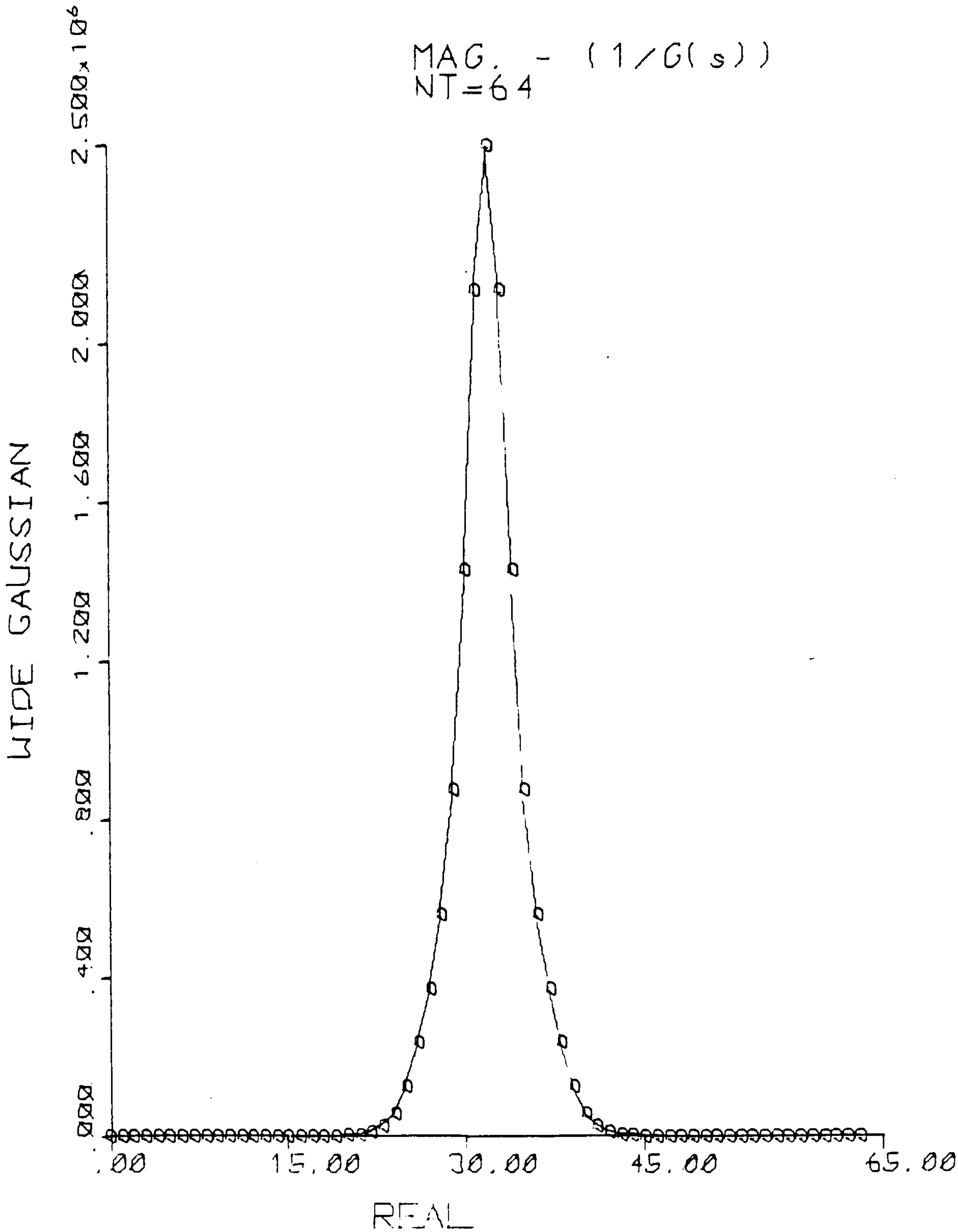
-1.600
-2.500
WIDE GAUSSIAN
.00
8.00
16.00
24.00
35.00
NT=32

Figure (2.9)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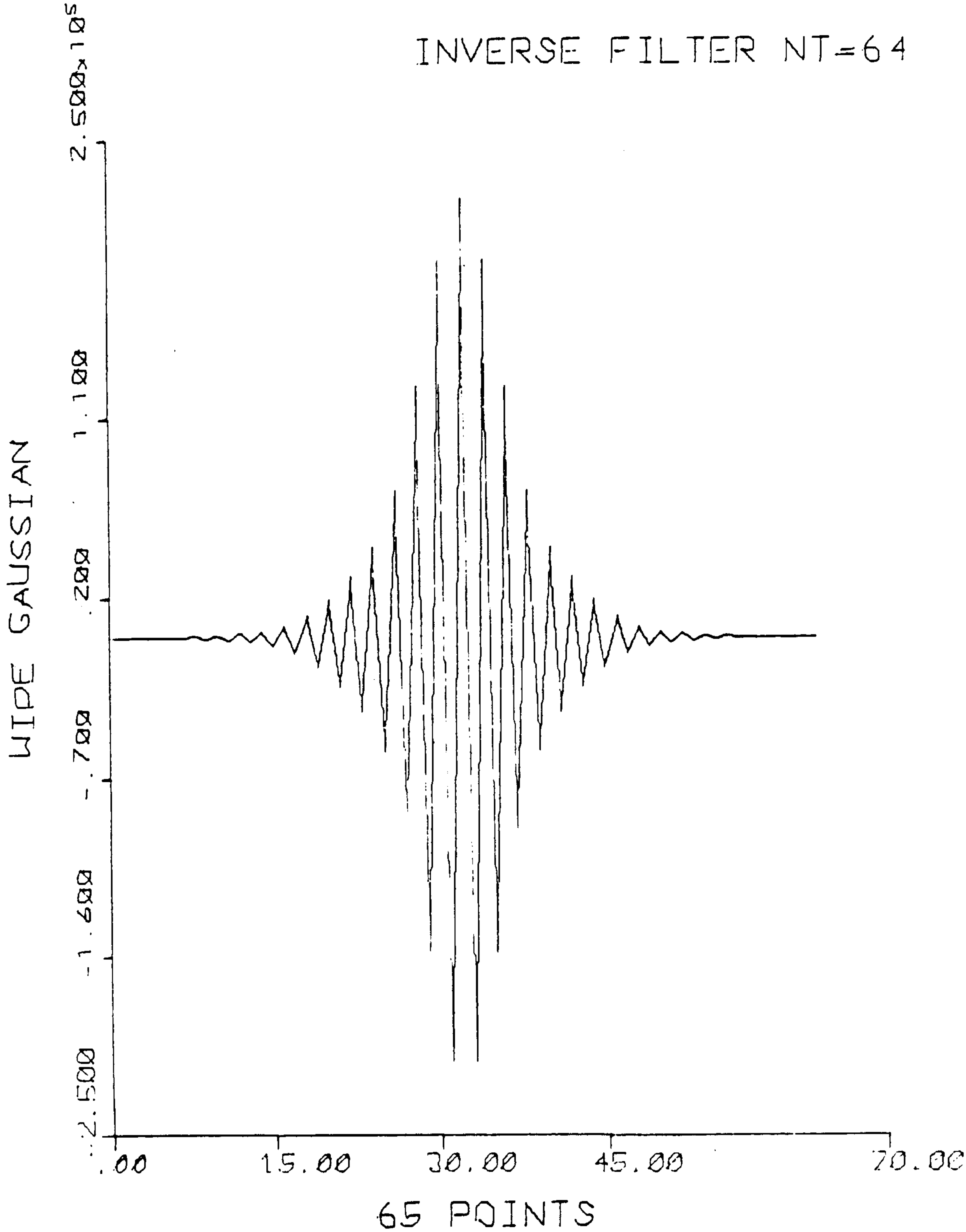
.400
.000
.00
15.00
30.00
45.00
65.00
REAL

Figure (2.10)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2.500×10^5
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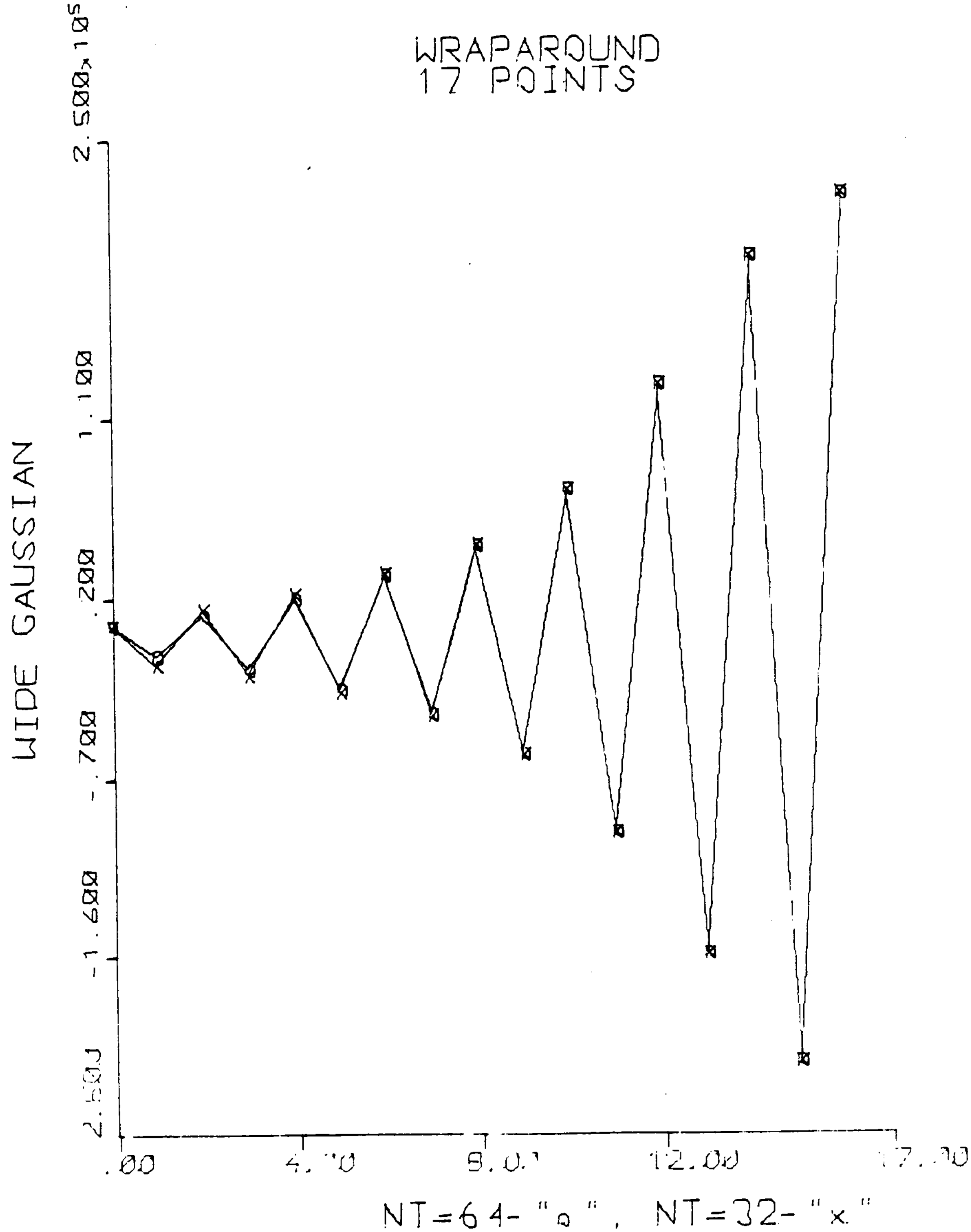
-2.500
.00
15.00
30.00
45.00
70.00
65 POINTS

Figure (2.11)


WRAPAROUND
17 POINTS
WIDE GAUSSIAN
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-.700
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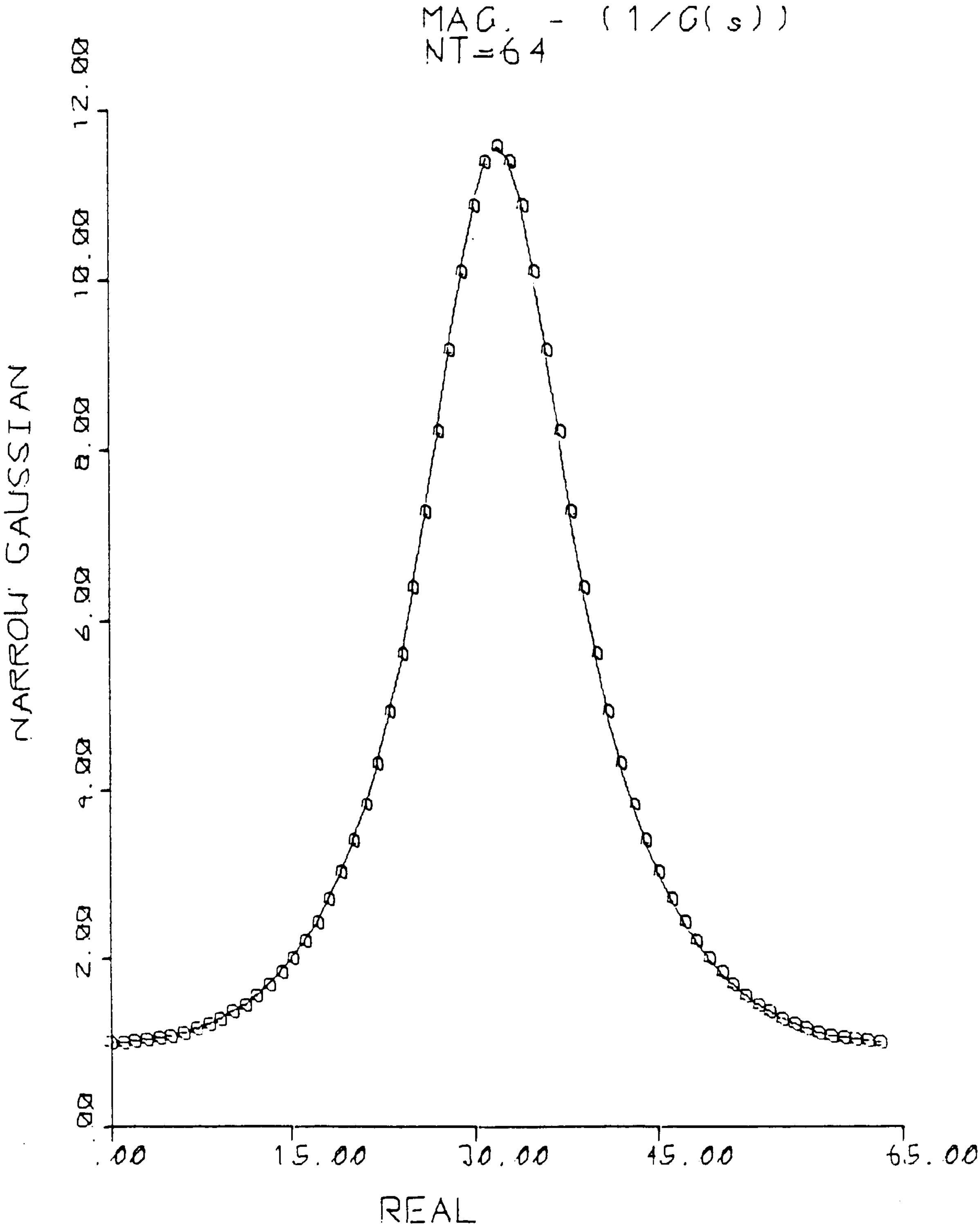
-2.500
.00
4.00
8.00
12.00
17.00
NT=64- "o" , NT=32- "x"

Figure (2.12)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NARROW GAUSSIAN
REAL
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2.00
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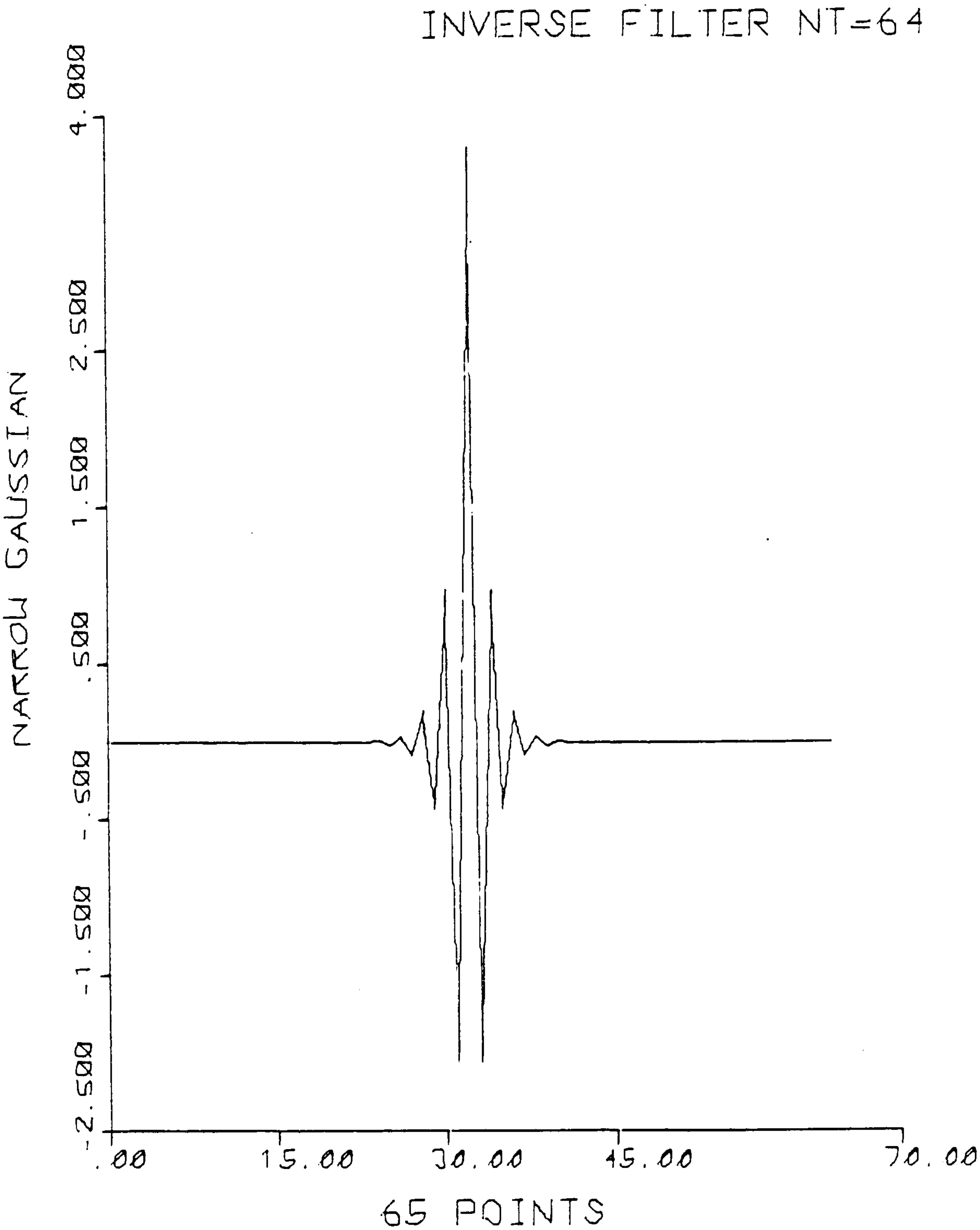
.00
15.00
30.00
45.00
65.00

Figure (2.13)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2.500
1.500
.500
-.500
-1.500
-2.500
NARROW GAUSSIAN
.00
15.00
30.00
45.00
70.00
65 POINTS

Figure (2.14)

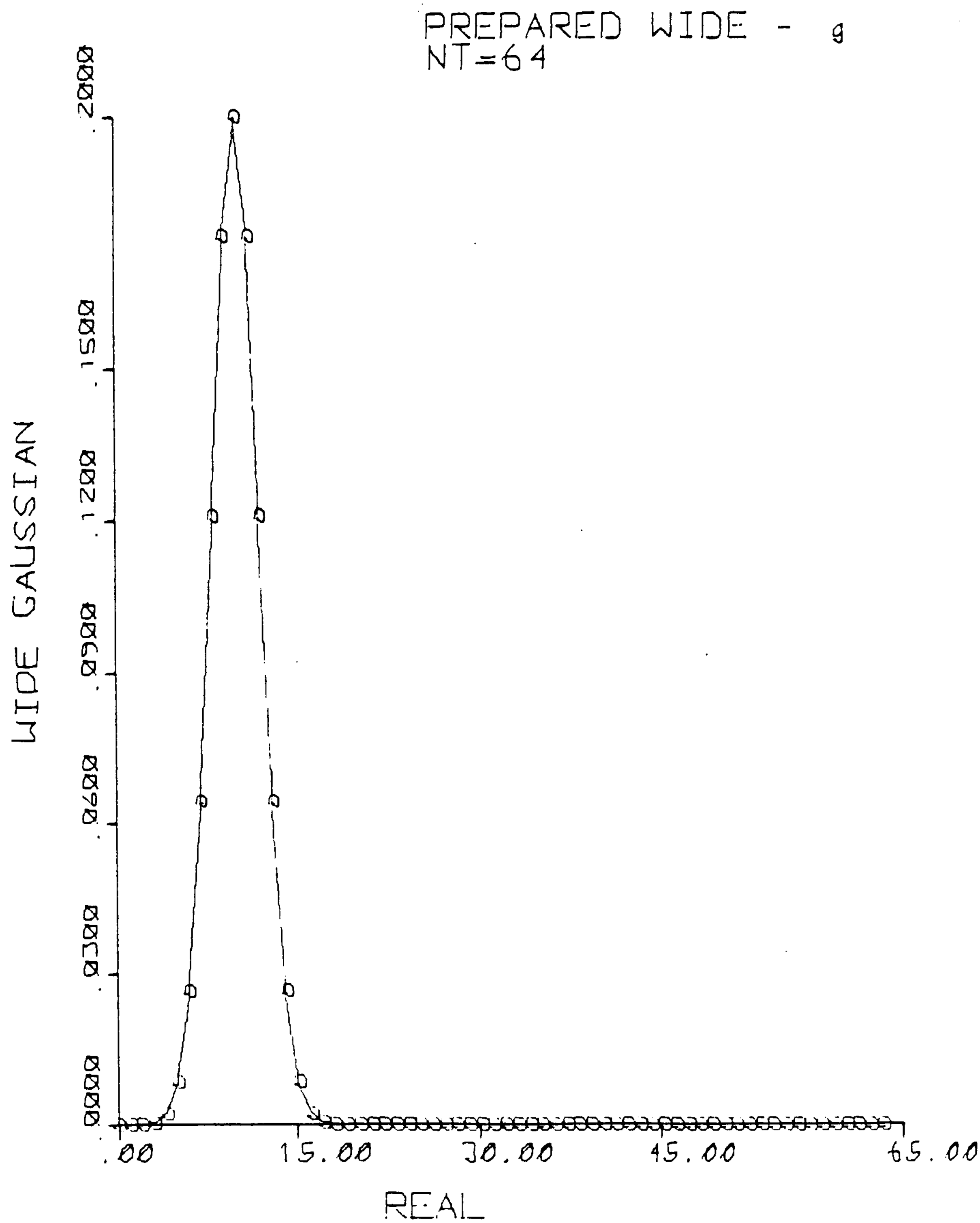
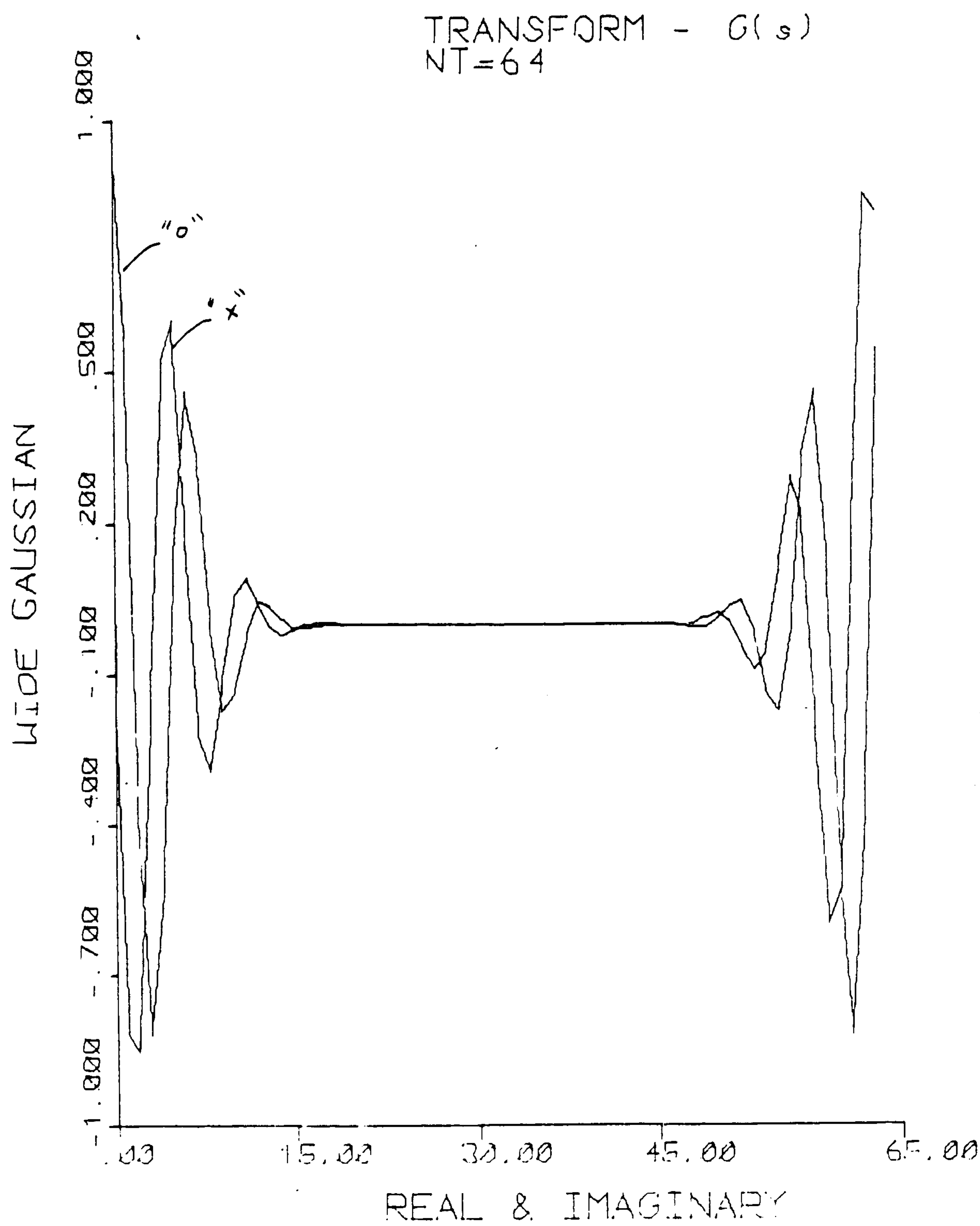

PREPARED WIDE - g
NT=64
WIDE GAUSSIAN
.2000
.1500
.1200
.0900
.0600
.0300
.0000
.00
15.00
30.00
45.00
65.00
REAL

Figure (2.15)


TRANSFORM - G(s)
NT=64
WIDE GAUSSIAN
REAL & IMAGINARY
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"x"
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-.100
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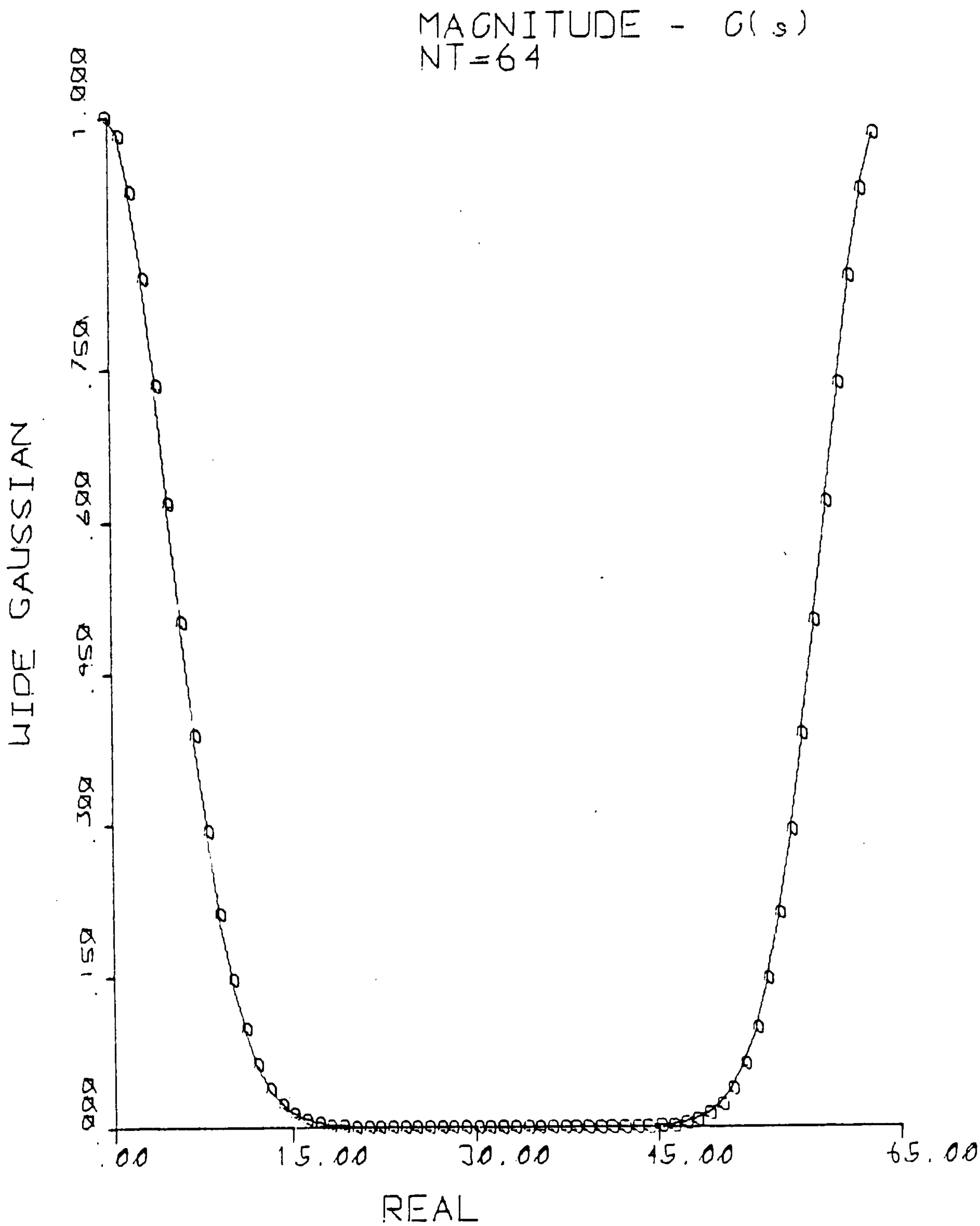
30.00
45.00
65.00

Figure (2.16)


MAGNITUDE - G(s)
NT=64
1.000
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.600
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.000
WIDE GAUSSIAN
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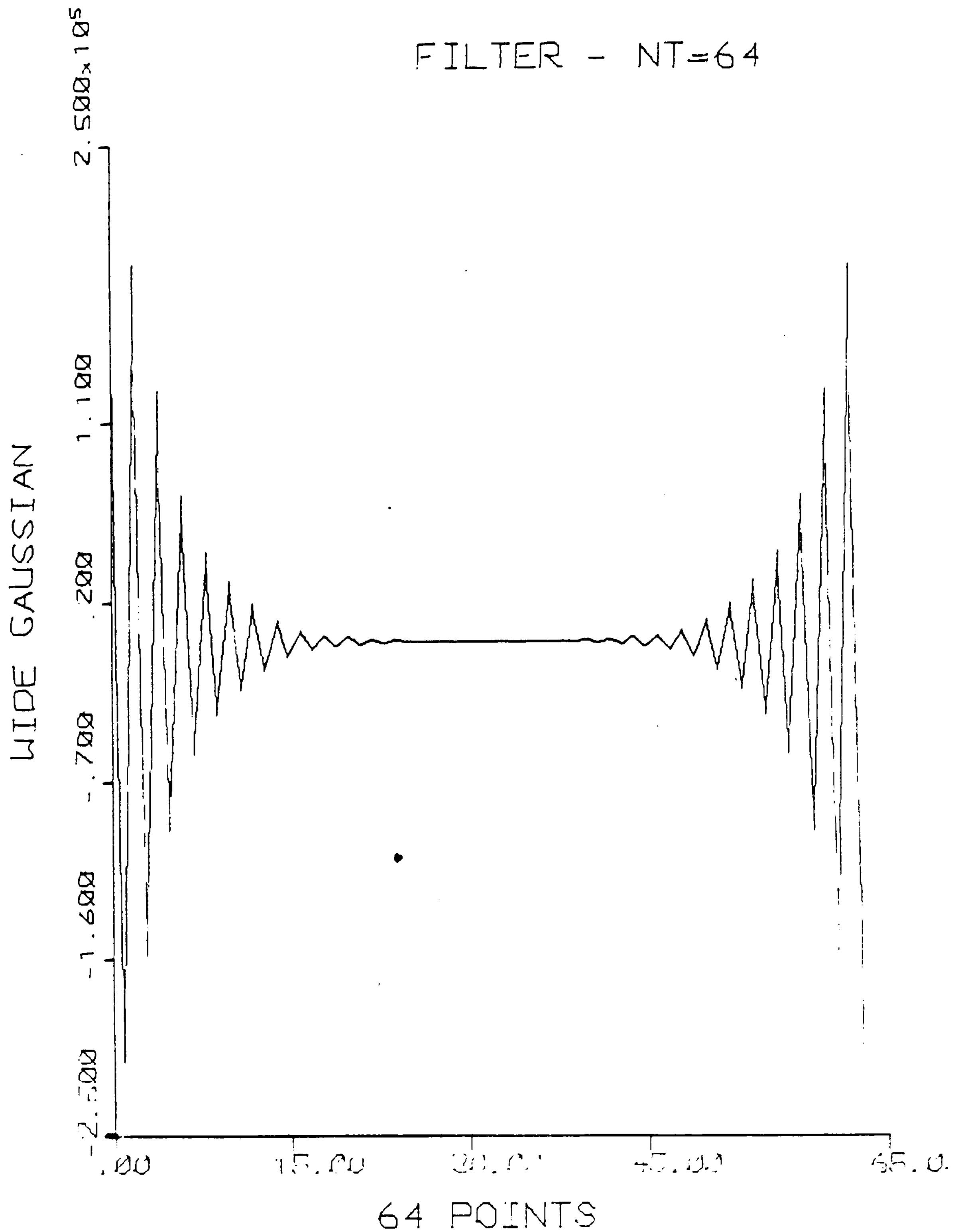
15.00
30.00
45.00
65.00
REAL

Figure (2.17)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WIDE GAUSSIAN
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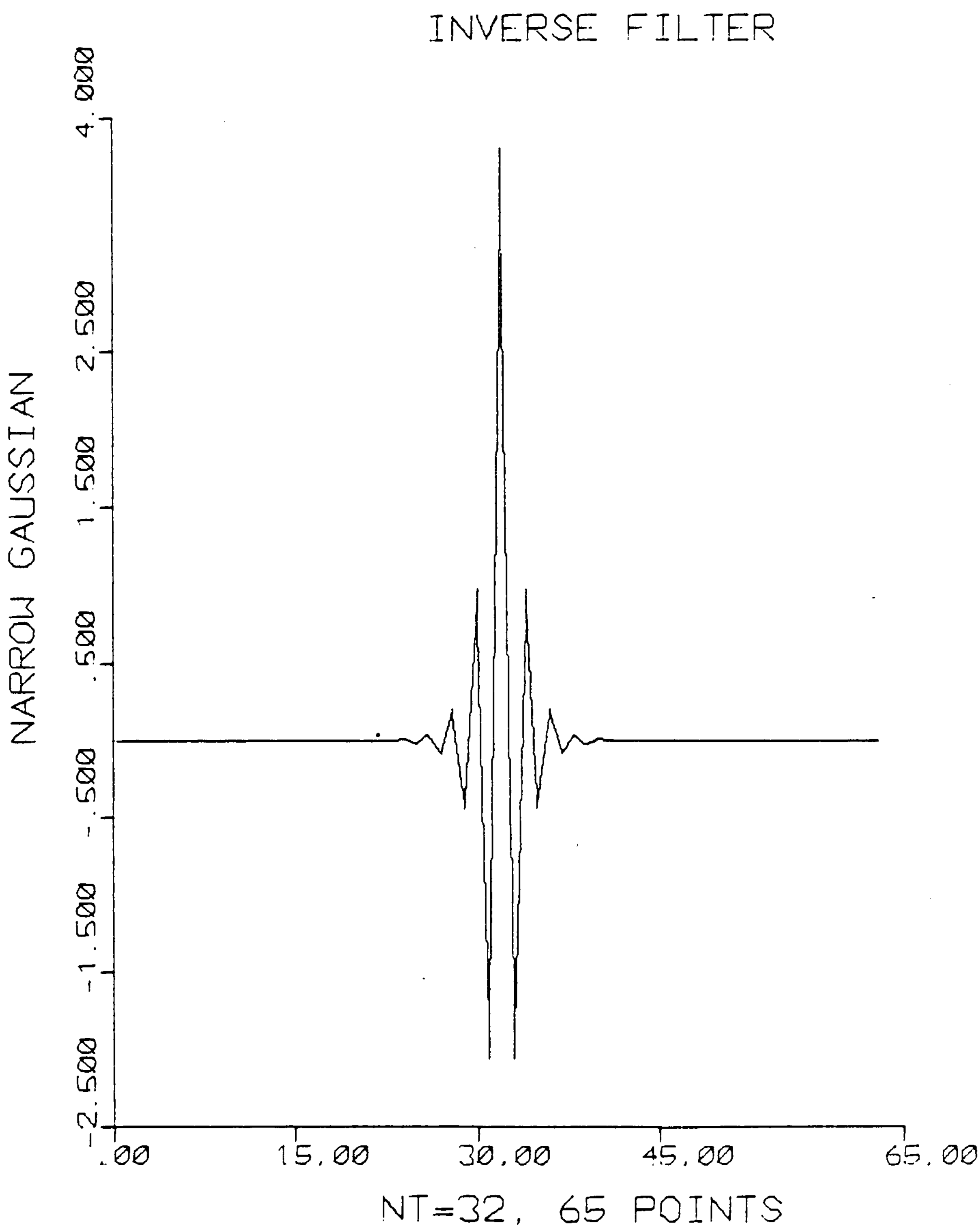
15.00
64 POINTS

Figure (2.18)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NARROW GAUSSIAN
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1.500
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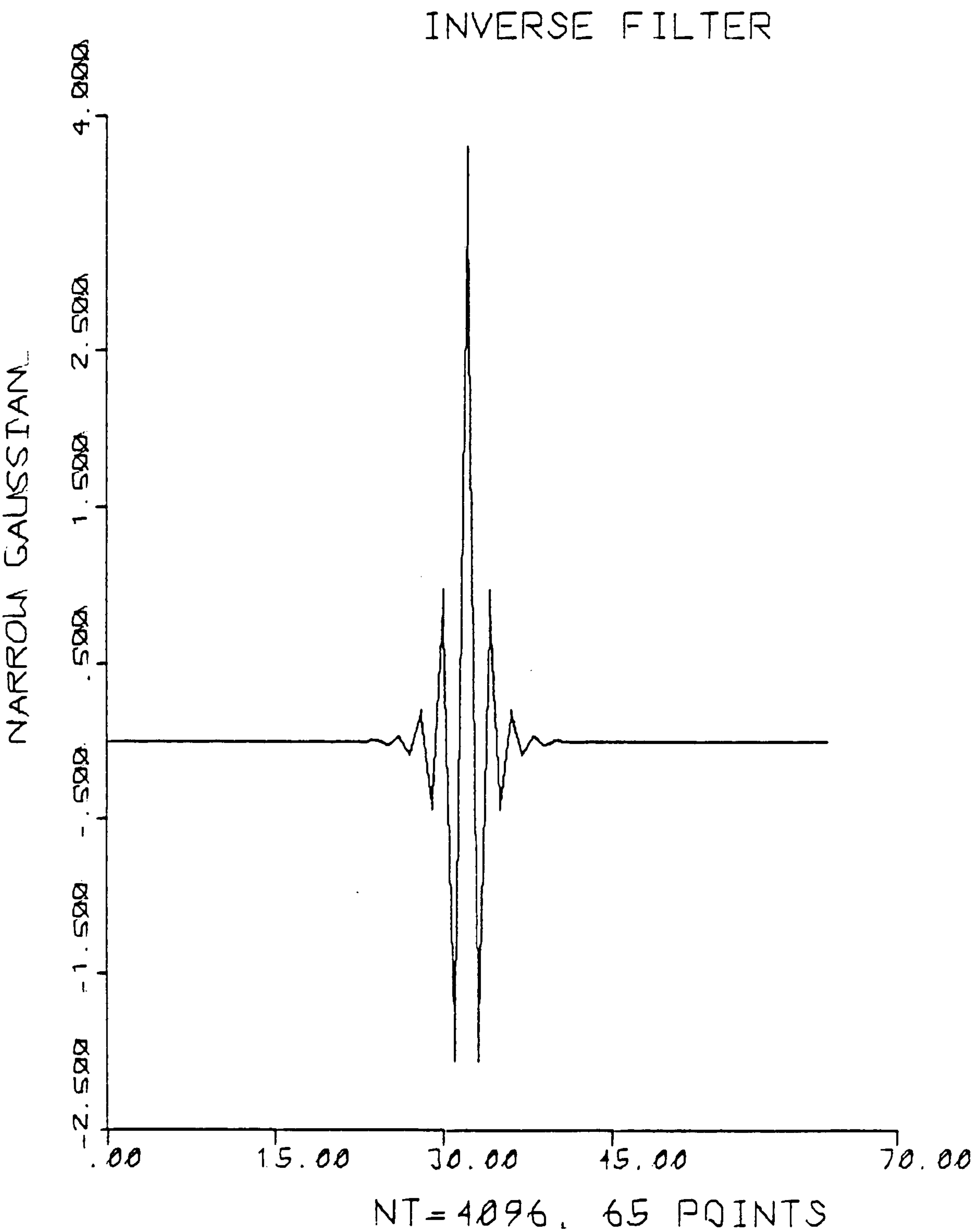
-1.500
-2.500
.00
15.00
30.00
45.00
65.00
NT=32, 65 POINTS

Figure (2.19)


INVERSE FILTER
NARROW GAUSSIAN
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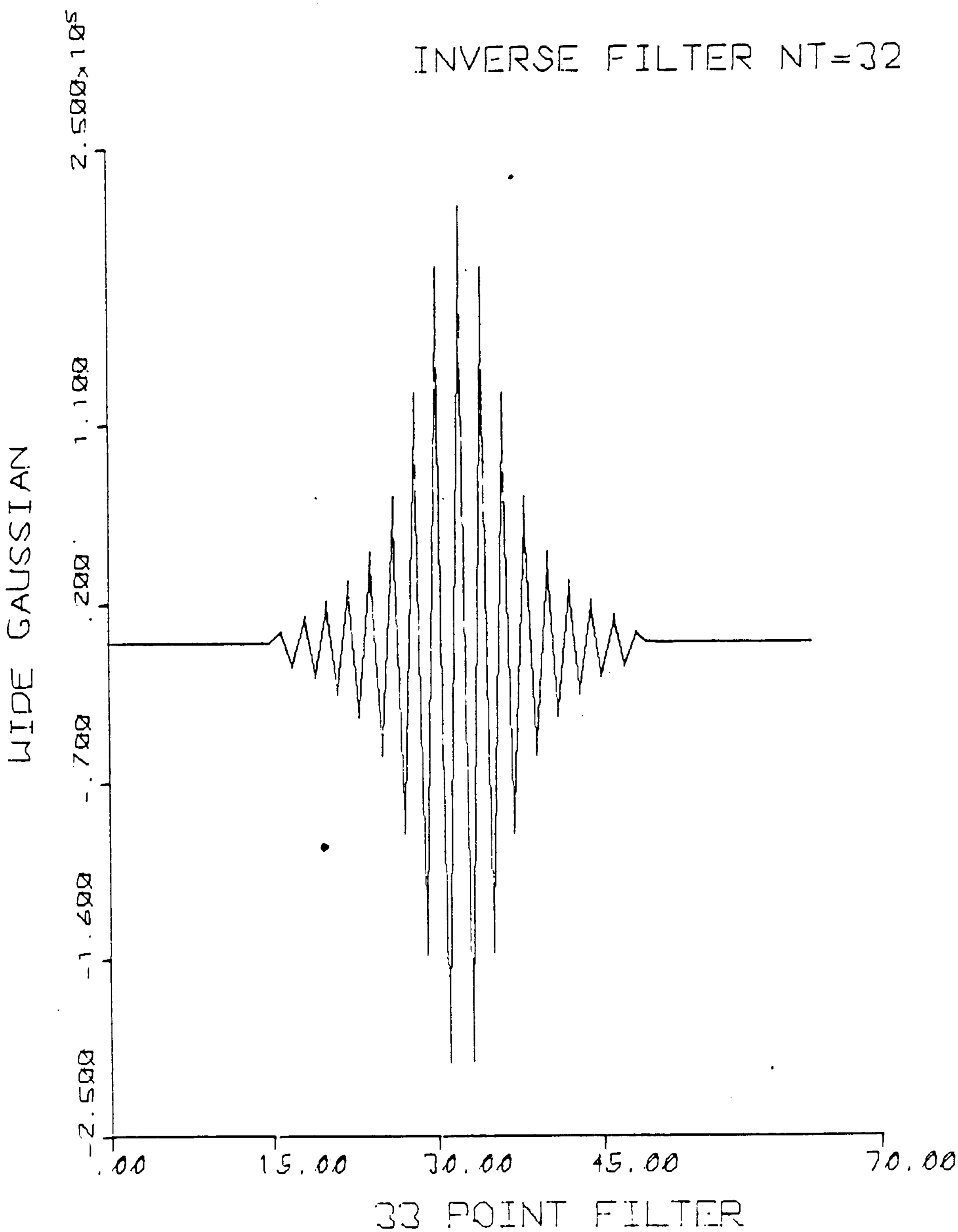
1.500
.500
-.500
-1.500
-2.500
.00
15.00
30.00
45.00
70.00
NT=4096, 65 POINTS

Figure (2.20)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2.500×10^5
1.100
.200
-.700
-1.600
-2.500
.00
15.00
30.00
45.00
70.00
33 POINT FILTER

Figure (2.21)

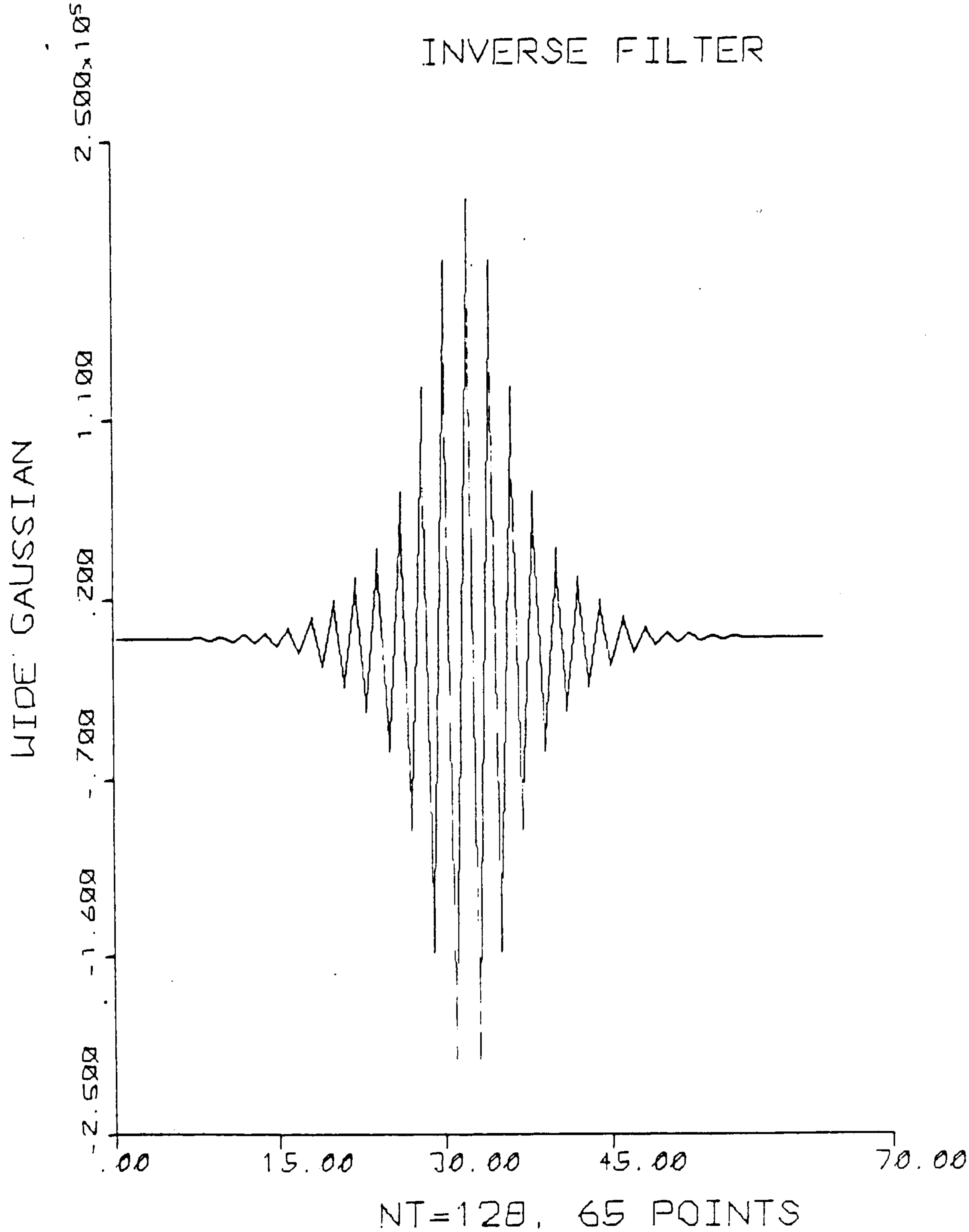

INVERSE FILTER
WIDE GAUSSIAN
2.500×10^5
1.100
.200
-.700
-1.600
-2.500
.00
15.00
30.00
45.00
70.00
NT=128, 65 POINTS

Figure (2.22)

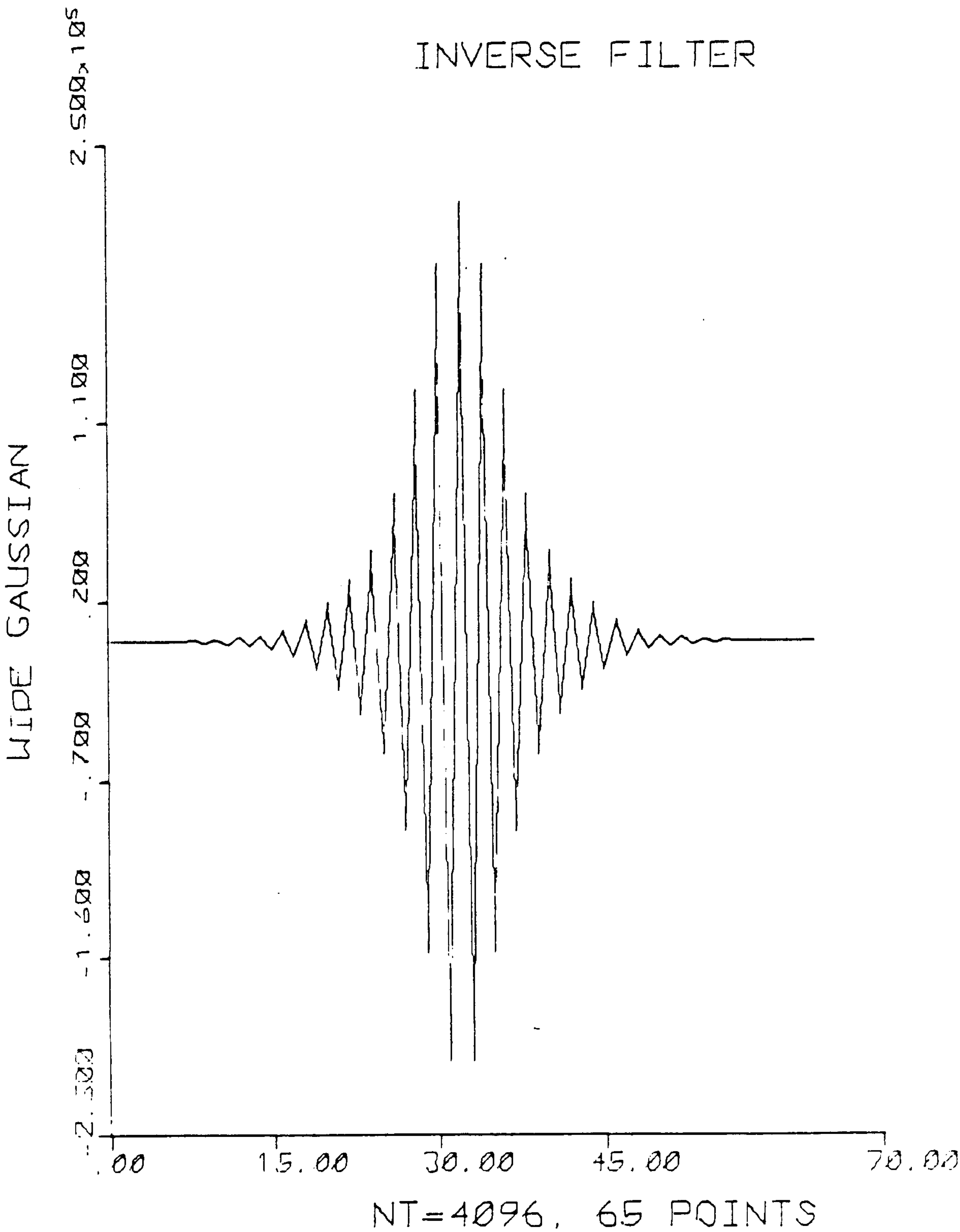

INVERSE FILTER
WIDE GAUSSIAN
2.500x10^5
1.100
.200
-.700
-1.600
-2.500
.00
15.00
30.00
45.00
70.00
NT=4096, 65 POINTS

Figure (2.23)

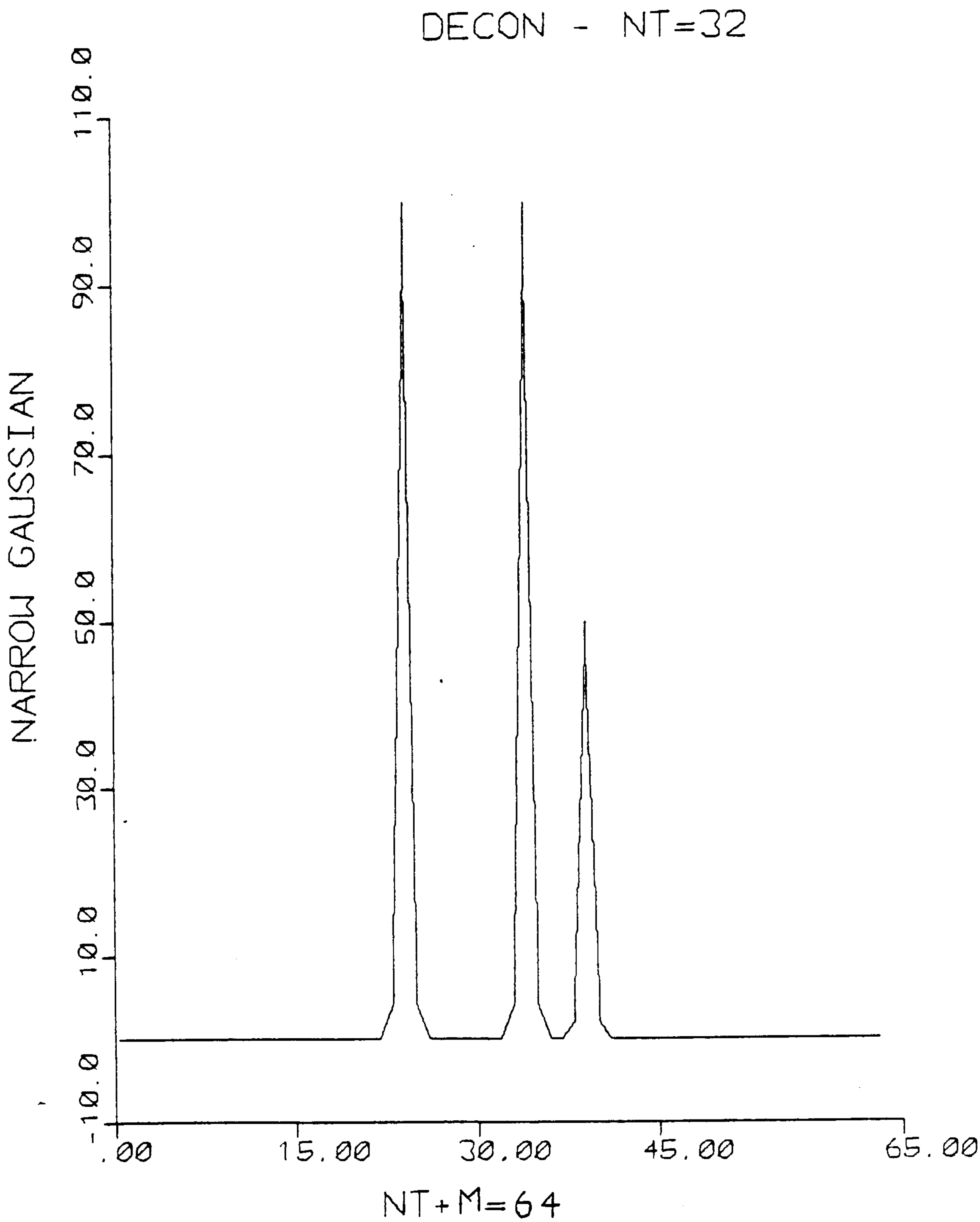

DECON - NT=32
NARROW GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.00
15.00
30.00
45.00
65.00
NT+M=64

Figure (2.24)

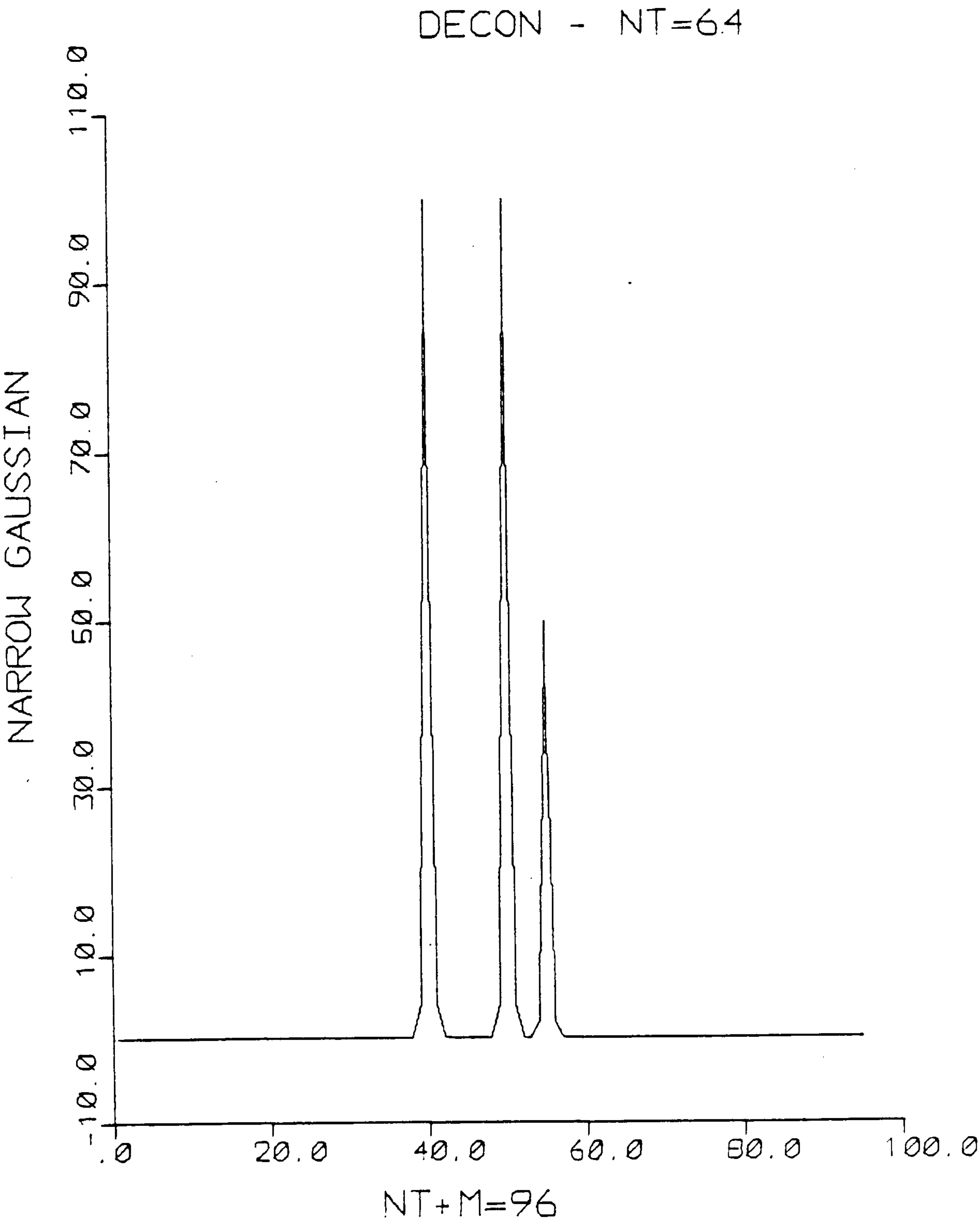

DECON - NT=64
NARROW GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.0
20.0
40.0
60.0
80.0
100.0
NT+M=96

Figure (2.25)

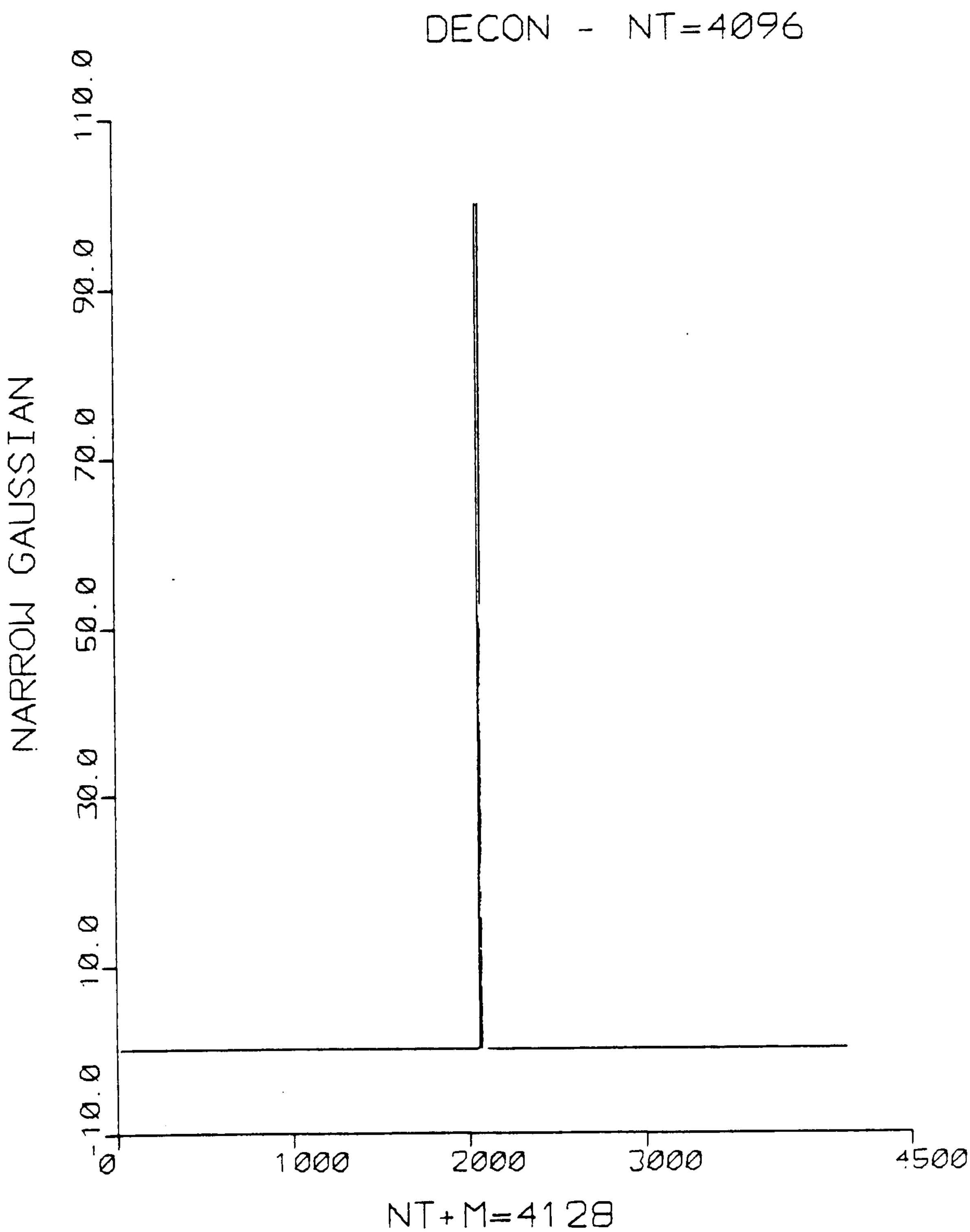

DECON - NT=4096
NARROW GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
0
1000
2000
3000
4500
NT+M=4128

Figure (2.26)

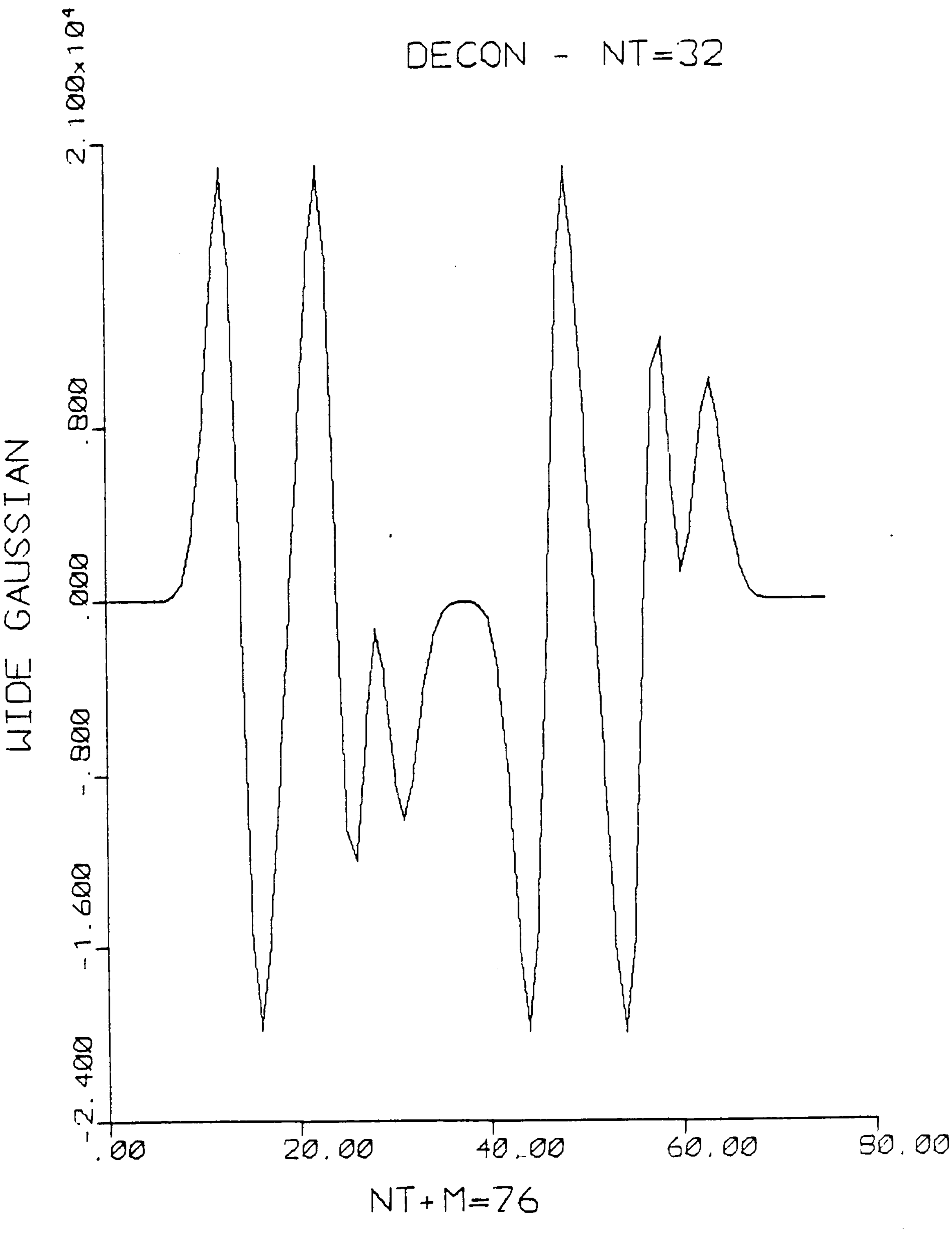

DECON - NT=32
2.100×10⁴
.800
.000
-.800
-1.600
-2.400
WIDE GAUSSIAN
.00
20.00
40.00
60.00
80.00
NT+M=76

Figure (2.27)

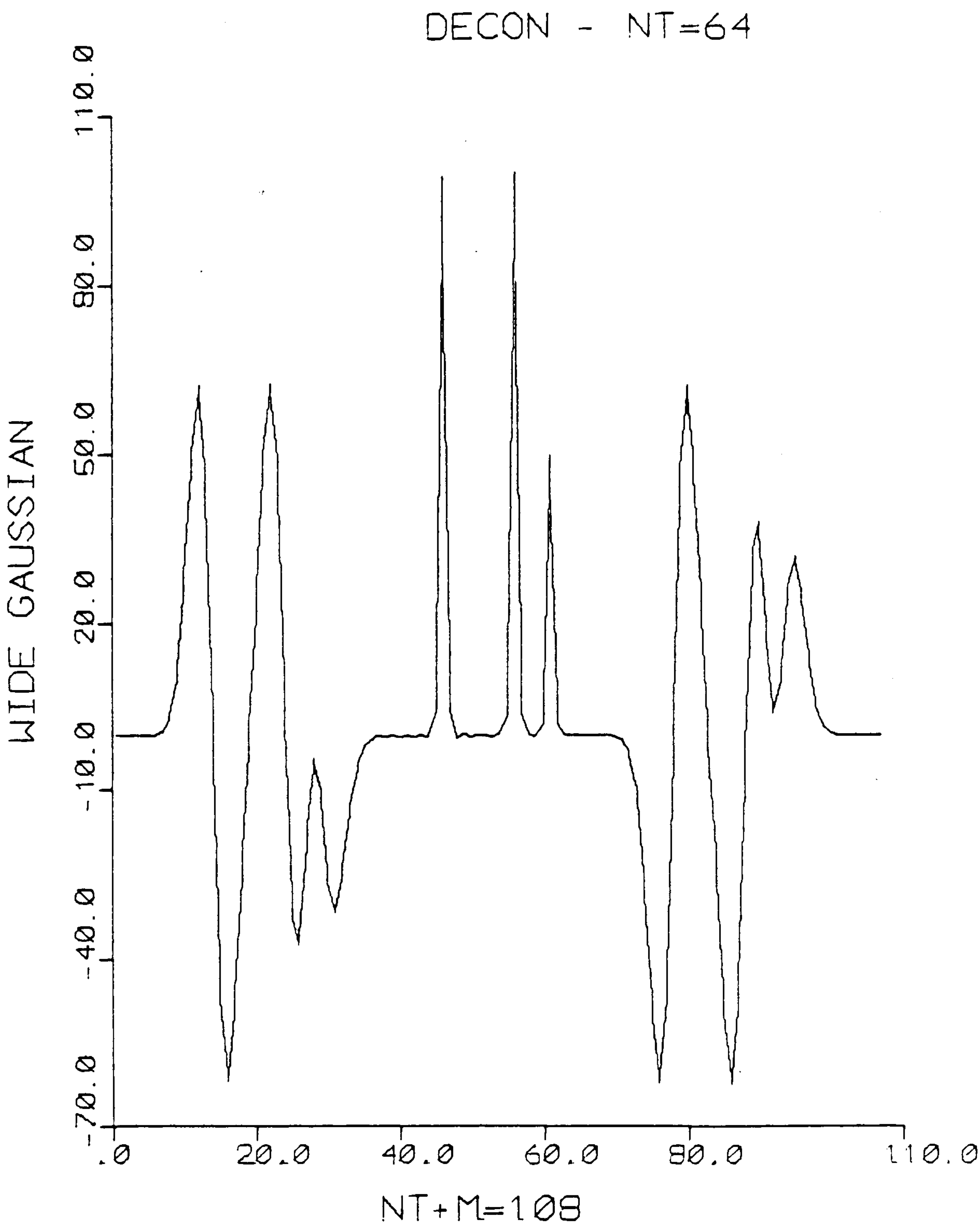

DECON - NT=64
WIDE GAUSSIAN
110.0
80.0
50.0
20.0
-10.0
-40.0
-70.0
.0
20.0
40.0
60.0
80.0
110.0
NT+M=108

Figure (2.28)

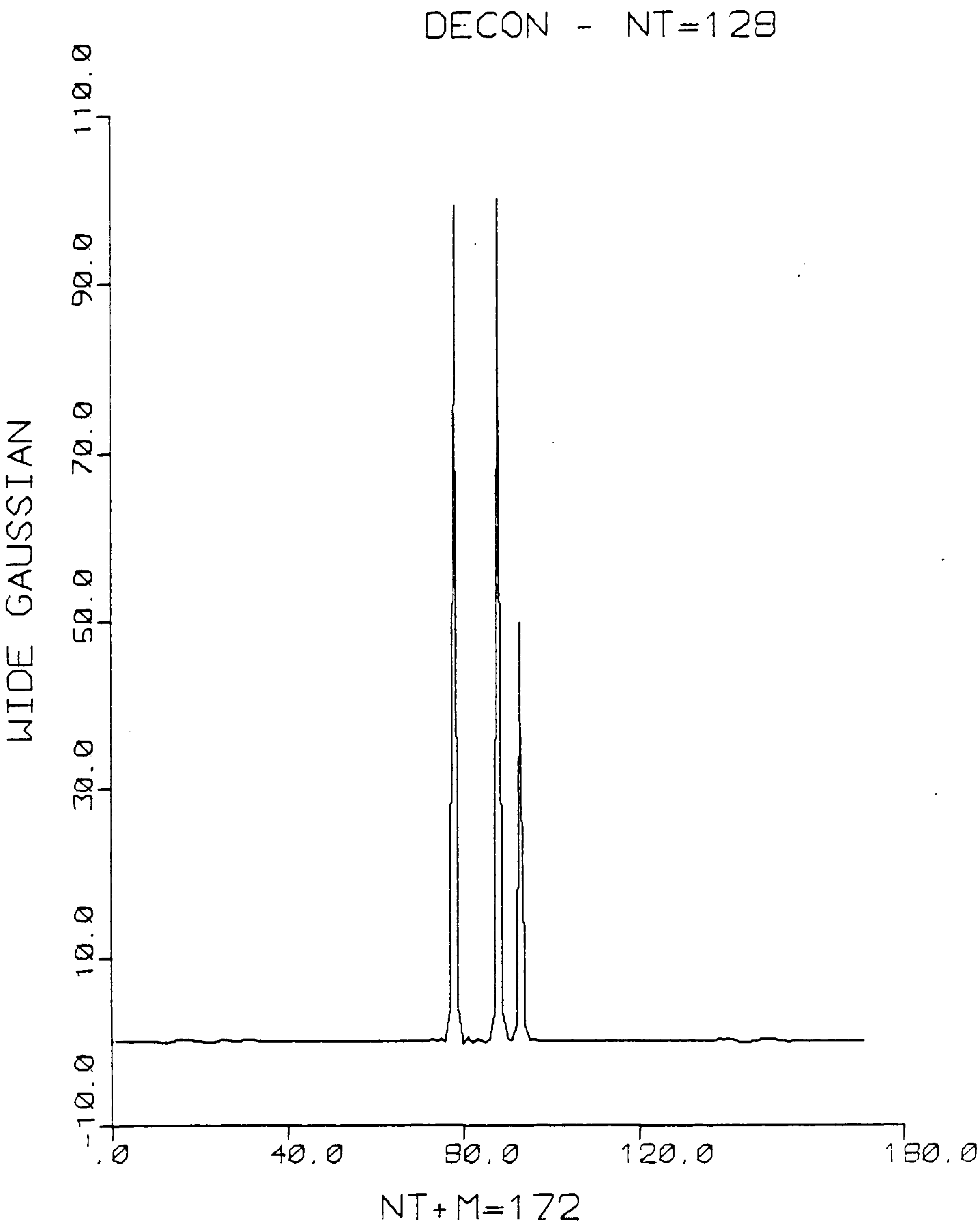
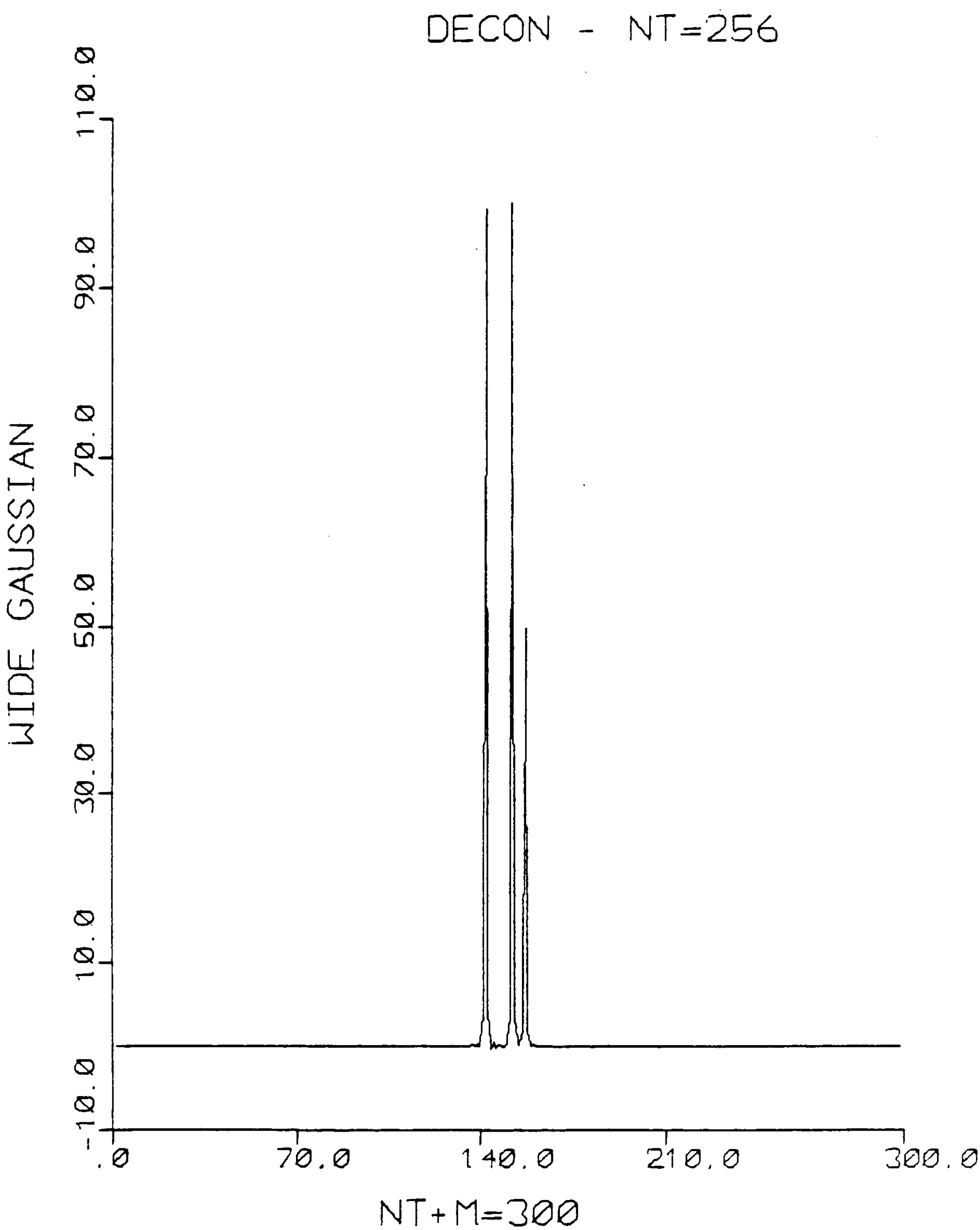

DECON - NT=128
WIDE GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.0
40.0
80.0
120.0
160.0
NT+M=172

Figure (2.29)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WIDE GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.0
70.0
140.0
210.0
300.0
NT+M=300

Figure (2.30)

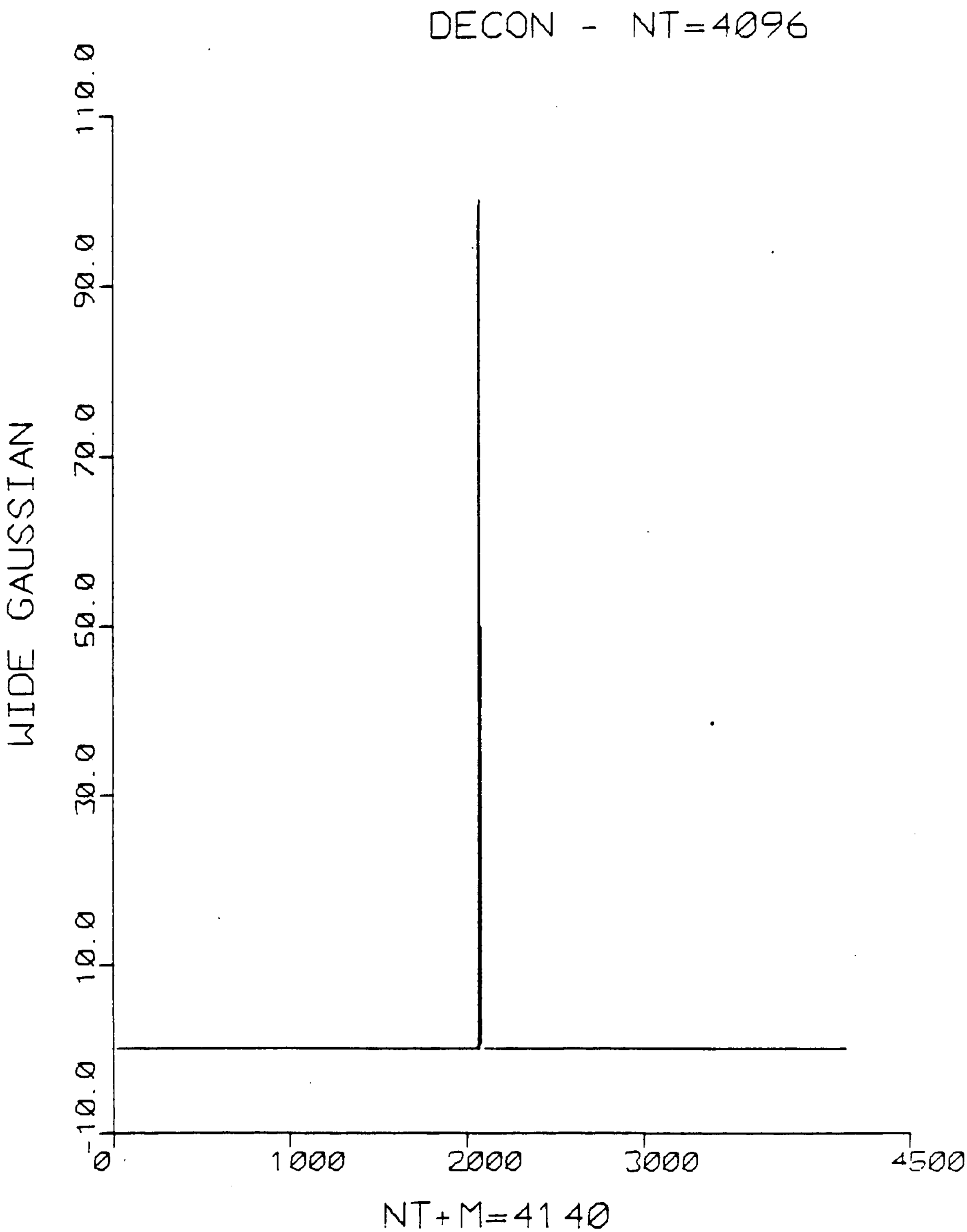

DECON - NT=4096
WIDE GAUSSIAN
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
0
1000
2000
3000
4500
NT+M=4140

Figure (2.31)

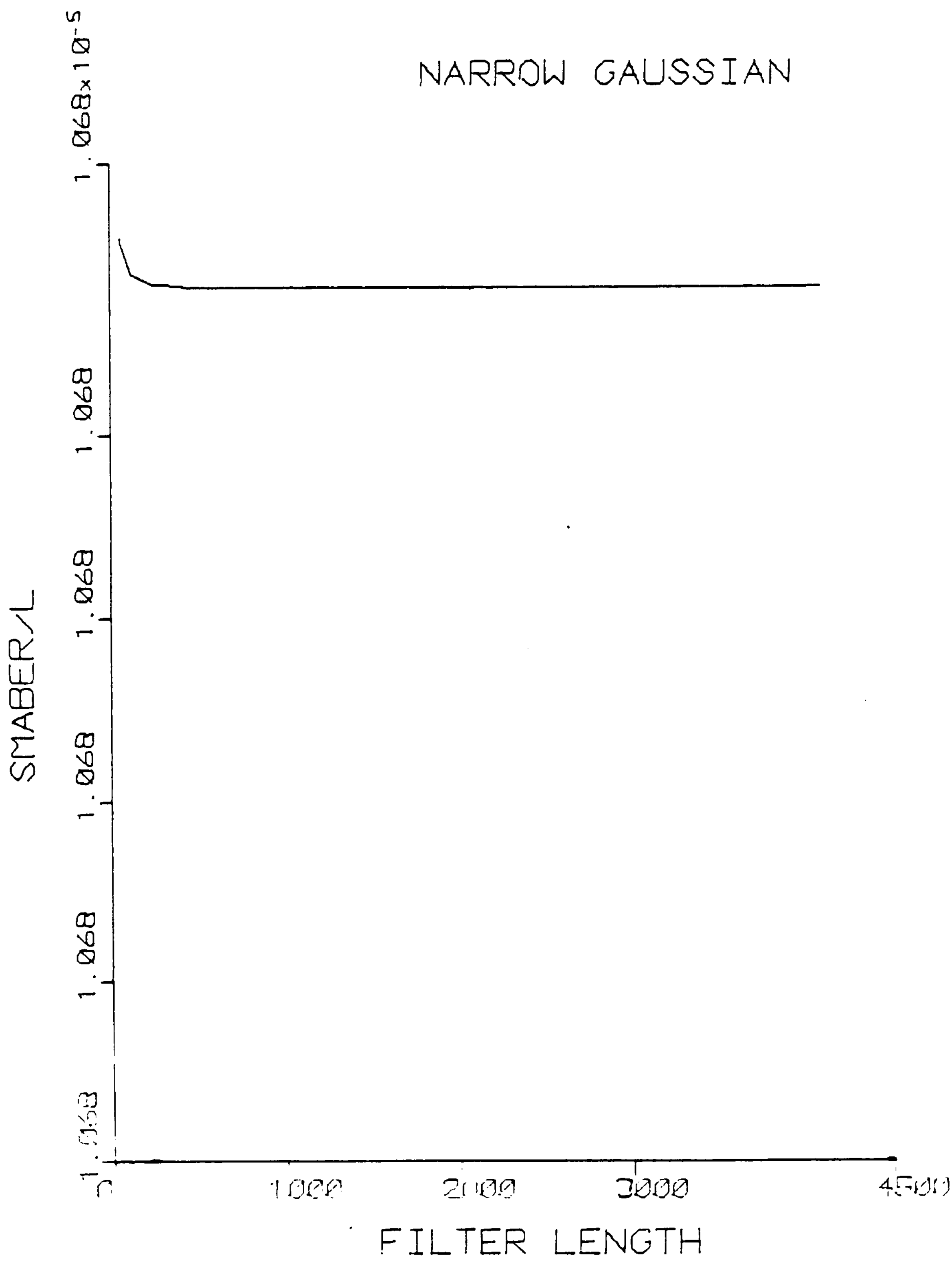

NARROW GAUSSIAN
1.068×10⁻⁵
1.068
1.068
1.068
1.068
SMABER/L
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.32)

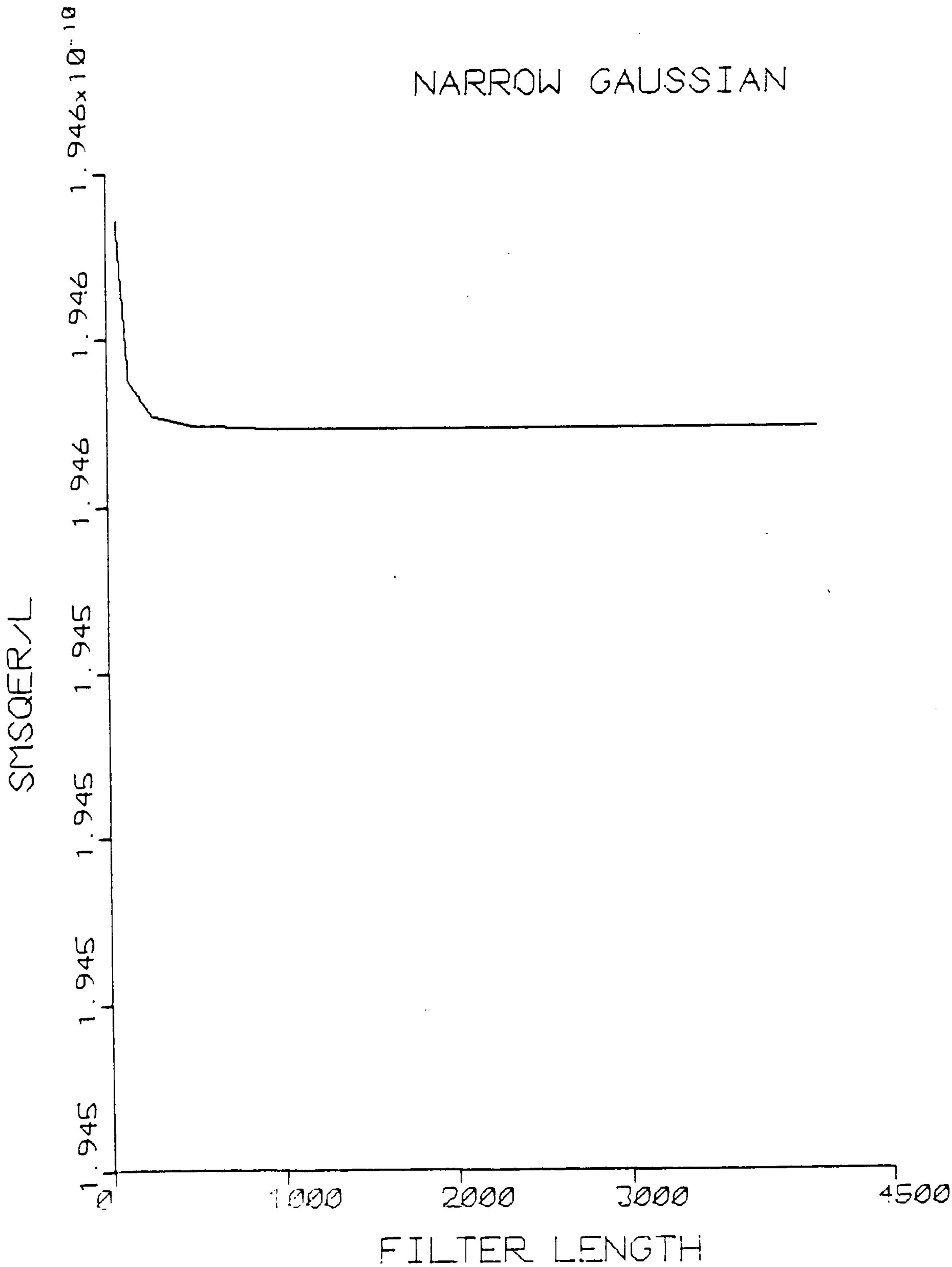

NARROW GAUSSIAN
1.946x10⁻¹⁰
1.946
1.946
1.945
1.945
1.945
1.945
SMSQER/L
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.33)

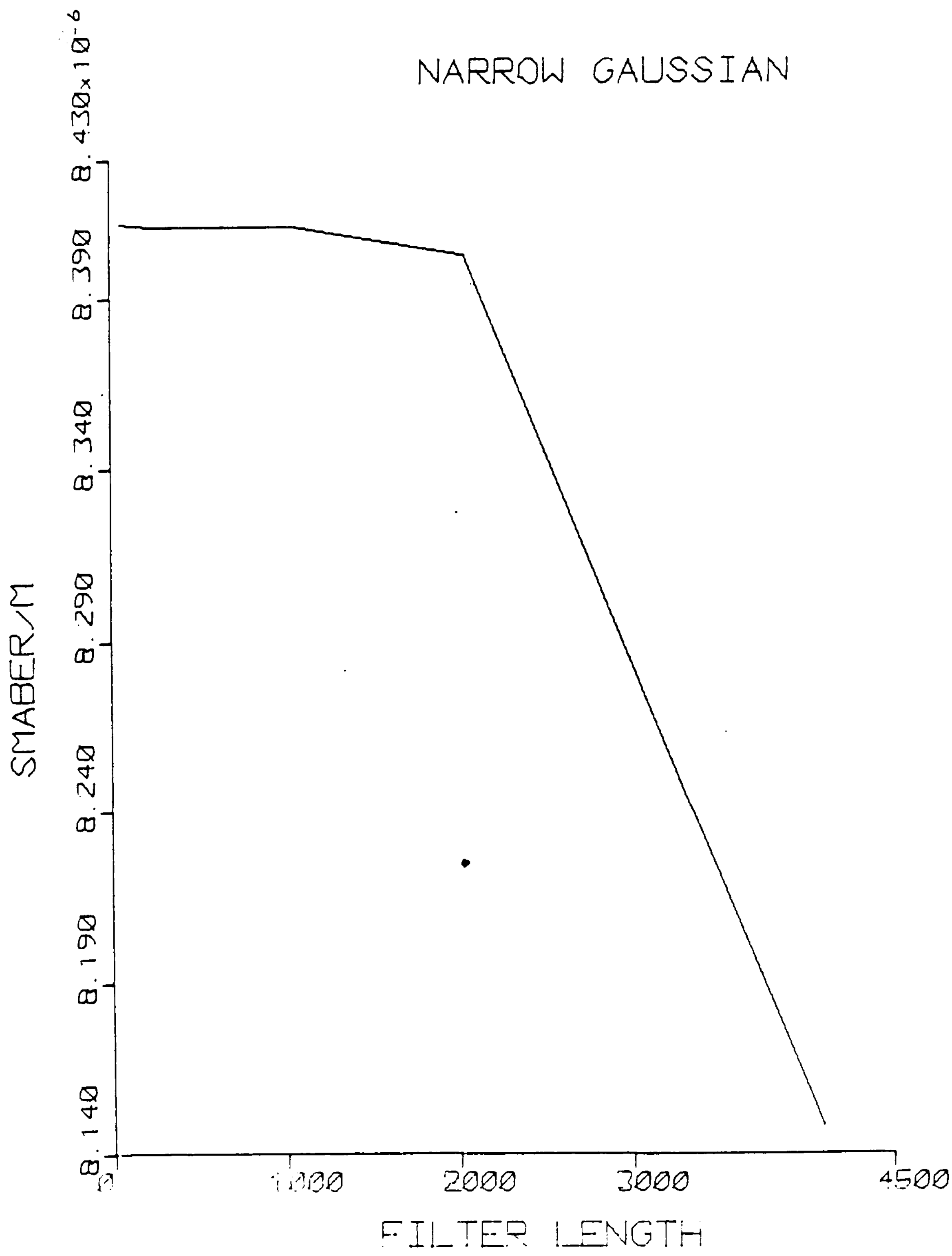

NARROW GAUSSIAN
8.430x10^-6
8.390
8.340
8.290
8.240
8.190
8.140
SMABER/M
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.34)

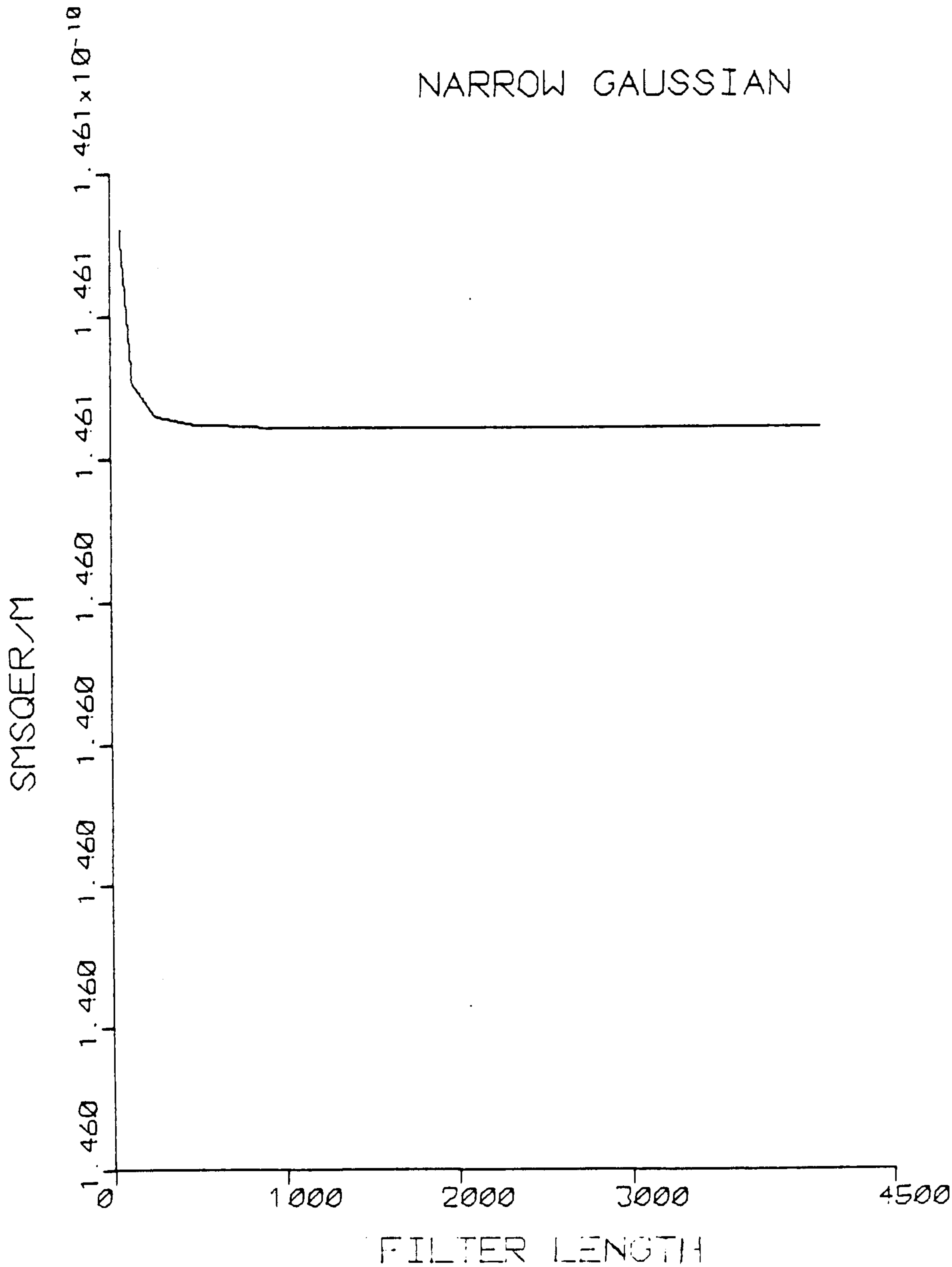

NARROW GAUSSIAN
SMSQER/M
1.461x10^-10
1.461
1.461
1.460
1.460
1.460
1.460
1.460
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.35)

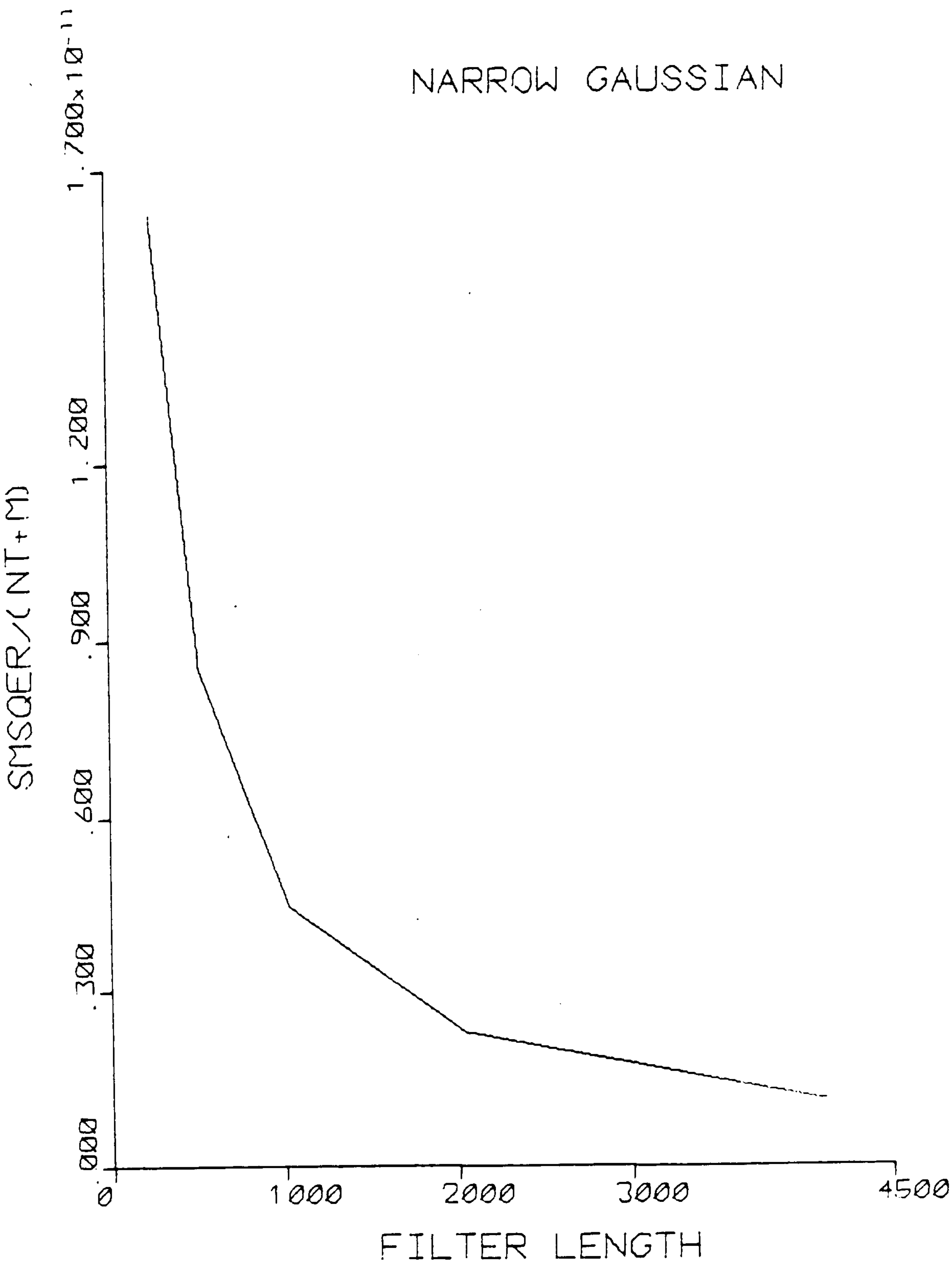
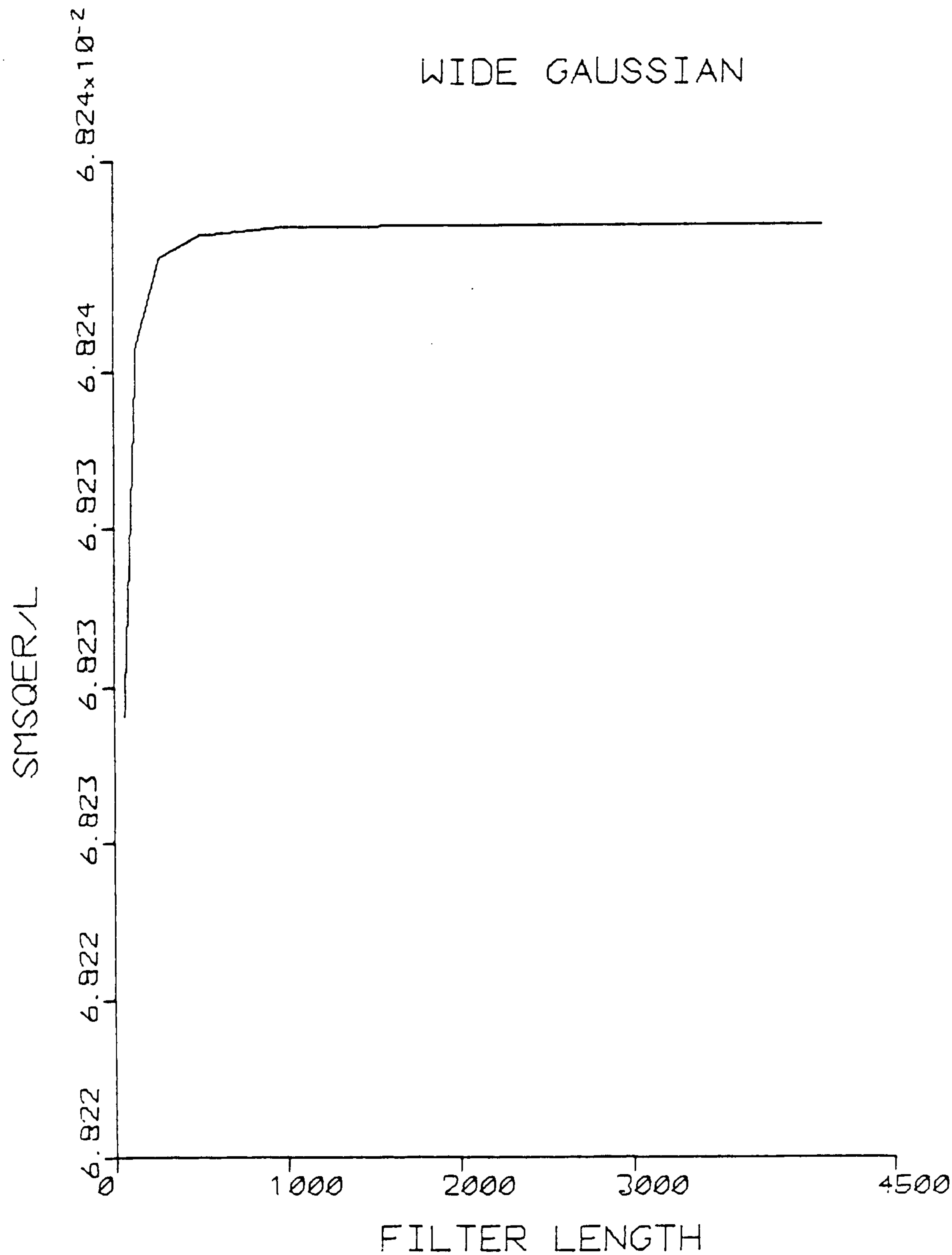

NARROW GAUSSIAN
1.700x10^-11
1.200
.900
.600
.300
.000
SMSQER/(NT+M)
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.36)



c-2

Figure (2.37)

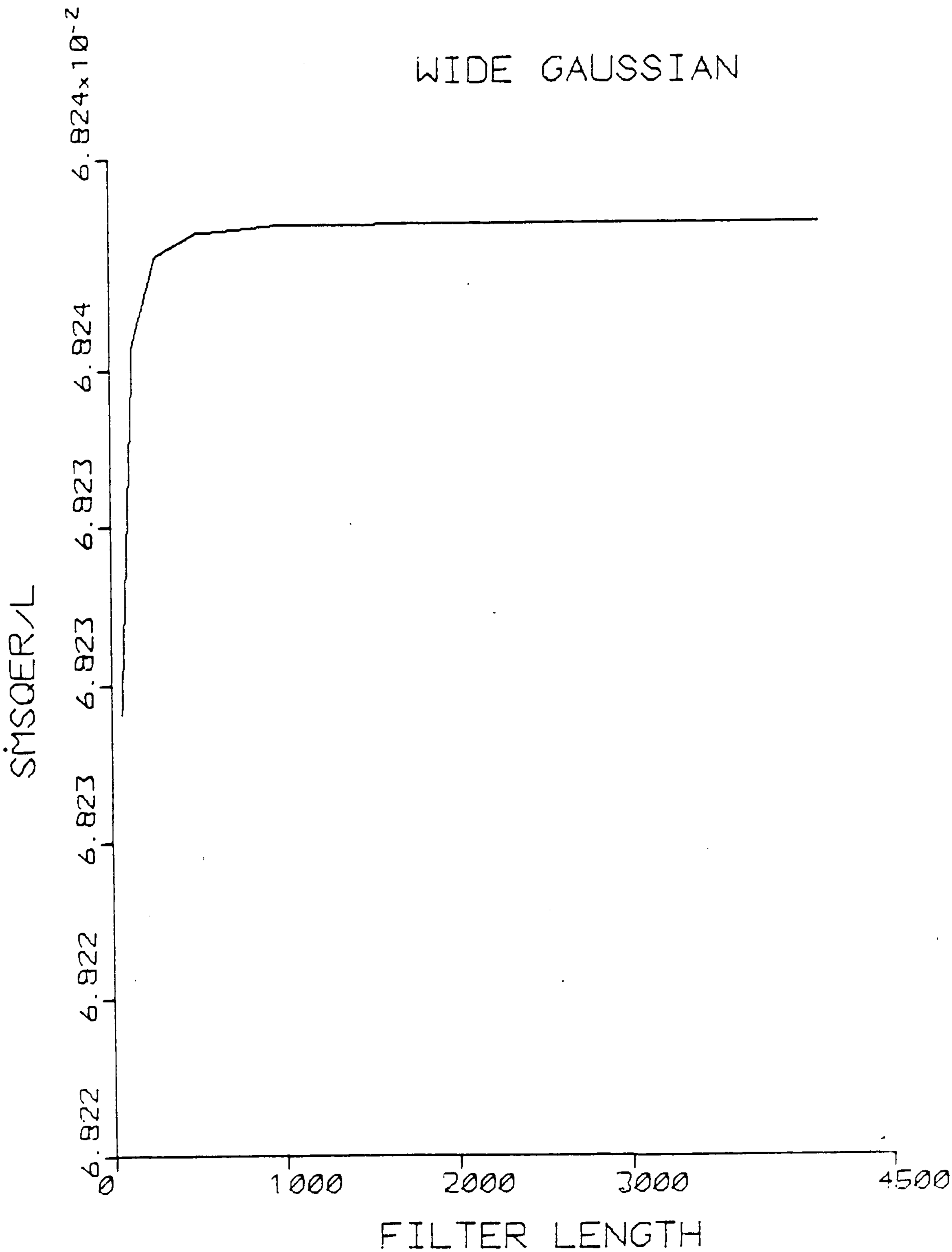

WIDE GAUSSIAN
6.824x10⁻²
6.824
6.823
6.823
6.823
6.822
6.822
SṀSQER/L
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.38)

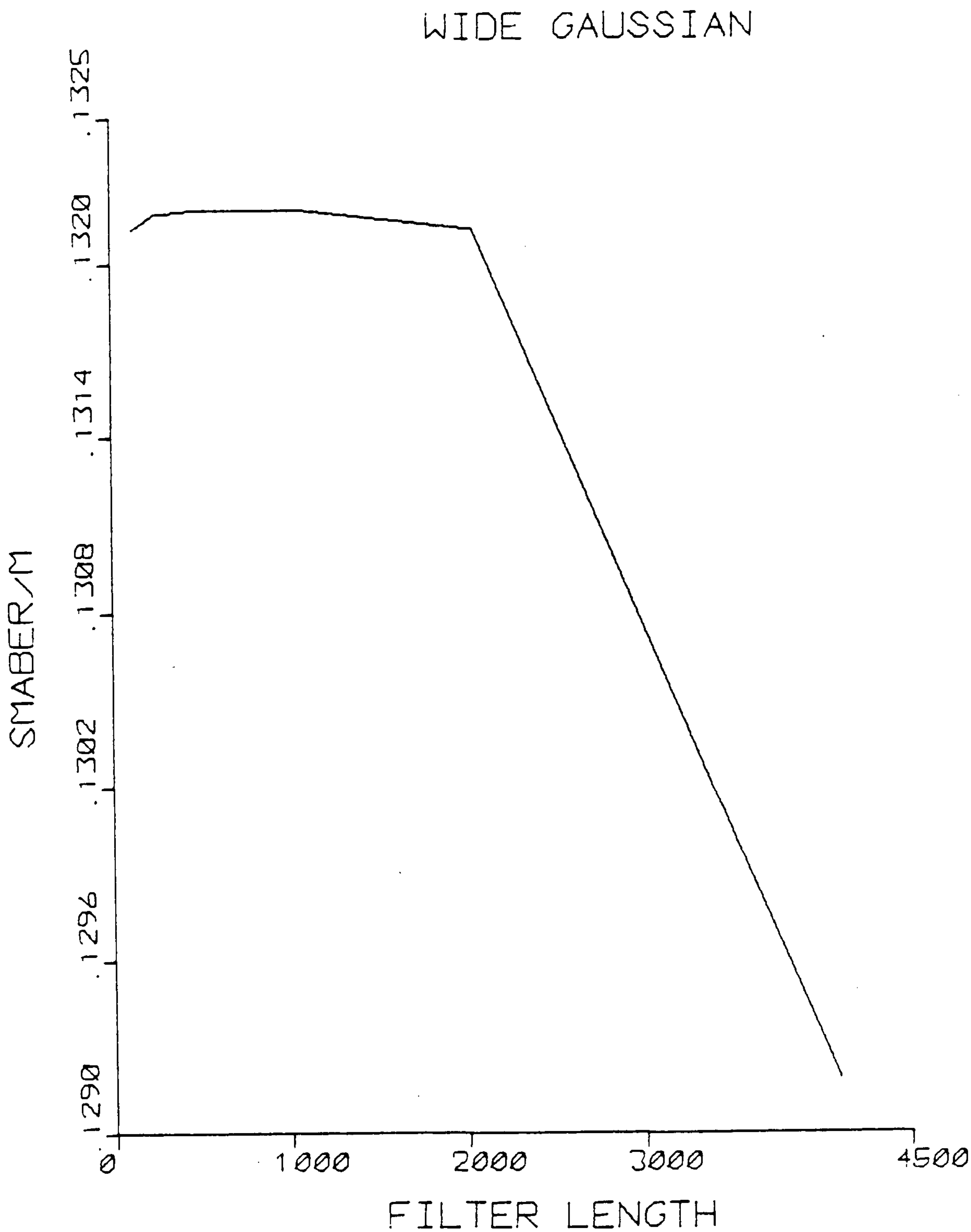

WIDE GAUSSIAN
SMABER/M
.1325
.1320
.1314
.1308
.1302
.1296
.1290
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.39)

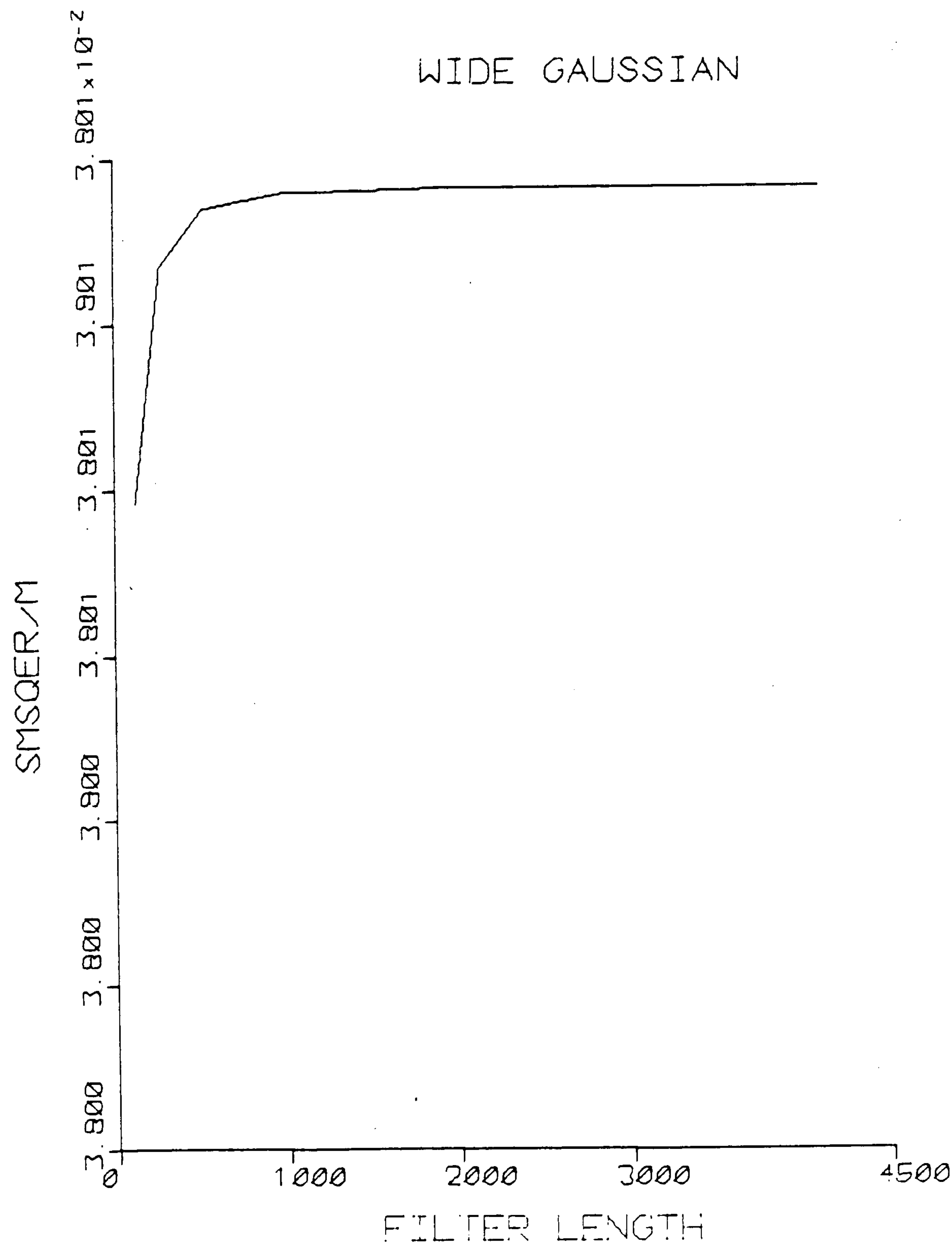

WIDE GAUSSIAN
3.801×10⁻²
3.901
3.801
3.801
3.900
3.800
3.800
SMSQER/M
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.40)

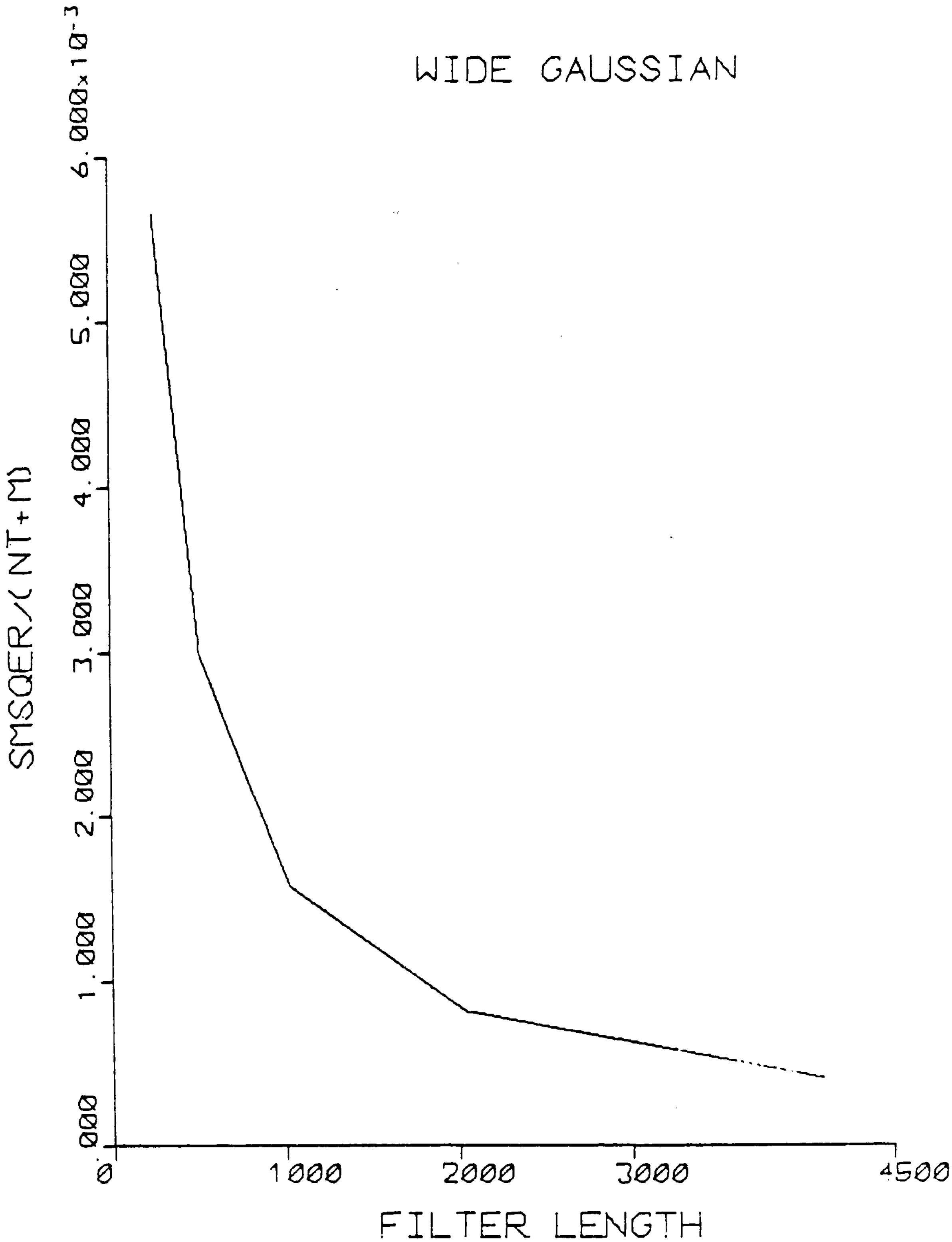

WIDE GAUSSIAN
SMSQER/(NT+M)
6.000x10^-3
5.000
4.000
3.000
2.000
1.000
.000
0
1000
2000
3000
4500
FILTER LENGTH

Figure (2.41)

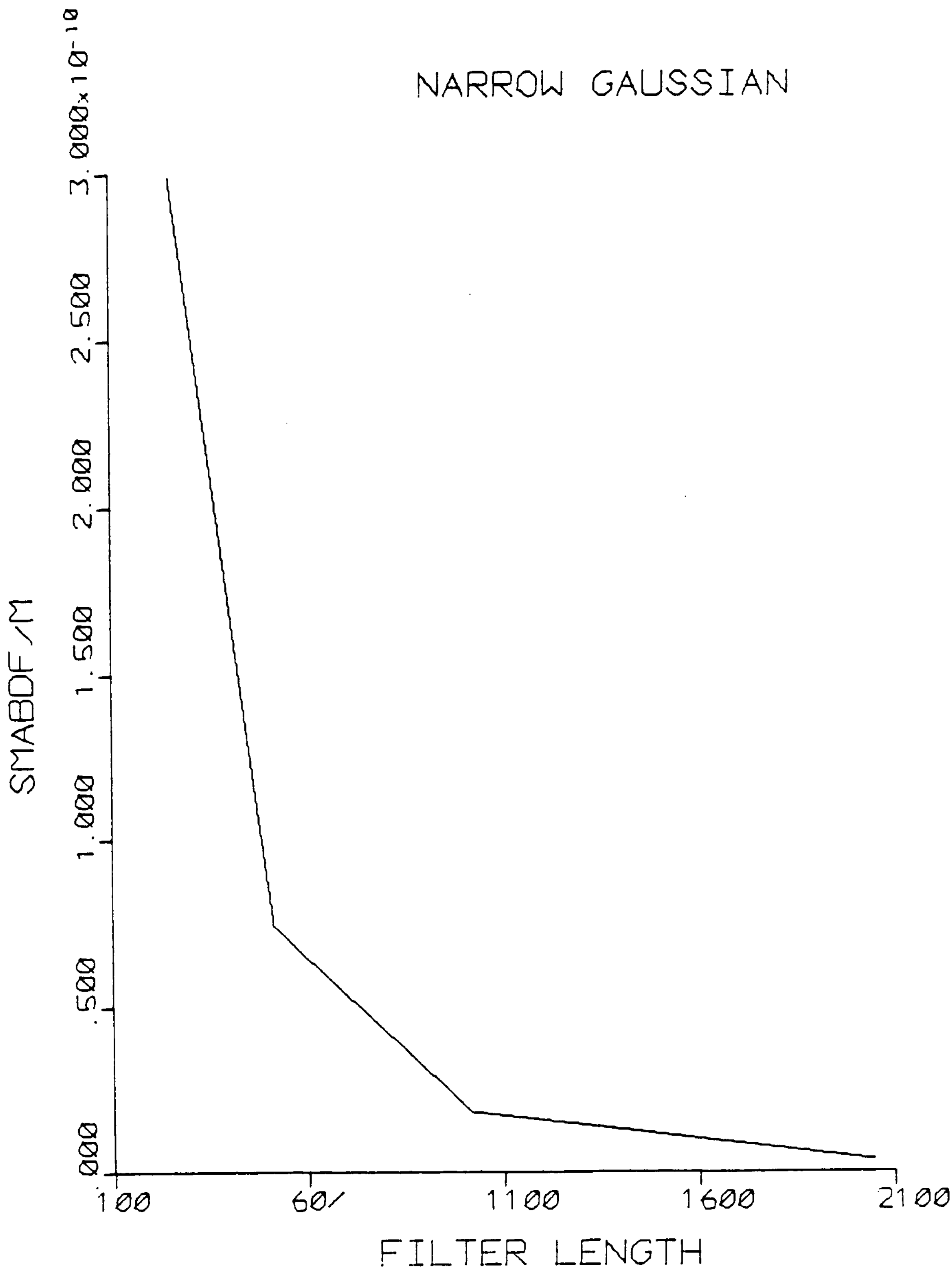

NARROW GAUSSIAN
3.000x10-10
2.500
2.000
1.500
1.000
.500
000
SMABDF/M
100
601
1100
1600
2100
FILTER LENGTH

Figure (2.42)

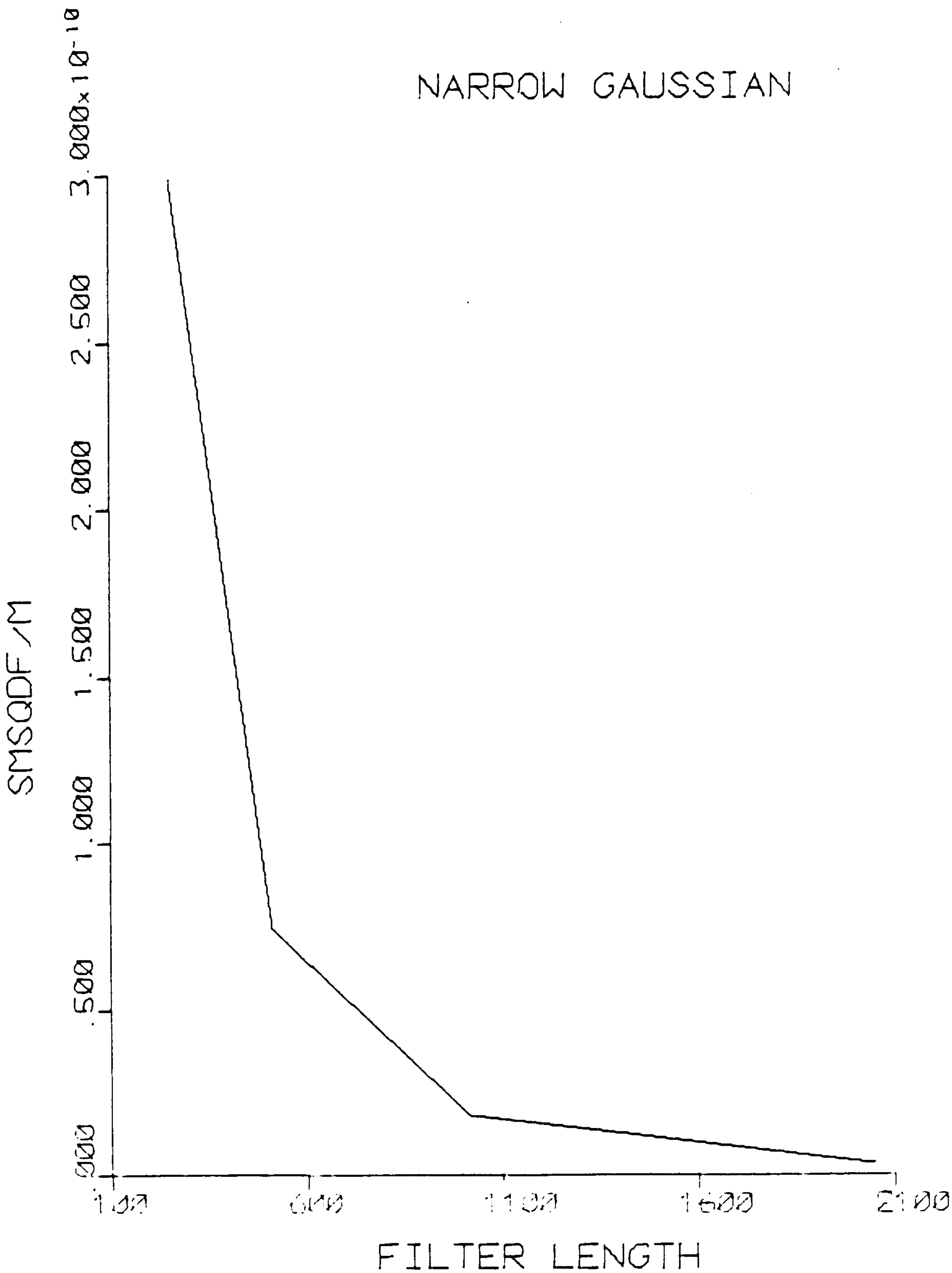

NARROW GAUSSIAN
3.000x10^-10
2.500
2.000
1.500
1.000
.500
.000
SMSQDF/M
100
600
1100
1600
2100
FILTER LENGTH

Figure (2.43)

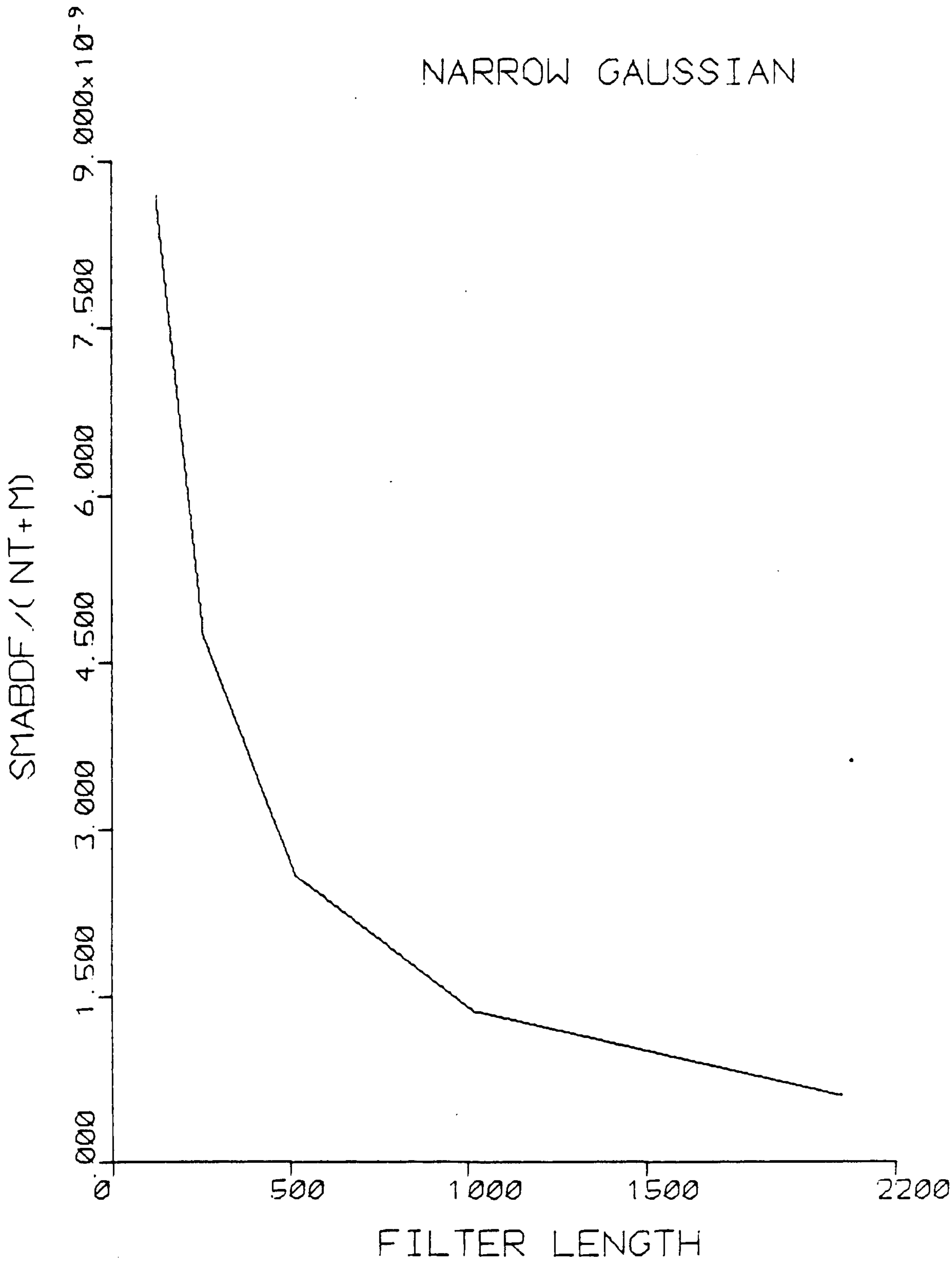

NARROW GAUSSIAN
SMABDF/(NT+M)
9.000x10⁻⁹
7.500
6.000
4.500
3.000
1.500
000
0
500
1000
1500
2200
FILTER LENGTH

Figure (2.44)

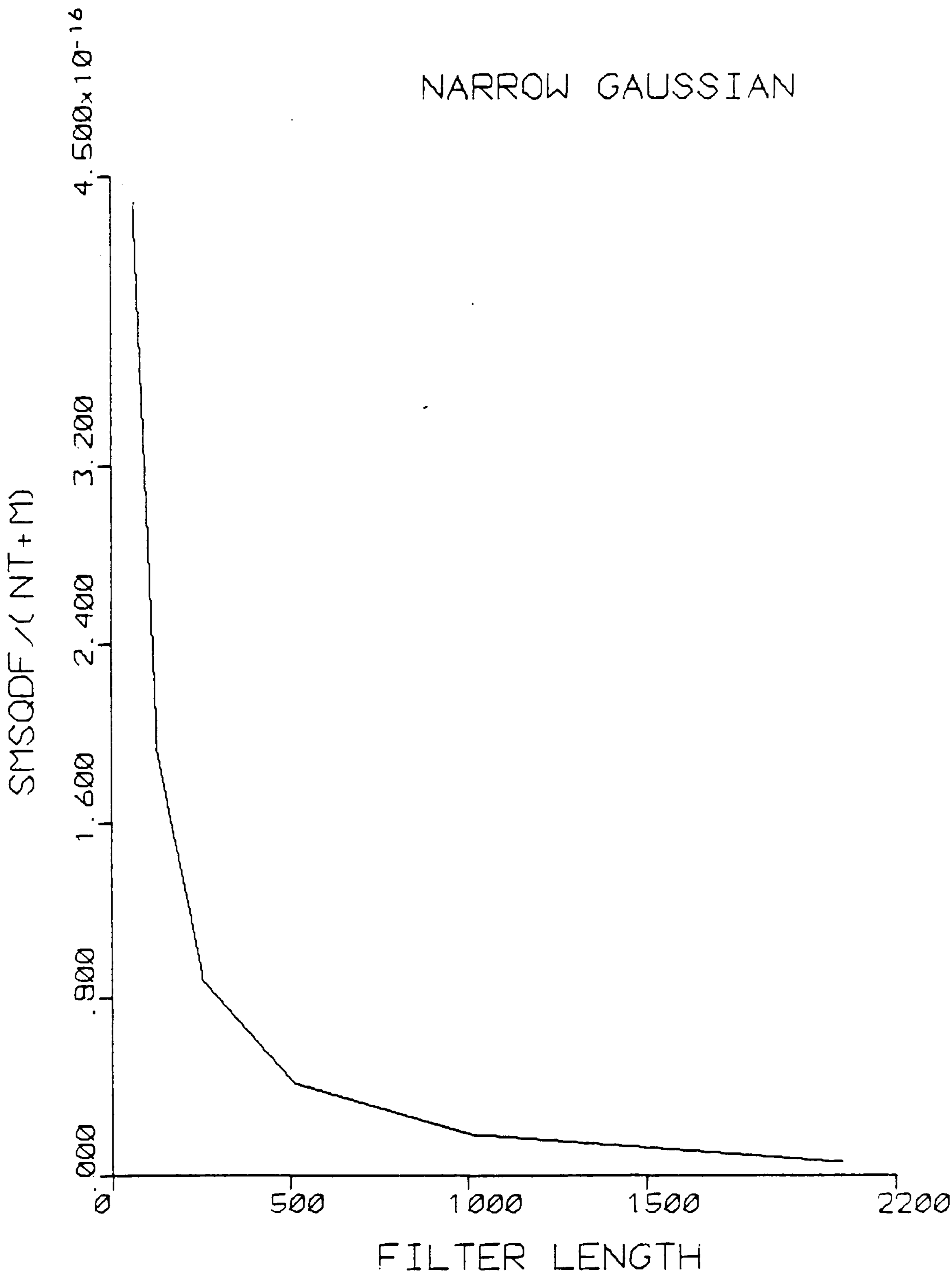

NARROW GAUSSIAN
4.500x10^-16
3.200
2.400
1.600
.800
.000
SMSQDF/(NT+M)
0
500
1000
1500
2200
FILTER LENGTH

Figure (2.45)

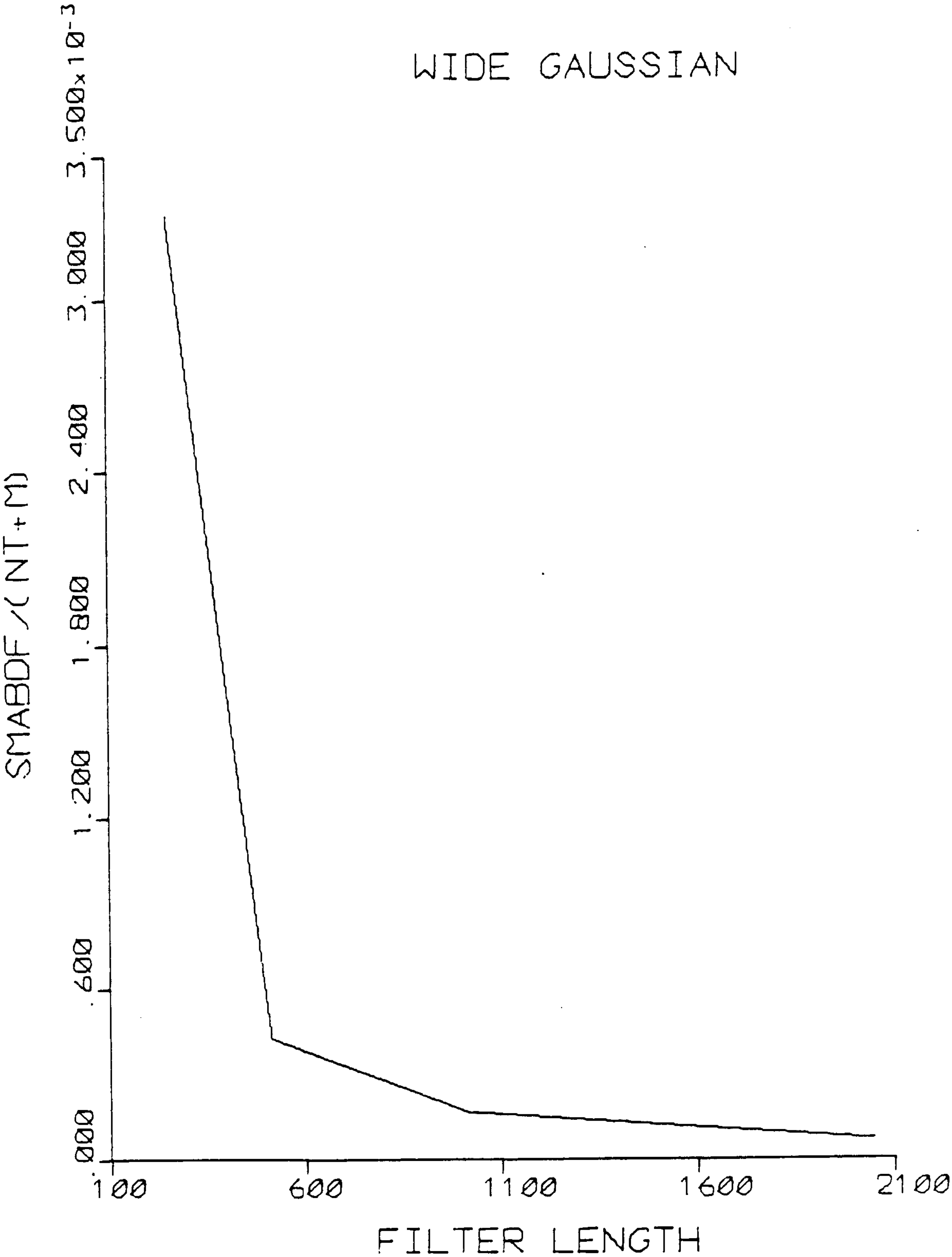

WIDE GAUSSIAN
3.500x10^-3
3.000
2.400
1.800
1.200
.600
.000
SMABDF/(NT+M)
100
600
1100
1600
2100
FILTER LENGTH

Figure (2.46)

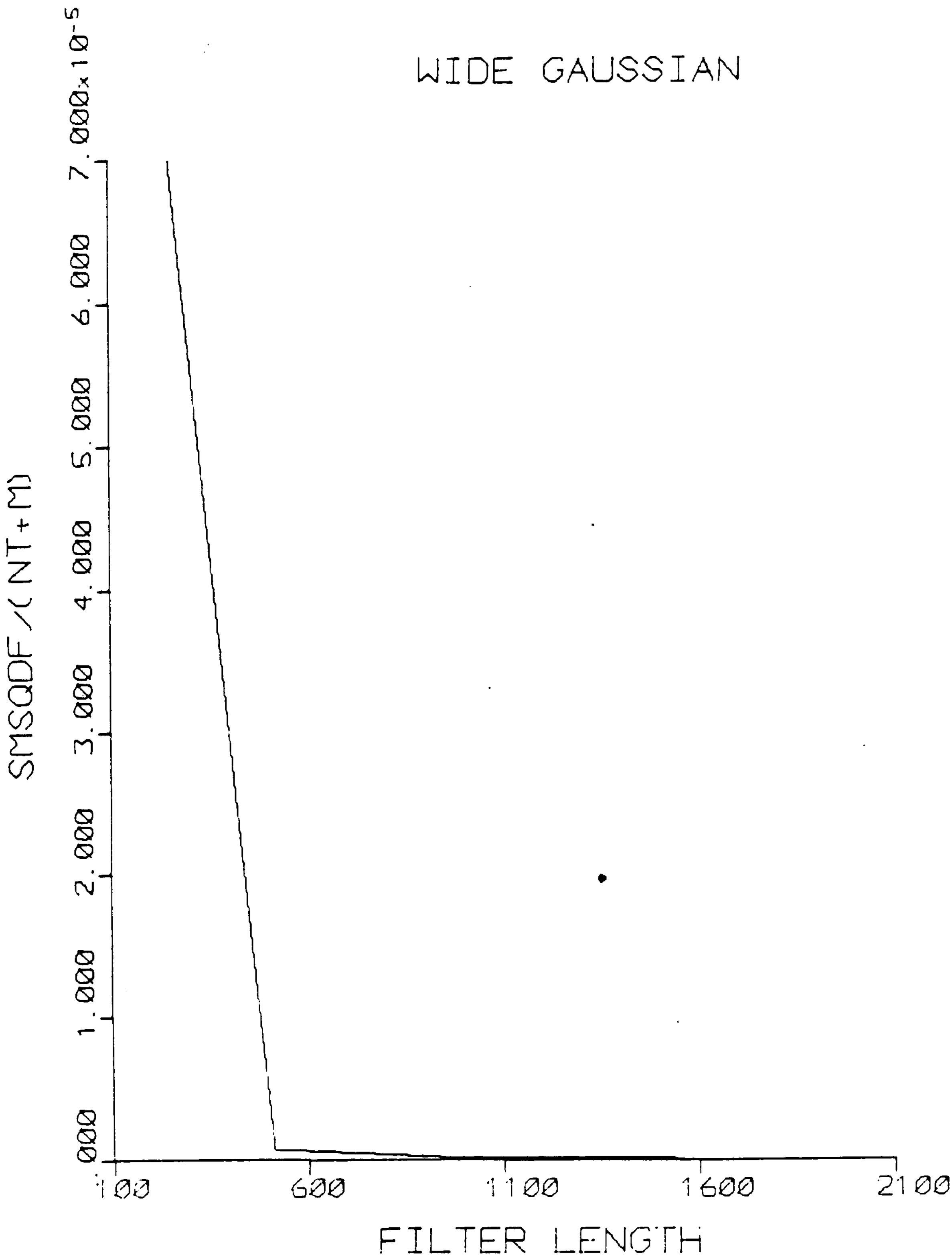
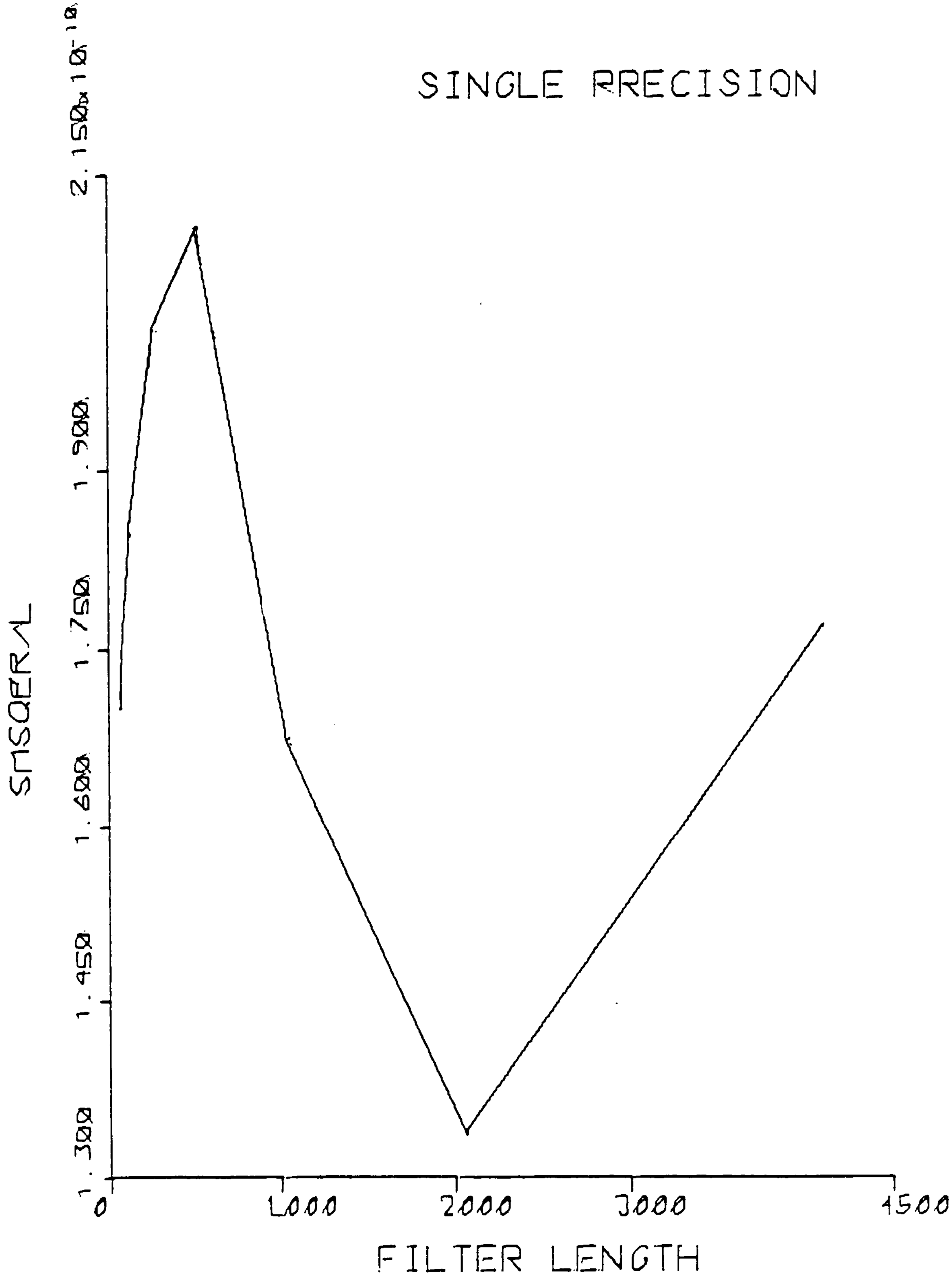

WIDE GAUSSIAN
7.000×10⁻⁵
6.000
5.000
4.000
3.000
2.000
1.000
.000
SMSQDF/(NT+M)
100
600
1100
1600
2100
FILTER LENGTH

Figure (2.47)


SINGLE PRECISION
2.150x10^-10
1.900
1.750
1.600
1.450
1.300
SMSQERAL
0
1000
2000
3000
4500
FILTER LENGTH

CHAPTER III

MORRISON´S METHOD FOR NOISE REMOVAL ALONE

Morrison´s iterative method of noise removal, or Morrison´s smoothing, is a technique in which the first iteration smoothes the data, and which with each subsequent iteration restores the data to the original, except for the removal of incompatable noise, upon convergence of the method, Ioup(1968).

For this work Morrison´s noise removal is applied in a simulation to noise added data for the determination of optimum use of the method.

The function and transform domain representations of Morrison´s smoothing are as follows (Ioup, 1968):

Function domain:

$$h_1 = h * g$$

$$h_n = h_{n-1} + [h - h_{n-1}] * g \quad ,n > 1$$

Transform domain:

$$H_1 = H\ G$$

$$H_n = H_{n-1} + [H - H_{n-1}]\ G \quad ,n > 1$$

or

$$H_n = [1-(1-G)^n]\ H$$

For the study undertaken in the present chapter g is one of the gaussian impulse response functions; h, hereupon denoted by hp, is the corresponding data set, defined in Chapter II, with noise added; and hn is the smoothed and/or restored result.

Detailed discussions of the conditions that assure convergence are outlined by Ioup(1968) and Wright(1980). Briefly, convergence is assured if $1-G(s) < 1$, or if $G(s) = 0$.

It should be noted, that since the narrow response has a wider frequency spectrum than does the wide gaussian, for a given s value $[1-(1-G(s))^n]$ is a number closer to one for any n for the narrow case, and Morrison's noise removal converges faster.

Morrison's method may be used for noise removal alone, or noise removal prior to deconvolution. The work in this chapter concerns a statistical study of the optimum use of Morrison's technique for noise removal alone. The application for deconvolution is discussed in Chapter IV.

Morrison's applied to noise added data, hp, restores both signal and noise with each iteration. In the restoration process very little distinction can be made between the restoration of noise and the restoration of signal except in those frequency regions where one significantly dominates the other.

It has been shown by Wright(1980) that the best approximation of the data, h, is obtainable by termination of the iterations before convergence of the method. At this optimum number of iterations there results the most favorable trade off between the restoration of noise and resolution of signal.

One would expect that the optimum number of iterations should increase monotonically as the noise level of the data to be restored is decreased. Since there is less noise to obscure the restoration, a greater number of Morrison's iterations may be performed to obtain increased resolution of the signal before noise distorts the result.

In previous studies Wright(1980) and Ioup(1981), and Ioup and Ioup(1981), developed a methodology for optimum use of Morrison's noise removal. An algorithm was developed for applying Morrison's method, as was a procedure to add ordinate-dependent and constant gaussian distributed noise to the data h. The signal-to-noise ratio (SNR), which is the ratio of the maximum ordinate value of h to the root-mean-square (RMS), or standard deviation, of the noisy data, was used as the measure to characterize the level of noise added to the data. These developments are used for this study.

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The data studied have SNR's of approximately 2 through 1000, and enough data sets are optimized for each SNR so that the result has statistical significance.

Noise Addition Procedure

The procedure for adding constant gaussian noise, i.e., noise having a constant standard deviation at each point, is as follows:

$$hp(I) = \left(\sum_{j=1}^{12} A_j - 6\right) * (NSF)^{1/2} + h(I)$$

where NSF, the noise scale factor, is chosen to vary the magnitude of the noise and thus the SNR; and A is a random number between zero and one generated by a system subroutine (Hamming, 1973). The index I denotes each discrete data element.

For addition of ordinate-dependent gaussian noise, i.e., noise having an ordinate dependent standard deviation, the procedure is:

$$hp(I) = \left(\sum_{j=1}^{12} A_j - 6\right) * (NSF*h(I))^{1/2} + h(I)$$

The only difference from the constant case is that the tandard deviation of the noise added is proportional to $(h(I))^{1/2}$. Figures (3.1) and (3.2) show data of SNR 2 for the narrow gaussian case with constant and ordinate-dependent noise added, respectivelv.

In the procedure for adding noise any negative hp(I) is set positive to keep the data set non-negative since the object of the study is to consider onlv such data. Also, for the ordinate data for any h(I) less than .0000001 (NSF*h(I)) is set equal to (NSF*.0000001) before noise is added.

As mentioned previouslv, the SNR is used as the measure of noisiness of the data sets, and as is evident from the noise addition procedures, the SNR is inversely proportional to the square root of the NSF.

Constant noise case:

$$SNR=h(max)/((1/M)\sum_{I=1}^{M}[h(I)-((\sum_{j=1}^{12}A_j-6)_I*(NSF)^{1/2}+h(I))]^2)^{1/2}$$

$$=h(max)(M)^{1/2}/((NSF)^{1/2}\sum_{I=1}^{M}[\sum_{j=1}^{12}A_j-6]^2)^{1/2}$$

$$SNR \propto 1/(NSF)^{1/2}$$

Ordinate noise case:

$$SNR=h(max)/((1/M)\sum_{I=1}^{M}[h(I)-((\sum_{j=1}^{12}A_j-6)_I*(NSF*h(I))^{1/2}+h(I)]^2)^{1/2}$$

$$=h(max)(M)^{1/2}/((NSF)^{1/2}\sum_{I=1}^{M}[(\sum_{j=1}^{12}A_j-6)_I*(h(I))^{1/2}]^2)^{1/2}$$

$$SNR \propto 1/(NSF)^{1/2}$$

A larger NSF corresponds to data having a higher noise level.

Since a given NSF produces a statistically distributed range of SNR values upon repeated use. something must be done to limit the SNR values to a small neighborhood about the mean SNR for a given NSF. The approach used here is to add noise 100 times to h, and calculate an average SNR, AVESNR, and standard deviation, SDSNR, for the 100 cases. The SNR of the data sets to be optimized will be confined to a range of plus and minus one-half SDSNR of AVESNR.

Plots of AVESNR versus $1/(NSF)^{1/2}$ are shown in figures (3.3) through (3.6). Figures (3.3) and (3.4) are of the narrow gaussian ordinate-dependent and constant noise cases, respectively and figures (3.5) and (3.6) are the wide gaussian ordinate and constant cases. All plots show a nearly linear relationship between AVESNR and $1/(NSF)^{1/2}$. The slopes of the lines for the constant and ordinate noise cases are as follows:

Constant noise case:

$$\text{Slope} = ((M)^{1/2} h(\max)/100)\,[\sum_{J=1}^{100} B_J] \quad ,$$

$$\text{where} \quad B_J = 1/(\sum_{I=1}^{M}(\sum_{j=1}^{12} A_j - 6)^2_{I,J})^{1/2}$$

Ordinate noise case:

$$\text{Slope} = ((M)^{1/2} h(\max)/100)\,[\sum_{J=1}^{100} C_J] \quad ,$$

$$\text{where} \quad C_J = 1/(\sum_{I=1}^{M}((\sum_{j=1}^{12} A_j - 6)_I * (h(I))_J^{1/2})^2 \quad)^{1/2}$$

The terms in brackets are esentially constant because of the large number of noise additions, and M is the number of points of a data set. A user need only pick out a NSF from the plots for a desired AVESNR.

As mentioned, Morrison's method is applied to data sets having SNR's of about 2 to 1000. A look ahead to figures (3.7) and (3.23) shows that the rate of change of the optimum iteration number and the error improvement with respect to SNR is much greater for the relatively low SNR's. For this reason more data points are required in the low SNR region so as not to lose too much information.

A procedure of first calculating an AVESNR of about 2, using the appropriate NSF, then dividing the NSF by 2 after each AVESNR is calculated until an AVESNR of about 1000 is attained, works quite well in calculating an effective range of average SNR's.

Two error measures are employed in this optimization. These are based on minimization of (a) the absolute error per point, and (b) the root-mean-square error, RMS, between h and hn. These measures are referred to as the L1 and L2 norms, respectively.

Convergence Criteria

The convergence criterion applied in the optimization terminates the iterations when a fractional difference, DF1, or an absolute difference , DF2, between the error at successive iterations is less than .0001.

Fractional difference:

$$DF1 = [\ e(i-1)-e(i)\ /e(i-1)] < .0001$$

Absolute difference:

$$DF2 = [\ e(i-1)-e(i)\ ] < .0001$$

where i denotes the iteration number of the current test.

Error values are in general higher for the lower SNR cases, so that two convergence measures are employed so as not to favor the larger or smaller errors over the complete SNR range. The fractional difference criterion results in faster convergence for the larger errors, and for smaller errors the absolute difference criterion gives convergence more rapidly. For very low SNR´s, approximately 2 to 15 depending on the width of the gaussian response and the noise type used, it is believed that optimization occurrs at an error minimum rather than convergence of error.

Choosing a suitable convergence criterion is somewhat subjective as a preference for reduction in noise or resolution of signal comes into play. But as this is a statistical study meant to make the selection of the optimum number of Morrison´s iterations more routine a convergence criterion is chosen which allows optimum error improvement in combination with results consistent with expected behavior. A useful selection also avoids a variance in iteration number so wide as to preclude user confidence in the selection of a iteration number.

The choice of .0001 as the convergence value was determined experimentally as test results were calculated using stronger and weaker values. Using a stronger value, .001, caused convergence to occur to quickly, as the number of iterations were lower and, more importantly, the error improvement was not as substantial. Using a weaker value, .00001, resulted in higher iteration numbers, but the improvement in error was not significantly better and the results of optimum iteration number versus SNR did not show as consistent a monotonically increasing behavior as the SNR increased. Also, the standard deviations in iteration numbers were significantly larger. Using no convergence criterion resulted in even less consistent data, and again not a significant improvement in error.

Optimization Procedure

The method for determining optimum average iteration number is to calculate AVESNR and SDSNR as previously outlined, and to continue adding noise for each SNR until 100 data sets having SNR's that fall within plus and minus one-half SDSNR for each AVESNR are stored. From these 100 data sets new averages, AVSNR2, standard deviations, SDSNR2, and maximum and minimum SNR's, MXSNR and MNSNR, that fall within the one-half SDSNR range are calculated. These values are listed in tables (3.1)-(3.8) for both gaussians, and both noise types, and on all plots versus AVSNR2 the confidence limits, MNSNR and MXSNR, of AVSNR2 are given. The NSF's used in calculating the average SNR's are listed in the tables. Having data sets with SNR's very close to a mean value, AVESNR, gives highly reliable results in determining the average optimum iteration number for each AVSNR2.

Morrison's noise removal is applied to the data sets and error is tested after each iteration by comparing the restored result to the noise-free h defined in Chapter II. The 100 optimum iteration numbers for each AVSNR2 are stored, and averages of iteration number are calculated, AVITNM, along with their standard deviations, SDITNM, and maximum and minimum iteration numbers, MXIT and MNIT. These values are listed in tables (3.9)-(3.16).

Figures (3.7)-(3.22) show AVITNM versus AVSNR2 and AVITNM versus the natural log of AVSNR2 for both the narrow and wide gaussians, L1 and L2 norms, and constant and ordinate-dependent noise types. Standard deviations of iteration number are given on the semilog plots.

In the calculation of the average improvement in error at each AVSNR2, the ratio of the error after to the error before applying Morrison's method is determined for each of the 100 data sets. The averages of each of the 100 ratios are calculated, AVERNM, along with their standard deviations SDERNM, and their maxima and minima, MXER and

MNER. Tables (3.17)-(3.24) list these values.

Plots of AVERNM versus AVSNR2 and AVERNM versus the natural log of AVSNR2 are shown in figures (3.23)-(3.38). Standard deviations of error improvement are included on the semilog figures.

In examining the data, figures and tables, one can note that the confidence limits given by the average SNR's, standard deviations, and MNSNR to MXSNR, are larger for the ordinate noise data than the corresponding constant noise result. This is a consequence of the noise types. There is more of a variance in the noise per point at large ordinates in the ordinate noise case because for each data point the noise is weighted by the square root of the ordinate value of h.

The width of the SNR error bars shown on the semilog figures does not correspond to the actual linear spread of SNR values, as the natural log is being plotted. The reader can refer to the values listed in the tables or on corresponding figures for easier interpretation, unless one has an intuitive feel for the properties of logarithms or does a logarithm calculation.

Narrow Gaussian Iteration Results

Results of the narrow gaussian study (examine figures (3.7)-(3.14) or tables (3.9) and (3.12)) show a nearly monotonic increase in average iteration number, AVITNM, as the average SNR, AVSNR2, increases. However for very low AVSNR2's, 2 and 3 of the ordinate result, the AVITNM's show a departure from this behavior, as the extremely high noise level for this SNR region is usually sufficient to cause termination of iterations after one smoothing iteration. For AVSNR2 135 and 190 of the ordinate L2 and constant L1 results, respectively, there is a slight decrease in AVITNM. It is believed that the dip in iteration number for both cases occurred in the SNR region where the absolute difference convergence criterion became effective. A slight weakening of this criterion would result in slightly higher AVITNM's and strict monotonically increasing behavior for the region in question. Also, at very high AVSNR2 values for both the L1 and L2 ordinate result and the constant L2 case there is some minor fluctuation in average iteration number. Since the percent difference between average iteration numbers is minimal and the restored result very good for this SNR region, this behavior is of little concern.

Both the L1 and L2 norm results of the ordinate and constant noise cases show a very rapid increase in AVITNM from AVSNR2 3 through 94 and 2 through 130, respectively.

The increase is 1 to 39 and 1 to 35 AVITNM's for the L1 and L2 ordinate cases, and 1.5 to 38 and 1 to 38 AVITNM's for the L1 and L2 constant results, respectively.

There is a slight decrease in the rate of AVITNM increase beginning at AVSNR2's 33 and 46 for the ordinate and constant cases. This behavior will be magnified when the error improvement results are analyzed as the rate of decrease in error improvement becomes slower for this AVSNR2 region. A leveling off of the rate of increase of AVITNM with respect to AVSNR2 occurrs in the AVSNR2 regions 95 through 545 , and 130 through 530 for the ordinate and constant results,respectively. The AVITNM's for the L1 and L2 ordinate result are 53 and 45, respectively, at AVSNR2 545, and for the L1 and L2 constant result are 42 and 45 at AVSNR2 530. Examination of the average iteration curves shows that this leveling off region is not well defined for all cases, and the leveling off is generally more abrupt for the constant L1 curve. For high AVSNR2's the curves have leveled off considerably, as for this low noise level region the iterations may be continued until a very accurate restored result is obtained.

By comparing the iteration results listed here with those calculated using no convergence criterion, it is determined that the fractional difference convergence criterion begins to affect the ordinate noise L1 and L2 norm results at AVSNR2 8.8. The convergence criterion becomes effective at AVSNR2's 4.3 and 11.8 for the constant noise L1 and L2 cases, respectively.

Wide Gaussian Iteration Results

The wide gaussian ordinate-noise results, figures (3.15)-(3.18) or tables (3.13) and (3.14), show a rapid increase in AVITNM from AVSNR2 1.9 through 66, an increase of 1.7 to 61 and 1 to 59 iterations for the L1 and L2 norms. It is believed that the absolute difference convergence criterion takes effect at AVSNR2 90 for both L1 and L2 norm types, where the AVITNM's are 62 and 63. The slopes of the curves, or rates of change of AVITNM's, then gradually decrease, until for high AVSNR2 the curves are relatively flat with maximum AVITNM's of 115 and 122 at AVSNR2 1088 for the L1 and L2 results, respectively.

The L1 and L2 results for the wide gaussian constant-noise cases, given in figures (3.19)-(3.22) or tables (3.15) and (3.16), demonstrate a rapid increase in AVITNM from AVSNR2 2.2 through 92, an increase of 2.6 to 72 and 1.4 to 72 average iterations for the L1 and L2 norms. Where there is a slight buckle in the curves at AVSNR2 133, the AVITNM's are 74 and 75 for the L1 and L2 norms, respectively. For these AVSNR2 the absolute difference convergence criterion begins to affect the result. Then there is a gradual decrease in the slopes of the curves as

AVSNR2 increases, with maximum AVITNM's of 112 and 120 at AVSNR2 1084 for the L1 and L2 norms, respectively.

The fractional difference convergence criterion becomes effective immediately for all wide gaussian results. Perhaps a better experimentation procedure would have been to weaken this criterion slightly for the very low SNR region and allow optimization as an error minimum is achieved. Another procedure which would have been useful in the analysis of results would be to set a marker or flag to indicate which termination method, i.e., error minimum, fractional, or absolute difference convergence, was used in the optimization at each AVSNR2. This would have made certain of the SNR regions where each of the criteria was used, and would allow a more complete understanding of the behavior of all results. Also, it is possible an even more suitable choice of convergence criteria could have been made with the use of this information, with perhaps different criteria for different SNR regions for each case.

It should be noted that in the analysis of convergence criteria given thus far, it is likely that once one criterion takes effect it is the only criterion used until the next one becomes effective. Some of the analysis to follow makes this general assumption.

Noise Spectra

Upon observation of figure (3.39), a plot of the ordinate-dependent and constant noise superimposed, both of SNR 2 for the narrow gaussian case, it is noticed that for constant noise the magnitudes of the oscillations about the noise free level remain relatively constant for the entire data region. The ordinate-dependent noise tends to more violent oscillations in regions where the ordinate values of the data are largest, and lesser magnitude oscillations where h is smallest. Thus the frequency distributions of the spectra of the ordinate and constant noise types differ. Large magnitude oscillations about the no-noise level at each data point correspond to large magnitude high frequencies.

The ordinate noise perhaps has a bimodal frequency distribution, with regions of large magnitude low and high frequencies. The latter possibility arises from the erratic behavior at large ordinate data. Since the ordinate-dependent noise has a trend following the data, it is also expected to have a relatively large low frequency component. There is possibly a more even distribution of the magnitudes of frequencies for the constant noise. However, the exact distributions are not known without examining the transform domain representations of the two noise types. This will be done in a future study.

The difference in frequency distributions should be less evident for the wide gaussian case, as there is a lesser variation in the ordinate values of the data. This implies that there is still a bimodal frequency distribution for the wide gaussian ordinate noise, but the low and high frequency regions of large magnitude are less pronounced than in the narrow gaussian case.

Examination of the average iteration results shows that there are differing AVITNM's between the L1 and L2 norm results for the same gaussian and noise types. There are also different iteration results between the ordinate and constant noise cases for the same gaussian and norm optimizations. These differences in AVITNM are of different degree and magnitude over differerent AVSNR2 regions.

For the case where the L1 and L2 norm AVITNM's are different, the difference can probably be attributed to the L2 norm favoring the reduction of larger errors at each data point, as the L2 norm gives weight to larger magnitude restored noise by squaring the error. The difference between AVITNM's for different noise types is a consequence of the differing frequency distributions of the ordinate and constant noise.

As previously alluded to, the wide gaussian results have higher iteration numbers than the corresponding narrow gaussian results because the convergence of Morrison's noise removal is faster for the narrow case.

Examinimg the average iteration semilog figures, or the corresponding tables, for both the narrow and wide gaussian cases, one observes a region of maximum standard deviation values, SDITNM´s, which occurrs in the middle to upper middle range of AVSNR2´s. At high noise levels, or low SNR values, noise is restored quickly for all cases and there is little chance for a wide variance in iteration number. For high SNR values the noise level is low for all data sets and iterations can be continued until a very good approximation of the signal is obtained. But for the intermediate range of SNR´s, noise is distributed more unevenly throughout the data, and in the restorative process the variation in optimum iteration is greatest.

It is noted that the standard deviations of the AVITNM´s for both the narrow and wide cases are in general larger for the ordinate results. This is probably due to the relative uneveness of the frequency distribution of the ordinate-dependent noise.

Error Improvement

In the examination of the plots of average error ratio, AVERNM, versus AVSNR2, figures (3.23)-(3.38) and tables (3.17)-(3.24), it should be noted that a lesser value corresponds to a greater improvement in error with the application of Morrison´s noise removal. An average error ratio, AVERNM, greater than one implies that there is no improvement of error in the restored result. For plots where there is a range of AVSNR2 for which no error improvement is achieved, a line equal to one is detailed on the graph. For semilog plots of AVERNM where the average standard deviation of the error, SDERNM, added to AVERNM is greater than one for some AVSNR2, a line equal to one is also plotted for easier interpretation of the results.

It should be remembered that, in general, greater improvement in error is expected after the data is deconvolved, as Morrison's method is designed for noise removal prior to deconvolution. It will be evident after the results of error improvement in Chapter IV are studied that this is indeed the case. Where there is no, or very little, error improvement in applying Morrison's method for noise removal alone, the results will show that after deconvolution there can be significant error improvement.

An average error ratio of .8 implies a 20% improvement of the data with the application of Morrison's noise removal. For this study the percent error improvements are calculated as follows, using .8 error improvement as an example:

ERR AFTER/ERR BEFORE = .8

$$ERR\ AFTER = (.8) ERR\ BEFORE$$

$$[(ERR\ BEFORE - (.8) ERR\ BEFORE)/ERR\ BEFORE] \times 100\% = 20\%$$

From the L2 norm result additional information may be derived, as the SNR of the noise removed result can be calculated:

$$L2 = RMSa/RMSb = (h(max)/RMSb)/(h(max)/RMSa)$$

$$= SNRb/SNRa = .8$$

$$SNRa = SNRb/.8 = (1.25) SNRb$$

RMSb and RMSa denote the root-mean-square noise of the data before and after Morrison´s method is applied, and a higher SNR corresponds to a lesser level of noise.

As one would expect, the percent error improvements for all results are greater for data of low SNR, since the noise level is so high for these cases before the application of Morrison´s. For the AVSNR2 regions studied, where there is a rapid decrease in the rate of error improvement with respect to AVSNR2, the noise levels chosen for the data are decreasing rapidly.

For the ordinate and constant noise error results, for both the L1 and L2 norms, some of the average error ratios, AVERNM's, at very low AVSNR2 values fluctuate instead of exhibiting steadily increasing behavior. This is a minor inconsistency as the noise level is very high for this SNR region and some oscillation of AVERNM can be expectd. This slightly uneven behavior is also somewhat present for for high SNR regions where the noise level of the data is low and the average error improvement is very little. This behavior is of little concern as the difference between AVERNM's is usually not more than 1%, and is often less.

Narrow Gaussian Error Results

The narrow case ordinate noise L1 norm error result demonstrates a rapid decrease in error improvement from 18% to 4% for AVSNR2 6.5 through 33. For the ordinate L2 norm case the decrease is from 29% to 7% for AVSNR2 2 through 33. For both norms the decrease in percent error improvement becomes less rapid from AVSNR2 33 through 94, as the average percent error improvements at AVSNR2 94 are 1% and 3% for the L1 and L2 norms, respectively. This less rapid decrease in error improvement corresponds to the slight decrease in the rate of AVITNM increase for the same range of AVSNR2's mentioned in the iteration number analysis. AVERNM's for AVSNR2's higher than 94 tend to level off with a small percent difference between AVERNM's for this SNR region. For the L1 case the error ratio is greater than one for AVSNR2 values greater than 264, implying that there is no improvement with appliction of Morrison's method for this region.

Average error results for the narrow constant case exhibit a relatively rapid decrease in error improvement from AVSNR2 8.3 to 46 for both L1 and L2 norms, a decrease from 6% to 2% and 10% to 2%, respectively, followed by a gradually less rapid decrease to 1% at AVSNR2 131 for both norm results. It is noted that there is a peak in AVERNM at AVSNR2 131 for the L1 data corresponding to the slight jutting of the AVITNM curve at the same AVSNR2. For higher AVSNR2 the data levels off with an error improvement of approximately 1% for all AVSNR2.

In the analysis of the narrow gaussian error results, it is noted that the error improvements are not that great for the low middle to middle SNR region. This is perhaps because the noise level is still high enough in this region to cause a termination of iterations before a very good approximation of the signal can be obtained; yet the noise level is not so high that the optimum iteration result is a great improvement over the unsmoothed data.

Wide Gaussian Error Results

Examination of the wide gaussian ordinate data, figures (3.31)-(3.34), shows that the AVERNM's oscillate somewhat for AVSNR2 1.8 through 16 with maximum and minimum error improvements of about 44% and 28% for the L1 norm result, and 50% and 42% for the L2 data, for this SNR region. This is followed by a leveling off of AVERNM's from AVSNR2 23 to 90, where the error improvements are 31% and 35% at AVSNR2 90. There is a general steady decrease in error improvement for the range of AVSNR2 higher than 90, and for very high AVSNR2's no error improvement is achieved.

The wide constant results, figures (3.35)-(3.38), show oscillation in AVERNM from AVSNR2 2 through 12, with maximun and minimum error improvements of 29% and 22% for the L1 norm data, and 30% and 29% for the L2 result. For AVSNR2 higher than 12 there is a monotonic decrease in error improvement, with AVERNM's greater than one at AVSNR2 1084 for both the L1 and L2 results. AVERNM's at specific SNR values for all results can of course be determined by examining the corresponding tables or figures.

It should be noted that for most of the AVSNR2 range the error improvements are much greater for the wide gaussian results than for the corresponding narrow gaussian case For the higher SNR regions, very roughly beginning at AVSNR2 700 and 1000 for the L1 and L2 ordinate cases, and

AVSNR2 900 and 1000 for the L1 and L2 constant results, respectively, the error improvement is greater for the narrow gaussian result. The behavior of greater error improvement for the wide gaussian is attributed to a much slower and less complete restoration of high frequency noise for the wide case results, as the wide case G(s) and H(s) are much narrower and Morrison's noise removal restores frequencies faster where G(s) is of larger magnitude. Thus where the wide case error improvement is better, much more of the high frequency noise is not present in the restored result.

For the high AVSNR2 region where the error improvement for the narrow case is somewhat better, the behavior is believed to be a consequence of the noise level being low everywhere and G(s) wider for the narrow gaussian. Thus a more complete restoration of the signal can be obtained before noise terminates the iterations.

It should be noted that although the results for noise removal alone show that in general the wide gaussian case restoration is more accurate (one can examine figures (3.40)-(3.66) of restored data for the wide and narrow cases at selected SNR values). This will not be the case for the deconvolution study analyzed in Chapter IV, as the narrowness of the wide gaussian transform G(s) will severely affect the deconvolved result.

The percent error improvements for the ordinate noise results are in general greater than the corresponding constant noise data. This can be attributed to the differing frequency distributions of the ordinate and constant noise types, since Morrison´s noise removal restores frequencies the quickest where G(s) is of greatest magnitude. Thus much of the large magnitude high frequensy noise is not restored for the ordinate noise optimization.

The values of the standard deviations of the AVERNM´s do not vary greatly over the total AVSNR2 region for each result. The only departure from this behavior is for the narrow ordinate L1 case, where beginning at about AVSNR2 70, the sizes of the standard deviations tend to decrease as the SNR´s increase.

The program used to calculate the results given in this chapter is listed in the appendix. Computer documentation is also included.

Table (3.1)

Narrow Ordinate

NSF	AVESNR	SDSNR
1.70000000E+02	1.96029300E+00	5.61205520E-01
8.50000000E+01	2.79243340E+00	7.81153560E-01
4.25000000E+01	3.71375740E+00	1.01832280E+00
2.12500000E+01	4.69034860E+00	1.18773710E+00
1.06250000E+01	6.51249120E+00	1.70446160E+00
5.31250000E+00	9.00232090E+00	2.62536350E+00
2.65625000E+00	1.30651860E+01	3.80092510E+00
1.32812500E+00	1.69554460E+01	3.76936220E+00
6.64062500E-01	2.40360940E+01	6.23609260E+00
3.32031250E-01	3.37090410E+01	9.05867140E+00
1.66015630E-01	4.74122270E+01	1.24969570E+01
8.30078130E-02	6.78369890E+01	1.81875100E+01
4.15039060E-02	9.51714690E+01	2.32580080E+01
2.07519530E-02	1.35422910E+02	3.32072740E+01
1.03759770E-02	1.94946870E+02	4.96578380E+01
5.18798830E-03	2.66852790E+02	6.46891880E+01
2.59399410E-03	3.83472150E+02	9.99510370E+01
1.29699710E-03	5.57087430E+02	1.51227360E+02
6.48498540E-04	7.76407750E+02	1.76105970E+02
3.24249270E-04	1.08432330E+03	2.74928420E+02

Table (3.2)

Narrow Ordinate

NSF	AVSNR2	MAXSNR	MINSNR	# NS ADD
1.70000000E+02	1.92377760E+00	2.22699290E+00	1.08012940E+00	4.12000000E+02
8.50000000E+01	2.74910650E+00	3.17890180E+00	2.41083580E+00	4.01000000E+02
4.25000000E+01	3.69794250E+00	4.20294740E+00	3.21324240E+00	3.85000000E+02
2.12500000E+01	4.66411260E+00	5.26622920E+00	4.09886150E+00	3.41000000E+02
1.06250000E+01	6.47347950E+00	7.35701920E+00	5.68456750E+00	3.93000000E+02
5.31250000E+00	8.81073130E+00	1.02706020E+01	7.71355480E+00	3.36000000E+02
2.65625000E+00	1.26118940E+01	1.48421800E+01	1.12010270E+01	3.29000000E+02
1.32812500E+00	1.66852610E+01	1.87390570E+01	1.50991280E+01	4.14000000E+02
6.64062500E-01	2.37050680E+01	2.70290250E+01	2.09953150E+01	3.46000000E+02
3.32031250E-01	3.29834560E+01	3.82037770E+01	2.92010170E+01	3.11000000E+02
1.66015630E-01	4.60520320E+01	5.34104090E+01	4.12055780E+01	3.56000000E+02
8.30078130E-02	6.71800270E+01	7.67143810E+01	5.88177500E+01	3.45000000E+02
4.15039060E-02	9.44389550E+01	1.06714500E+02	8.37168620E+01	3.79000000E+02
2.07519530E-02	1.34259230E+02	1.51812920E+02	1.19005720E+02	3.37000000E+02
1.03759770E-02	1.92292050E+02	2.18518140E+02	1.71428780E+02	3.60000000E+02
5.18798830E-03	2.64294420E+02	2.98891680E+02	2.34934890E+02	3.73000000E+02
2.59399410E-03	3.79991580E+02	4.25227870E+02	3.34780330E+02	3.33000000E+02
1.29699710E-03	5.45349020E+02	6.29204190E+02	4.81610200E+02	3.69000000E+02
6.48498540E-04	7.61858230E+02	8.64431600E+02	6.93586250E+02	4.13000000E+02
3.24249270E-04	1.07516340E+03	1.22129810E+03	9.47407360E+02	3.59000000E+02

Table (3.3)

Narrow Constant

NSF	AVESNR	SDSNR
6.90000000E+02	2.21569530E+00	3.22775940E-01
3.45000000E+02	3.07991790E+00	3.97942870E-01
1.72500000E+02	4.31713370E+00	5.73964840E-01
8.62500000E+01	6.02645860E+00	8.31765260E-01
4.31250000E+01	8.31010530E+00	9.38954140E-01
2.15625000E+01	1.17756780E+01	1.45367890E+00
1.07812500E+01	1.69563530E+01	2.45264560E+00
5.39062500E+00	2.36175430E+01	2.78871680E+00
2.69531250E+00	3.31841790E+01	5.06943090E+00
1.34765630E+00	4.62395420E+01	6.08474030E+00
6.73828130E-01	6.55854010E+01	8.69559790E+00
3.36914060E-01	9.24665780E+01	1.28733100E+01
1.68457030E-01	1.30219270E+02	1.48203880E+01
8.42285160E-02	1.89645050E+02	1.98776470E+01
4.21142580E-02	2.62691040E+02	3.31342360E+01
2.10571290E-02	3.74356240E+02	4.72224880E+01
1.05285640E-02	5.31644360E+02	6.73786200E+01
5.26428220E-03	7.29911830E+02	8.86358780E+01
2.63214110E-03	1.04636540E+03	1.22282770E+02

Table (3.4)

Narrow Constant

NSF	AVSNR2	MAXSNR	MINSNR	# NS ADD
6.90000000E+02	2.19849690E+00	2.37690680E+00	2.05959910E+00	3.59000000E+02
3.45000000E+02	3.08304960E+00	3.27319300E+00	2.88149030E+00	3.84000000E+02
1.72500000E+02	4.29768540E+00	4.60207470E+00	4.03770880E+00	3.19000000E+02
8.62500000E+01	5.98241990E+00	6.43671350E+00	5.62645370E+00	3.83000000E+02
4.31250000E+01	8.30321620E+00	8.76980160E+00	7.87596860E+00	3.92000000E+02
2.15625000E+01	1.17733760E+01	1.24849590E+01	1.10547450E+01	3.83000000E+02
1.07812500E+01	1.68707650E+01	1.81825960E+01	1.57335240E+01	3.32000000E+02
5.39062500E+00	2.34295110E+01	2.50021100E+01	2.22728320E+01	3.81000000E+02
2.69531250E+00	3.29376840E+01	3.56273750E+01	3.06906240E+01	3.22000000E+02
1.34765630E+00	4.58802300E+01	4.92568080E+01	4.32250790E+01	3.74000000E+02
6.73828130E-01	6.54620420E+01	6.98763690E+01	6.13321050E+01	3.78000000E+02
3.36914060E-01	9.13545050E+01	9.79639480E+01	8.60373740E+01	3.22000000E+02
1.68457030E-01	1.30546160E+02	1.37151860E+02	1.23557160E+02	3.73000000E+02
8.42285160E-02	1.89924970E+02	1.99573700E+02	1.79797450E+02	3.73000000E+02
4.21142580E-02	2.62015200E+02	2.78788310E+02	2.46426480E+02	3.62000000E+02
2.10571290E-02	3.73498300E+02	3.97350430E+02	3.51104310E+02	3.63000000E+02
1.05285640E-02	5.29024890E+02	5.65027950E+02	5.00111850E+02	3.70000000E+02
5.26428220E-03	7.27310260E+02	7.73987880E+02	6.86049820E+02	3.39000000E+02
2.63214110E-03	1.04307260E+03	1.10609910E+03	9.87750820E+02	4.40000000E+02

Table (3.5)

Wide Ordinate

NSF	AVESNR	SDSNR
4.00000000E+01	1.89760970E+00	4.02904140E-01
2.00000000E+01	2.66290030E+00	5.78134370E-01
1.00000000E+01	3.33581340E+00	6.12147580E-01
5.00000000E+00	4.30289890E+00	6.89630320E-01
2.50000000E+00	5.99577810E+00	9.11552410E-01
1.25000000E+00	8.23995470E+00	1.32685140E+00
6.25000000E-01	1.14018120E+01	1.85676350E+00
3.12500000E-01	1.65409460E+01	2.87781170E+00
1.56250000E-01	2.33132030E+01	3.69915660E+00
7.81250000E-02	3.26821780E+01	5.49741540E+00
3.90625000E-02	4.78969200E+01	8.75749430E+00
1.95312500E-02	6.62406820E+01	1.10866120E+01
9.76562500E-03	9.06496550E+01	1.38853850E+01
4.88281250E-03	1.30067350E+02	2.17376680E+01
2.44140630E-03	1.90013760E+02	3.48469730E+01
1.22070310E-03	2.60641660E+02	3.99140370E+01
6.10351560E-04	3.77192170E+02	6.09278450E+01
3.05175780E-04	5.29009860E+02	9.82990260E+01
1.52587890E-04	7.60721590E+02	1.33169580E+02
7.62939450E-05	1.09680400E+03	2.00941560E+02
3.81469730E-05	1.48609970E+03	2.35515640E+02

Table (3.6)

Wide Ordinate

NSF	AVSNR2	MAXSNR	MINSNR	\# NS ADD
4.00000000E+01	1.86797610E+00	2.09296870E+00	1.70364530E+00	3.54000000E+02
2.00000000E+01	2.65160370E+00	2.94667090E+00	2.38160850E+00	3.52000000E+02
1.00000000E+01	3.32796080E+00	3.63577950E+00	3.04685030E+00	3.58000000E+02
5.00000000E+00	4.27589750E+00	4.62914600E+00	3.95837310E+00	3.73000000E+02
2.50000000E+00	5.98967180E+00	6.44525430E+00	5.55333790E+00	3.66000000E+02
1.25000000E+00	8.26380590E+00	8.89695320E+00	7.57695360E+00	3.66000000E+02
6.25000000E-01	1.14142490E+01	1.23046360E+01	1.05189160E+01	3.39000000E+02
3.12500000E-01	1.63208220E+01	1.79379160E+01	1.51103320E+01	3.80000000E+02
1.56250000E-01	2.32159230E+01	2.51508690E+01	2.14692410E+01	3.77000000E+02
7.81250000E-02	3.25605750E+01	3.53983590E+01	2.99459880E+01	3.31000000E+02
3.90625000E-02	4.72816240E+01	5.20911580E+01	4.35861420E+01	3.50000000E+02
1.95312500E-02	6.60898170E+01	7.16948440E+01	6.07447560E+01	3.46000000E+02
9.76562500E-03	9.00335260E+01	9.74513180E+01	8.41795730E+01	3.68000000E+02
4.88281250E-03	1.30728600E+02	1.40823980E+02	1.19240390E+02	3.40000000E+02
2.44140630E-03	1.90708500E+02	2.07090430E+02	1.73510110E+02	3.26000000E+02
1.22070310E-03	2.59845920E+02	2.80359480E+02	2.40730940E+02	3.67000000E+02
6.10351560E-04	3.76173600E+02	4.07029620E+02	3.46801940E+02	3.48000000E+02
3.05175780E-04	5.24010450E+02	5.78091330E+02	4.83513750E+02	3.52000000E+02
1.52587890E-04	7.60647970E+02	8.26480300E+02	6.94211140E+02	3.42000000E+02
7.62939450E-05	1.08757060E+03	1.19105070E+03	9.98714320E+02	3.52000000E+02
3.81469730E-05	1.47114670E+03	1.60034890E+03	1.36911640E+03	3.72000000E+02

Table (3.7)

Wide Constant

NSF	AVESNR	SDSNR
1.20000000E+02	2.25708330E+00	2.45354590E-01
6.00000000E+01	3.03060050E+00	3.47971120E-01
3.00000000E+01	4.25607190E+00	4.13175680E-01
1.50000000E+01	5.93029450E+00	5.86873570E-01
7.50000000E+00	8.48506590E+00	8.53335850E-01
3.75000000E+00	1.19155190E+01	1.28222630E+00
1.87500000E+00	1.66837810E+01	1.95842950E+00
9.37500000E-01	2.39946670E+01	2.93410540E+00
4.68750000E-01	3.29554830E+01	3.40136140E+00
2.34375000E-01	4.75190830E+01	5.86280400E+00
1.17187500E-01	6.72700220E+01	7.16236450E+00
5.85937500E-02	9.21130750E+01	8.92380360E+00
2.92968750E-02	1.32692670E+02	1.27885450E+01
1.46484380E-02	1.86254680E+02	1.83092890E+01
7.32421880E-03	2.68273670E+02	3.06772380E+01
3.66210940E-03	3.79999950E+02	3.71271100E+01
1.83105470E-03	5.31704340E+02	5.64713870E+01
9.15527340E-04	7.51445280E+02	8.53014670E+01
4.57763670E-04	1.08356940E+03	1.09737630E+02

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Table (3.8)

Wide Constant

NSF	AVSNR2	MAXSNR	MINSNR	# NS ADD
1.20000000E+02	2.23809910E+00	2.36993940E+00	2.13491600E+00	3.60000000E+02
6.00000000E+01	3.03384880E+00	3.20347810E+00	2.86452950E+00	3.27000000E+02
3.00000000E+01	4.23902950E+00	4.46000800E+00	4.05232300E+00	3.73000000E+02
1.50000000E+01	5.91136340E+00	6.21328910E+00	5.63904840E+00	3.87000000E+02
7.50000000E+00	8.44401310E+00	8.90920280E+00	8.06018570E+00	3.58000000E+02
3.75000000E+00	1.18532630E+01	1.25492850E+01	1.12859280E+01	3.56000000E+02
1.87500000E+00	1.66577860E+01	1.76458280E+01	1.57511130E+01	3.55000000E+02
9.37500000E-01	2.38334150E+01	2.54389350E+01	2.25322160E+01	3.47000000E+02
4.68750000E-01	3.28980590E+01	3.46379640E+01	3.12988080E+01	3.49000000E+02
2.34375000E-01	4.72060020E+01	5.03960010E+01	4.46630620E+01	2.96000000E+02
1.17187500E-01	6.69249780E+01	7.06379700E+01	6.38188290E+01	3.25000000E+02
5.85937500E-02	9.21733510E+01	9.65600050E+01	8.76949780E+01	4.10000000E+02
2.92968750E-02	1.32529540E+02	1.38986680E+02	1.26558840E+02	3.89000000E+02
1.46484380E-02	1.86152090E+02	1.95323270E+02	1.77263300E+02	3.66000000E+02
7.32421880E-03	2.66812790E+02	2.83096680E+02	2.53209990E+02	3.24000000E+02
3.66210940E-03	3.79314060E+02	3.97693350E+02	3.61923660E+02	3.96000000E+02
1.83105470E-03	5.32292300E+02	5.59843220E+02	5.03932720E+02	3.72000000E+02
9.15527340E-04	7.47176270E+02	7.92569410E+02	7.09063710E+02	3.37000000E+02
4.57763670E-04	1.08383420E+03	1.13789260E+03	1.03191340E+03	3.80000000E+02

Table (3.9)

Narrow Ordinate

AVSNR2	SDSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
1.9237776E+00	1.6768450E-01	1.2600000E+00	8.3210570E-01	1.0000000E+00	0.0000000E+00
2.7491065E+00	2.1097697E-01	1.2100000E+00	4.5376207E-01	1.0000000E+00	0.0000000E+00
3.6979425E+00	3.0063858E-01	1.7700000E+00	9.2579700E-01	1.0100000E+00	9.9498747E-02
4.6641126E+00	3.4233715E-01	2.3900000E+00	1.3992498E+00	1.3000000E+00	5.5677642E-01
6.4734795E+00	4.7517917E-01	2.6300000E+00	1.0550356E+00	2.0200000E+00	7.4806419E-01
8.8107313E+00	7.0843413E-01	4.0500000E+00	4.6526874E+00	2.8900000E+00	1.3030350E+00
1.2611894E+01	1.0669934E+00	5.4800000E+00	6.4163538E+00	4.4700000E+00	2.3683538E+00
1.6685261E+01	1.1219323E+00	8.5599999E+00	9.4544379E+00	6.7200000E+00	5.7010176E+00
2.3705068E+01	1.7673277E+00	1.4740000E+01	1.5249013E+01	1.0660000E+01	7.9714741E+00
3.2983456E+01	2.5913000E+00	2.1720000E+01	1.6106570E+01	1.8190000E+01	1.1784477E+01
4.6052032E+01	3.6162412E+00	2.4830000E+01	1.6345063E+01	2.1210000E+01	1.2635898E+01
6.7180027E+01	4.7735628E+00	3.0010000E+01	1.7022042E+01	2.6040000E+01	1.4140665E+01
9.4438955E+01	5.8747037E+00	3.8800000E+01	1.4925146E+01	3.4900000E+01	1.4194013E+01
1.3425923E+02	9.9014403E+00	4.0500000E+01	1.5274489E+01	3.4190000E+01	1.3179298E+01
1.9229205E+02	1.3564061E+01	4.3870000E+01	1.3640128E+01	3.6730000E+01	1.3058220E+01
2.6429442E+02	1.8085080E+01	4.9110000E+01	1.0331404E+01	4.1370000E+01	1.0757002E+01
3.7999158E+02	2.7727457E+01	4.9800000E+01	1.0358571E+01	4.1750000E+01	1.0566338E+01
5.4534902E+02	4.3063780E+01	5.2620000E+01	7.7055565E+00	4.5220000E+01	9.7381518E+00
7.6185823E+02	4.7663744E+01	5.5070000E+01	5.1734998E+00	4.6290000E+01	8.3705376E+00
1.0751634E+03	7.1455349E+01	5.4950000E+01	5.5197373E+00	4.6480000E+01	6.6460214E+00

Table (3.10)

Narrow Ordinate

AVEIT# L1	MAXIT1	MINIT1	AVEIT# L2	MAXIT2	MINIT2
1.2600000E+00	6.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.2100000E+00	3.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.7700000E+00	6.0000002E+00	1.0000000E+00	1.0100000E+00	2.0000000E+00	1.0000000E+00
2.3900000E+00	9.0000000E+00	1.0000000E+00	1.3000000E+00	3.0000000E+00	1.0000000E+00
2.6300000E+00	9.0000000E+00	1.0000000E+00	2.0200000E+00	4.0000000E+00	1.0000000E+00
4.0500000E+00	3.9000000E+01	2.0000000E+00	2.8900000E+00	1.0000000E+01	1.0000000E+00
5.4800000E+00	4.0000000E+01	2.0000000E+00	4.4700000E+00	1.4000000E+01	2.0000000E+00
8.5599999E+00	5.0000000E+01	2.0000000E+00	6.7200000E+00	3.2000000E+01	2.0000000E+00
1.4740000E+01	5.7000000E+01	3.0000000E+00	1.0660000E+01	3.9000000E+01	3.0000000E+00
2.1720000E+01	5.7000000E+01	4.0000000E+00	1.8190000E+01	4.4000000E+01	5.0000000E+00
2.4830000E+01	5.8000000E+01	5.0000000E+00	2.1210000E+01	4.9000000E+01	7.0000000E+00
3.0010000E+01	5.7000000E+01	8.0000000E+00	2.6040000E+01	5.4000000E+01	9.0000000E+00
3.8800000E+01	6.0000000E+01	1.1000000E+01	3.4900000E+01	5.7000000E+01	1.1000000E+01
4.0500000E+01	6.0000000E+01	1.3000000E+01	3.4190000E+01	5.8000000E+01	1.4000000E+01
4.3870000E+01	6.0000000E+01	1.7000000E+01	3.6730000E+01	5.9000000E+01	1.6000000E+01
4.9110000E+01	6.2000000E+01	2.0000000E+01	4.1370000E+01	5.9000000E+01	1.9000000E+01
4.9800000E+01	6.2000000E+01	2.0000000E+01	4.1750000E+01	6.0000000E+01	2.2000000E+01
5.2620000E+01	6.2000000E+01	2.7000000E+01	4.5220000E+01	6.1000000E+01	2.5000000E+01
5.5070000E+01	6.4000000E+01	4.0000000E+01	4.6290000E+01	6.1000000E+01	3.0000000E+01
5.4950000E+01	6.3000000E+01	3.5000000E+01	4.6480000E+01	6.1000000E+01	3.2000000E+01

Table (3.11)

Narrow Constant

AVSNR2	SDSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.1984969E+00	9.8769877E-02	1.5400000E+00	1.1867604E+00	1.0000000E+00	0.0000000E+00
3.0830496E+00	1.1573699E-01	2.5100000E+00	1.3152566E+00	1.0800000E+00	2.7129319E-01
4.2976854E+00	1.6454316E-01	4.0500000E+00	3.9048046E+00	1.9400000E+00	5.0635954E-01
5.9824199E+00	2.4119694E-01	4.7000000E+00	3.0967726E+00	2.7900000E+00	6.6775745E-01
8.3032162E+00	2.6240156E-01	5.8000000E+00	4.5122058E+00	3.5800000E+00	7.2360214E-01
1.1773376E+01	4.3620304E-01	7.2800000E+00	5.9867853E+00	4.9300000E+00	1.8775250E+00
1.6870765E+01	7.5877468E-01	7.7400000E+00	6.2315648E+00	7.0800000E+00	3.5005142E+00
2.3429511E+01	8.0126706E-01	1.3710000E+01	1.1570907E+01	1.0930000E+01	5.4134185E+00
3.2937684E+01	1.3975217E+00	2.0120000E+01	1.2713206E+01	1.6720000E+01	9.2488701E+00
4.5880230E+01	1.7610850E+00	2.8380000E+01	1.5150367E+01	2.4340000E+01	1.0780742E+01
6.5462042E+01	2.4662378E+00	3.0020000E+01	1.3668197E+01	2.8350000E+01	1.1479003E+01
9.1354505E+01	3.3428283E+00	3.2820000E+01	1.3677266E+01	3.3170000E+01	1.1844032E+01
1.3054616E+02	3.8408037E+00	3.7630000E+01	1.0973290E+01	3.7590000E+01	1.0593484E+01
1.8992497E+02	5.5471737E+00	3.7510000E+01	1.0261087E+01	3.9200000E+01	9.7375561E+00
2.6201520E+02	9.3163421E+00	3.8960000E+01	9.7158841E+00	4.0540000E+01	9.5377356E+00
3.7349830E+02	1.3864522E+01	4.0160000E+01	7.7520577E+00	4.2480000E+01	8.4148440E+00
5.2902489E+02	1.8335504E+01	4.1760000E+01	7.5922593E+00	4.4540000E+01	6.9114687E+00
7.2731026E+02	2.6524155E+01	4.2200000E+01	6.0266078E+00	4.4270000E+01	5.7146391E+00
1.0430726E+03	3.3778027E+01	4.4910000E+01	5.3779084E+00	4.7230000E+01	4.8453172E+00

Table (3.12)

Narrow Constant

AVEIT* L1	MAXIT1	MINIT1	AVEIT* L2	MAXIT2	MINIT2
1.5400000E+00	8.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
2.5100000E+00	7.0000000E+00	1.0000000E+00	1.0800000E+00	2.0000000E+00	1.0000000E+00
4.0500000E+00	2.4000000E+01	1.0000000E+00	1.9400000E+00	3.0000000E+00	1.0000000E+00
4.7000000E+00	2.3000000E+01	2.0000000E+00	2.7900000E+00	5.0000000E+00	2.0000000E+00
5.8000000E+00	3.3000000E+01	2.0000000E+00	3.5800000E+00	6.0000000E+00	2.0000000E+00
7.2800000E+00	3.4000000E+01	2.0000000E+00	4.9300000E+00	1.9000000E+01	3.0000000E+00
7.7400000E+00	3.7000000E+01	2.0000000E+00	7.0800000E+00	2.4000000E+01	3.0000000E+00
1.3710000E+01	4.8000000E+01	3.0000000E+00	1.0930000E+01	3.0000000E+01	4.0000000E+00
2.0120000E+01	5.1000000E+01	5.0000000E+00	1.6720000E+01	4.0000000E+01	6.0000000E+00
2.8080000E+01	5.6000000E+01	7.0000000E+00	2.4340000E+01	4.9000000E+01	9.0000000E+00
3.0020000E+01	5.5000000E+01	1.0000000E+01	2.8350000E+01	5.2000000E+01	1.2000000E+01
3.2820000E+01	5.8000000E+01	1.5000000E+01	3.3170000E+01	5.5000000E+01	1.6000000E+01
3.7630000E+01	5.6000000E+01	1.6000000E+01	3.7590000E+01	5.6000000E+01	1.5000000E+01
3.7510000E+01	5.7000000E+01	1.8000000E+01	3.9200000E+01	5.7000000E+01	2.0000000E+01
3.8960000E+01	5.9000000E+01	2.2000000E+01	4.0540000E+01	5.9000000E+01	2.3000000E+01
4.0160000E+01	5.4000000E+01	2.3000000E+01	4.2480000E+01	5.7000000E+01	2.5000000E+01
4.1760000E+01	5.7000000E+01	2.7000000E+01	4.4540000E+01	6.0000000E+01	3.0000000E+01
4.2200000E+01	5.5000000E+01	3.1000000E+01	4.4270000E+01	5.7000000E+01	3.3000000E+01
4.4910000E+01	5.9000000E+01	3.4000000E+01	4.7230000E+01	6.1000000E+01	3.6000000E+01

Table (3.13)

Wide Ordinate

AVSNR2	SDSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
1.8679761E+00	1.0443113E-01	1.6800000E+00	1.4344338E+00	1.0300000E+00	2.2158518E-01
2.6516037E+00	1.6500915E-01	2.6100000E+00	1.4275503E+00	1.5000000E+00	7.8102497E-01
3.3279608E+00	1.7653041E-01	3.0400000E+00	1.7828067E+00	2.2500000E+00	1.2678722E+00
4.2758905E+00	1.8740406E-01	4.2800000E+00	2.9191779E+00	3.3600000E+00	1.6883128E+00
5.9896718E+00	2.5759132E-01	5.0700000E+00	4.7016063E+00	4.2000000E+00	2.0880613E+00
8.2638059E+00	3.6546863E-01	7.3500000E+00	6.5808433E+00	6.8900000E+00	4.4494831E+00
1.1414249E+01	5.1774306E-01	9.2400000E+00	8.8950772E+00	7.9100000E+00	4.6197293E+00
1.6320822E+01	7.8676112E-01	1.4530000E+01	1.0894453E+01	1.5600000E+01	1.0203921E+01
2.3215923E+01	1.1273327E+00	2.4940000E+01	1.8473127E+01	2.5310000E+01	1.3254958E+01
3.2560575E+01	1.5689055E+00	4.0710000E+01	1.9775386E+01	3.8480000E+01	1.6608721E+01
4.7281624E+01	2.2539937E+00	4.9030000E+01	1.7895505E+01	4.8500000E+01	1.4963623E+01
6.6089817E+01	3.0232606E+00	6.0850000E+01	1.9349613E+01	5.8630000E+01	1.7773944E+01
9.0033526E+01	3.8345536E+00	6.1860000E+01	1.7873455E+01	6.2890000E+01	1.6810648E+01
1.3072860E+02	6.3939841E+00	7.5610000E+01	1.7422339E+01	7.5720000E+01	1.7229092E+01
1.9070850E+02	1.0029630E+01	8.4750000E+01	1.4397482E+01	8.5430000E+01	1.4242996E+01
2.5984592E+02	1.2336361E+01	9.2330000E+01	1.4375016E+01	9.2250000E+01	1.4332742E+01
3.7617360E+02	1.7152487E+01	9.8610000E+01	1.3471373E+01	1.0028000E+02	1.3265806E+01
5.2401045E+02	2.8180989E+01	1.0487000E+02	1.1683026E+01	1.0821000E+02	1.1791773E+01
7.6064797E+02	3.9114555E+01	1.0860000E+02	9.3123575E+00	1.1571000E+02	8.9624716E+00
1.0875700E+03	5.5442237E+01	1.1473000E+02	6.8056669E+00	1.2240000E+02	7.3891611E+00
1.4711467E+03	6.7169269E+01	1.1709000E+02	5.0992058E+00	1.2699000E+02	5.1254172E+00

Table (3.14)

Wide Ordinate

AVEIT# L1	MAXIT1	MINIT1	AVEIT# L2	MAXIT2	MINIT2
1.6800000E+00	8.0000000E+00	1.0000000E+00	1.0300000E+00	3.0000000E+00	1.0000000E+00
2.6100000E+00	9.0000000E+00	1.0000000E+00	1.5000000E+00	4.0000000E+00	1.0000000E+00
3.0400000E+00	1.4000000E+01	1.0000000E+00	2.2500000E+00	7.0000000E+00	1.0000000E+00
4.2800000E+00	2.7000000E+01	1.0000000E+00	3.3600000E+00	9.0000000E+00	1.0000000E+00
5.0700000E+00	4.3000000E+01	2.0000000E+00	4.2000000E+00	1.3000000E+01	2.0000000E+00
7.3500000E+00	4.6000000E+01	2.0000000E+00	6.8900000E+00	2.5000000E+01	2.0000000E+00
9.2400000E+00	7.0000000E+01	3.0000000E+00	7.9100000E+00	3.0000000E+01	3.0000000E+00
1.4530000E+01	6.7000000E+01	4.0000000E+00	1.5600000E+01	4.9000000E+01	4.0000000E+00
2.4940000E+01	1.0000000E+02	5.0000000E+00	2.5310000E+01	6.5000000E+01	5.0000000E+00
4.0710000E+01	9.7000000E+01	7.0300000E+00	3.8480000E+01	8.3000000E+01	7.0000000E+00
4.9030000E+01	9.9000000E+01	2.3000000E+01	4.8500000E+01	8.6000000E+01	2.1000000E+01
6.0850000E+01	1.0900000E+02	2.6000000E+01	5.8630000E+01	1.0200000E+02	2.6000000E+01
6.1860000E+01	1.0300000E+02	2.8000000E+01	6.2890000E+01	1.0400000E+02	2.9000000E+01
7.5610000E+01	1.2100000E+02	4.3000000E+01	7.5720000E+01	1.1400000E+02	4.2000000E+01
8.4750000E+01	1.1800000E+02	5.1000000E+01	8.5430000E+01	1.1300000E+02	5.0000000E+01
9.2330000E+01	1.2400000E+02	6.1000000E+01	9.2250000E+01	1.2400000E+02	6.1000000E+01
9.8610000E+01	1.2600000E+02	6.4000000E+01	1.0028000E+02	1.2600000E+02	7.5000000E+01
1.0487000E+02	1.2800000E+02	7.7000000E+01	1.0821000E+02	1.3100000E+02	7.7000000E+01
1.0860000E+02	1.3100000E+02	8.5000000E+01	1.1571000E+02	1.3700000E+02	9.7000000E+01
1.1473000E+02	1.2900000E+02	9.8000000E+01	1.2249000E+02	1.3700000E+02	1.0300000E+02
1.1709000E+02	1.2900000E+02	1.0000000E+02	1.2699000E+02	1.3700000E+02	1.1500000E+02

Table (3.15)

Wide Constant

AVSNR2	SDSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.2380991E+00	6.7956447E-02	2.5900000E+00	1.8766726E+00	1.3500000E+00	6.2249495E-01
3.0338488E+00	1.0060984E-01	4.7400000E+00	4.7825099E+00	2.7000000E+00	8.9999998E-01
4.2390295E+00	1.2076209E-01	4.8200000E+00	1.9818174E+00	3.7200000E+00	1.1923087E+00
5.9113634E+00	1.8238080E-01	7.0300000E+00	5.4944608E+00	4.8600000E+00	1.7493999E+00
8.4440131E+00	2.3062478E-01	8.1100000E+00	5.0535037E+00	6.6500000E+00	2.6697378E+00
1.1853263E+01	3.3234950E-01	1.3600000E+01	1.1212493E+01	1.1370000E+01	6.4802084E+00
1.6657786E+01	5.6293696E-01	1.6690000E+01	1.2338310E+01	1.5460000E+01	8.7022067E+00
2.3833415E+01	8.4194596E-01	2.7510000E+01	2.0860726E+01	2.5270000E+01	1.2707364E+01
3.2898059E+01	9.7756235E-01	4.0660000E+01	1.8121932E+01	4.1480000E+01	1.3576067E+01
4.7206002E+01	1.6090208E+00	5.3080000E+01	1.8058062E+01	5.2640000E+01	1.3968909E+01
6.6924978E+01	1.9576777E+00	6.1180000E+01	1.6302380E+01	6.1210000E+01	1.3881855E+01
9.2173351E+01	2.5656407E+00	7.1960000E+01	1.3844074E+01	7.2300000E+01	1.2266621E+01
1.3252954E+02	3.6231027E+00	7.3780000E+01	1.3245814E+01	7.5470000E+01	1.1783425E+01
1.8615209E+02	5.4963413E+00	8.3730000E+01	1.3176384E+01	8.5420000E+01	1.1767056E+01
2.6681279E+02	8.5530880E+00	9.0010000E+01	1.1032221E+01	9.1820000E+01	9.7502615E+00
3.7931406E+02	1.0680329E+01	9.6630000E+01	9.7269266E+00	9.9810000E+01	9.4198672E+00
5.3229230E+02	1.5758287E+01	1.0054000E+02	8.6676641E+00	1.0600000E+02	7.9082236E+00
7.4717627E+02	2.4360501E+01	1.0611000E+02	7.6077525E+00	1.1168000E+02	6.5603047E+00
1.0838342E+03	3.3245461E+01	1.1249000E+02	6.4303887E+00	1.2044000E+02	5.3913263E+00

Table (3.16)

Wide Constant

AVEIT# L1	MAXIT1	MINIT1	AVEIT# L2	MAXIT2	MINIT2
2.5900000E+00	1.2000000E+01	1.0000000E+00	1.3500000E+00	3.0000000E+00	1.0000000E+00
4.7400000E+00	3.1000000E+01	1.0000000E+00	2.7000000E+00	5.0000000E+00	1.0000000E+00
4.8200000E+00	1.2000000E+01	2.0000000E+00	3.7200000E+00	8.0000000E+00	2.0000000E+00
7.0300000E+00	4.2000000E+01	2.0000000E+00	4.8600000E+00	1.2000000E+01	2.0000000E+00
8.1100000E+00	3.9000000E+01	3.0000000E+00	6.6500000E+00	1.5000000E+01	3.0000000E+00
1.3600000E+01	6.3000000E+01	4.0000000E+00	1.1370000E+01	3.1000000E+01	4.0000000E+00
1.6690000E+01	6.8000000E+01	4.0000000E+00	1.5460000E+01	4.2000000E+01	4.0000000E+00
2.7510000E+01	9.8000000E+01	6.0000000E+00	2.5270000E+01	5.8000000E+01	6.0000000E+00
4.0660000E+01	1.0100000E+02	7.0000000E+00	4.1480000E+01	7.4000000E+01	1.7000000E+01
5.3080000E+01	9.3000000E+01	1.9000000E+01	5.2640000E+01	8.2000000E+01	2.3000000E+01
6.1180000E+01	9.6000000E+01	3.0000000E+01	6.1210000E+01	9.1000000E+01	3.4000000E+01
7.1960000E+01	9.9000000E+01	4.0000000E+01	7.2300000E+01	1.0000000E+02	4.3000000E+01
7.3780000E+01	1.0200000E+02	4.6000000E+01	7.5470000E+01	1.0600000E+02	4.5000000E+01
8.3730000E+01	1.1400000E+02	5.3000000E+01	8.5420000E+01	1.0800000E+02	5.9000000E+01
9.0010000E+01	1.1800000E+02	6.4000000E+01	9.1820000E+01	1.1500000E+02	6.3000000E+01
9.6630000E+01	1.2300000E+02	7.1000000E+01	9.9810000E+01	1.2700000E+02	7.9000000E+01
1.0054000E+02	1.2000000E+02	8.2000000E+01	1.0620000E+02	1.2200000E+02	8.3000000E+01
1.0611000E+02	1.2200000E+02	9.0000000E+01	1.1168000E+02	1.2700000E+02	9.7000000E+01
1.1249000E+02	1.2700000E+02	9.5000000E+01	1.2044000E+02	1.3400000E+02	1.0600000E+02

Table (3.17)

Narrow Ordinate

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
1.92377760E+00	8.80486650E-01	8.29669000E-02	7.12844510E-01	6.91801090E-02
2.74910650E+00	8.50105040E-01	8.74556730E-02	6.90764730E-01	8.24548190E-02
3.69794250E+00	8.08352330E-01	9.93013150E-02	6.93265100E-01	8.74882920E-02
4.66411260E+00	8.38126520E-01	1.04056260E-01	7.45673010E-01	1.09965860E-01
6.47347950E+00	8.22077800E-01	1.17290150E-01	7.65936550E-01	1.23166070E-01
8.81073130E+00	8.52164380E-01	1.44877560E-01	8.12674840E-01	1.30428780E-01
1.26118940E+01	8.91495880E-01	1.07813550E-01	8.54288880E-01	1.12366360E-01
1.66852610E+01	8.97217610E-01	1.20416560E-01	8.75497980E-01	1.20813680E-01
2.37050680E+01	9.23150470E-01	1.08444570E-01	9.00907830E-01	1.03142060E-01
3.29834560E+01	9.57617310E-01	9.65766880E-02	9.34806110E-01	1.04494550E-01
4.60520320E+01	9.68966580E-01	7.91030290E-02	9.46000970E-01	7.92137030E-02
6.71800270E+01	9.71839730E-01	5.33769270E-02	9.56217350E-01	6.21540930E-02
9.44389550E+01	9.89998070E-01	3.70214440E-02	9.74983560E-01	5.54626470E-02
1.34259230E+02	9.93502510E-01	5.25597070E-02	9.67948700E-01	6.68358080E-02
1.92292050E+02	9.94608070E-01	3.12204180E-02	9.68928680E-01	5.84783820E-02
2.64294420E+02	1.00495210E+00	2.56399370E-02	9.86021660E-01	4.39855350E-02
3.79991580E+02	1.01010440E+00	2.43502140E-02	9.78949470E-01	5.31336450E-02
5.45349020E+02	1.01508840E+00	1.27261600E-02	9.81679440E-01	5.54975410E-02
7.61858230E+02	1.02094550E+00	9.13564200E-03	9.89141470E-01	3.42215840E-02
1.07516340E+03	1.02792850E+00	1.46436940E-02	9.83405150E-01	5.10723390E-02

Table (3.18)

Narrow Ordinate

AVERROR L1	MAXER1	MINER1	AVERROR L2	MAXER2	MINER2
8.8048665E-01	1.0058589E+00	9.8196024E-01	7.1284451E-01	8.5036106E-01	5.3370778E-01
8.5010504E-01	9.9730111E-01	9.4237413E-01	6.9076473E-01	8.6819011E-01	5.0412302E-01
8.6835233E-01	9.8594745E-01	8.4504993E-01	6.9326510E-01	9.0282536E-01	2.9711910E-01
8.3812652E-01	1.0191329E+00	7.0153076E-01	7.4587301E-01	9.6909658E-01	4.6690657E-01
8.2207780E-01	1.0120876E+00	7.9582785E-01	7.6593655E-01	9.8877177E-01	3.6362502E-01
8.5216438E-01	1.0441605E+00	8.5215282E-01	8.1267484E-01	9.9686772E-01	3.7087088E-01
8.9149588E-01	1.1569053E+00	9.3325596E-01	8.5428868E-01	1.0003681E+00	5.6452983E-01
8.9721761E-01	1.0640275E+00	9.9103338E-01	8.7549798E-01	1.0007194E+00	4.5105624E-01
9.2315047E-01	1.0788268E+00	9.2168315E-01	9.0090783E-01	1.0007984E+00	5.3113122E-01
9.5761731E-01	1.1663354E+00	1.0097555E+00	9.3480611E-01	1.0010192E+00	4.8025258E-01
9.6896658E-01	1.0769964E+00	1.0319296E+00	9.4600697E-01	1.0009234E+00	6.5837106E-01
9.7183973E-01	1.0717119E+00	9.3341718E-01	9.5621735E-01	1.0016056E+00	7.0889655E-01
9.8999867E-01	1.0294097E+00	1.0029548E+00	9.7498356E-01	1.0020205E+00	6.9352169E-01
9.9350251E-01	1.0574377E+00	1.0055826E+00	9.6794870E-01	1.0027675E+00	5.2250693E-01
9.9460807E-01	1.0409436E+00	1.0064362E+00	9.6892868E-01	1.0038562E+00	6.7334458E-01
1.0049521E+00	1.1101225E+00	1.0093780E+00	9.8602166E-01	1.0052320E+00	6.6910086E-01
1.0101044E+00	1.1054601E+00	1.0134700E+00	9.7894947E-01	1.0075757E+00	6.9077525E-01
1.0150884E+00	1.0712936E+00	1.0228199E+00	9.8167944E-01	1.0110487E+00	7.2113143E-01
1.0209455E+00	1.0336248E+00	1.0189650E+00	9.8914147E-01	1.0145881E+00	8.5341001E-01
1.0279285E+00	1.0502215E+00	1.0375570E+00	9.8340515E-01	1.0192209E+00	7.6734661E-01

Table (3.19)

Narrow Constant

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.1984969E+00	9.2974083E-01	3.4496251E-02	8.4318783E-01	3.3954524E-02
3.0830496E+00	9.2122030E-01	4.4826828E-02	8.4829417E-01	4.5937608E-02
4.2976854E+00	9.2777820E-01	4.9247166E-02	8.8025896E-01	4.9490641E-02
5.9824199E+00	9.4660608E-01	3.6439533E-02	8.9637543E-01	4.4168058E-02
8.3032162E+00	9.4049696E-01	3.8754738E-02	9.0660157E-01	4.0573988E-02
1.1773376E+01	9.4183509E-01	4.6956859E-02	9.2475373E-01	4.3642670E-02
1.6870765E+01	9.5093086E-01	4.8636303E-02	9.3847282E-01	5.0136696E-02
2.3429511E+01	9.6644638E-01	4.5528383E-02	9.5878451E-01	4.1190477E-02
3.2937681E+01	9.7568481E-01	3.8039697E-02	9.7187778E-01	3.4617807E-02
4.5880230E+01	9.8427135E-01	2.9261765E-02	9.8403427E-01	2.5181776E-02
6.5462042E+01	9.8368069E-01	3.1498138E-02	9.8537170E-01	2.7276061E-02
9.1354505E+01	9.8696882E-01	2.1753541E-02	9.9153559E-01	1.4968139E-02
1.3054616E+02	9.9294451E-01	2.0365917E-02	9.9164584E-01	2.6807566E-02
1.8992497E+02	9.8877702E-01	2.6287987E-02	9.9150839E-01	2.1934135E-02
2.6201520E+02	9.8561919E-01	2.7836551E-02	9.9139054E-01	1.9397972E-02
3.7349830E+02	9.8449211E-01	3.4490412E-02	9.9088103E-01	2.6763887E-02
5.2902489E+02	9.8852215E-01	2.6951665E-02	9.9494906E-01	1.8232135E-02
7.2731026E+02	9.8353689E-01	3.2841989E-02	9.8991594E-01	2.6022151E-02
1.0430726E+03	9.9213782E-01	3.0990910E-02	9.9550702E-01	2.3275577E-02

Table (3.20)

Narrow Constant

AVERROR L1	MAXER1	MINER1	AVERROR L2	MAXER2	MINER2
9.2974083E-01	9.9648993E-01	9.0952392E-01	8.4318783E-01	9.2317404E-01	7.4649411E-01
9.2122030E-01	9.9271687E-01	9.5016219E-01	8.4829417E-01	9.3435176E-01	6.9194841E-01
9.2777820E-01	1.0005469E+00	8.1322392E-01	8.8025896E-01	9.6564264E-01	6.9426958E-01
9.3660608E-01	1.0007451E+00	9.4491600E-01	8.9637543E-01	9.6609823E-01	7.3965996E-01
9.4049696E-01	1.0127476E+00	9.4905347E-01	9.0660157E-01	9.8230555E-01	7.9070534E-01
9.4180509E-01	1.0191145E+00	8.8699706E-01	9.2475373E-01	9.9853002E-01	8.0231497E-01
9.5093086E-01	1.0476480E+00	9.2354713E-01	9.3847282E-01	1.0005431E+00	7.4184471E-01
9.6644638E-01	1.0286936E+00	9.5023298E-01	9.5878451E-01	1.0010053E+00	7.9042474E-01
9.7568481E-01	1.0334927E+00	9.8455836E-01	9.7187778E-01	1.0020653E+00	8.5081360E-01
9.8427135E-01	1.0252779E+00	9.0737212E-01	9.8403427E-01	1.0012389E+00	8.8581946E-01
9.8368069E-01	1.0064488E+00	1.0010147E+00	9.8537170E-01	1.0025206E+00	8.6118349E-01
9.8696882E-01	1.0163725E+00	1.0019045E+00	9.9153559E-01	1.0021069E+00	9.3613772E-01
9.9294451E-01	1.0035426E+00	1.0028115E+00	9.9164584E-01	1.0026240E+00	7.7220719E-01
9.8877702E-01	1.0069243E+00	1.0021019E+00	9.9150839E-01	1.0037866E+00	8.6355708E-01
9.8561919E-01	1.0082320E+00	1.0002341E+00	9.9139054E-01	1.0051399E+00	8.9986008E-01
9.8449211E-01	1.0098410E+00	9.8120588E-01	9.9088103E-01	1.0072521E+00	8.2740986E-01
9.8852215E-01	1.0139814E+00	9.4768141E-01	9.9494906E-01	1.0097452E+00	9.2932466E-01
9.8353689E-01	1.0163773E+00	1.0084231E+00	9.8991594E-01	1.0132248E+00	8.6247491E-01
9.9213782E-01	1.0321590E+00	9.9088771E-01	9.9550702E-01	1.0178353E+00	8.9301813E-01

Table (3.21)

Wide Ordinate

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
1.86797610E+00	7.19259580E-01	1.03610220E-01	5.66904510E-01	9.20855100E-02
2.65160370E+00	5.97786350E-01	1.05629020E-01	4.97466360E-01	9.14784270E-02
3.32796080E+00	5.63686140E-01	1.15088540E-01	4.95354100E-01	1.01510740E-01
4.27589050E+00	5.65819130E-01	1.32469740E-01	5.19585300E-01	1.25045160E-01
5.98967180E+00	5.62426990E-01	1.37881050E-01	5.23807120E-01	1.31848080E-01
8.26380590E+00	5.72078860E-01	1.24313040E-01	5.42532520E-01	1.16761510E-01
1.14142490E+01	6.14152460E-01	1.17493990E-01	5.77336240E-01	1.14810220E-01
1.63208220E+01	5.99663460E-01	1.16050890E-01	5.66822980E-01	1.09626530E-01
2.32159230E+01	6.80284600E-01	1.23433320E-01	6.40334260E-01	1.21541130E-01
3.25605750E+01	6.86974210E-01	1.25207210E-01	6.49388390E-01	1.18604900E-01
4.72816240E+01	6.95312130E-01	1.26583620E-01	6.63181800E-01	1.20026080E-01
6.60898170E+01	7.04957980E-01	1.24917130E-01	6.63339550E-01	1.22221380E-01
9.00335260E+01	6.92056850E-01	1.18236730E-01	6.48066460E-01	1.14008980E-01
1.30728600E+02	7.49794320E-01	1.29720620E-01	6.94364350E-01	1.20591360E-01
1.90708500E+02	7.45790890E-01	1.22184050E-01	6.85410650E-01	1.17842820E-01
2.59845920E+02	7.76836340E-01	1.15507550E-01	7.03389920E-01	1.12945790E-01
3.76173600E+02	8.38633250E-01	1.34746050E-01	7.42778720E-01	1.14725560E-01
5.24010450E+02	9.16417810E-01	1.28807400E-01	7.93738360E-01	1.16579340E-01
7.60647970E+02	1.06551670E+00	1.30610070E-01	8.76060660E-01	1.00369450E-01
1.08757060E+03	1.25319130E+00	1.41138210E-01	9.95440120E-01	9.90892270E-02
1.47114670E+03	1.55966560E+00	1.66584830E-01	1.15638440E+00	9.55084700E-02

Table (3.22)

Wide Ordinate

AVERROR L1	MAXER1	MINER1	AVERROR L2	MAXER2	MINER2
7.1925958E-01	9.5186836E-01	6.4544822E-01	5.6690451E-01	8.1590225E-01	3.1007581E-01
5.9778635E-01	8.2425648E-01	5.8156039E-01	4.9746636E-01	7.0022809E-01	2.9905440E-01
5.6368614E-01	8.9621310E-01	4.2450303E-01	4.9535410E-01	8.4800332E-01	2.7417423E-01
5.6581913E-01	8.9788204E-01	4.0783282E-01	5.1958530E-01	8.3383545E-01	2.6098839E-01
5.6242699E-01	9.1631141E-01	3.8747998E-01	5.2380712E-01	7.8209703E-01	2.4599129E-01
5.7207886E-01	8.6237038E-01	3.7741357E-01	5.4253252E-01	8.1019070E-01	2.7521061E-01
6.1415246E-01	9.1484625E-01	3.9162502E-01	5.7733624E-01	8.7963086E-01	3.6755943E-01
5.9966346E-01	8.8702310E-01	7.1934012E-01	5.6682298E-01	8.4013750E-01	2.8341076E-01
6.8028460E-01	9.5228823E-01	5.8197693E-01	6.4033426E-01	9.2951512E-01	3.2040157E-01
6.8697421E-01	9.3634336E-01	8.8624231E-01	6.4938839E-01	8.7437201E-01	3.2874640E-01
6.9531213E-01	9.2325743E-01	7.0116714E-01	6.6318180E-01	8.9023821E-01	3.8170975E-01
7.0495798E-01	1.0335252E+00	8.6569379E-01	6.6333955E-01	9.5701135E-01	3.5226744E-01
6.9205685E-01	9.7904216E-01	5.5495623E-01	6.4806646E-01	9.0355401E-01	4.1034057E-01
7.4979432E-01	1.0445739E+00	7.7160300E-01	6.9436435E-01	9.0781478E-01	3.1349516E-01
7.4579089E-01	9.7907887E-01	9.7301672E-01	6.8541065E-01	9.3060213E-01	4.1434295E-01
7.7683634E-01	9.9770760E-01	6.5062737E-01	7.0338992E-01	9.0751678E-01	3.2821263E-01
8.3863325E-01	1.1039619E+00	9.6080320E-01	7.4277872E-01	1.0118718E+00	3.6467602E-01
9.1641781E-01	1.2035906E+00	9.7986841E-01	7.9373836E-01	1.0395938E+00	5.2387682E-01
1.0655167E+00	1.3452913E+00	1.3053945E+00	8.7606066E-01	1.1240121E+00	5.7635469E-01
1.2531913E+00	1.6184889E+00	1.0697468E+00	9.9544012E-01	1.2233035E+00	7.1603896E-01
1.5596656E+00	2.0085041E+00	1.4555568E+00	1.1563844E+00	1.4054019E+00	9.5024951E-01

Table (3.23)

Wide Constant

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.23809910E+00	7.80474360E-01	6.19669190E-02	7.08525050E-01	5.37647880E-02
3.03384880E+00	7.78374700E-01	6.24967060E-02	7.10337360E-01	5.29658310E-02
4.23902950E+00	7.64527250E-01	7.53781060E-02	7.06220010E-01	6.80459910E-02
5.91136340E+00	7.45812050E-01	8.10085270E-02	6.95488300E-01	6.81802970E-02
8.44401310E+00	7.44603180E-01	7.69764600E-02	7.04003570E-01	7.06188630E-02
1.18532630E+01	7.44289870E-01	6.77825790E-02	7.07662300E-01	5.75537040E-02
1.66577860E+01	7.71574440E-01	6.85330780E-02	7.34538290E-01	6.07804050E-02
2.38334150E+01	7.71431510E-01	7.41345980E-02	7.43934930E-01	6.46693770E-02
3.28980590E+01	7.96157000E-01	7.18541870E-02	7.63423080E-01	6.01312910E-02
4.72060020E+01	7.79321220E-01	7.53490950E-02	7.49286370E-01	6.88323330E-02
6.69249780E+01	7.95677620E-01	6.91141410E-02	7.64169250E-01	5.92355570E-02
9.21733510E+01	7.91592470E-01	7.25673430E-02	7.58667660E-01	6.30424740E-02
1.32529540E+02	8.02783410E-01	7.49743680E-02	7.70532600E-01	6.06648110E-02
1.86152090E+02	8.07657710E-01	7.94769690E-02	7.74189650E-01	7.19254060E-02
2.66812790E+02	8.13797620E-01	7.55272800E-02	7.82944750E-01	6.43667450E-02
3.79314060E+02	8.44454520E-01	7.58133160E-02	8.12899970E-01	6.39893040E-02
5.32292300E+02	8.92463100E-01	7.41355050E-02	8.45895030E-01	5.91204740E-02
7.47176270E+02	9.53547210E-01	8.60223370E-02	9.08033940E-01	7.54620830E-02
1.08383420E+03	1.13033020E+00	9.27599550E-02	1.05113380E+00	6.55478430E-02

Table (3.24)

Wide Constant

AVERROR L1	MAXER1	MINER1	AVERROR L2	MAXER2	MINER2
7.8047436E-01	9.0928611E-01	7.9681277E-01	7.0852505E-01	8.1708077E-01	5.3682556E-01
7.7837470E-01	9.1398961E-01	7.4385051E-01	7.1033736E-01	8.1259314E-01	5.7041327E-01
7.6452725E-01	9.3308275E-01	6.9666368E-01	7.0622001E-01	8.6157448E-01	5.3477035E-01
7.4581205E-01	9.5657673E-01	7.7961954E-01	6.9548830E-01	8.7206373E-01	5.1206995E-01
7.4460318E-01	9.0650609E-01	8.0663992E-01	7.0400357E-01	8.3996978E-01	4.7106544E-01
7.4428987E-01	9.1043721E-01	7.4429163E-01	7.0766230E-01	8.4620991E-01	5.9155154E-01
7.7157444E-01	9.2489880E-01	8.3238221E-01	7.3453829E-01	8.7039610E-01	5.8661412E-01
7.7143151E-01	9.3529452E-01	8.1863607E-01	7.4393493E-01	8.7686841E-01	5.6809987E-01
7.9615700E-01	9.4940272E-01	8.5851625E-01	7.6342308E-01	8.8161750E-01	6.0407656E-01
7.7932122E-01	9.2555521E-01	7.2182515E-01	7.4928637E-01	8.8492669E-01	5.7683368E-01
7.9567762E-01	9.5911949E-01	8.2231008E-01	7.6416925E-01	9.1066216E-01	6.0333160E-01
7.9159247E-01	1.0089695E+00	7.9170425E-01	7.5866766E-01	9.4595678E-01	6.1032980E-01
8.0278341E-01	9.4038892E-01	7.5571357E-01	7.7053260E-01	9.1892117E-01	5.8419433E-01
8.0765771E-01	9.8945271E-01	8.4826744E-01	7.7418965E-01	8.9860850E-01	5.8443605E-01
8.1379762E-01	9.6415109E-01	8.3835202E-01	7.8294475E-01	9.5829338E-01	6.4599732E-01
8.4445452E-01	1.0031311E+00	9.4697428E-01	8.1289997E-01	9.5062426E-01	6.1000720E-01
8.9246310E-01	1.0554190E+00	9.2298888E-01	8.4589503E-01	1.0443800E+00	7.2206888E-01
9.5354721E-01	1.1787730E+00	9.7789980E-01	9.0803394E-01	1.1058540E+00	7.2996358E-01
1.1303302E+00	1.3499875E+00	1.0727244E+00	1.0511338E+00	1.1935611E+00	8.7321852E-01

Figure (3.1)

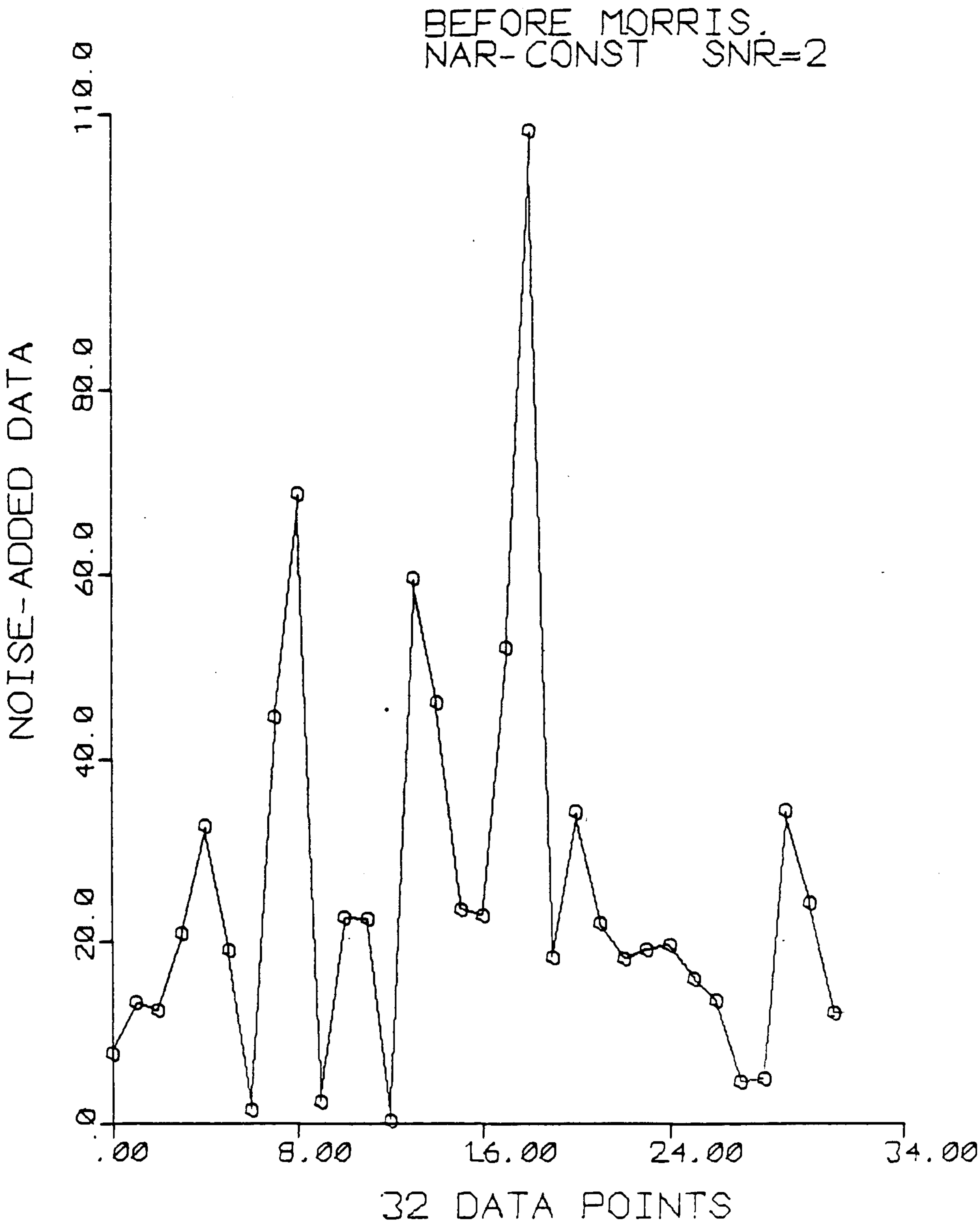

BEFORE MORRIS.
NAR-CONST SNR=2
NOISE-ADDED DATA
110.0
80.0
60.0
40.0
20.0
0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.2)

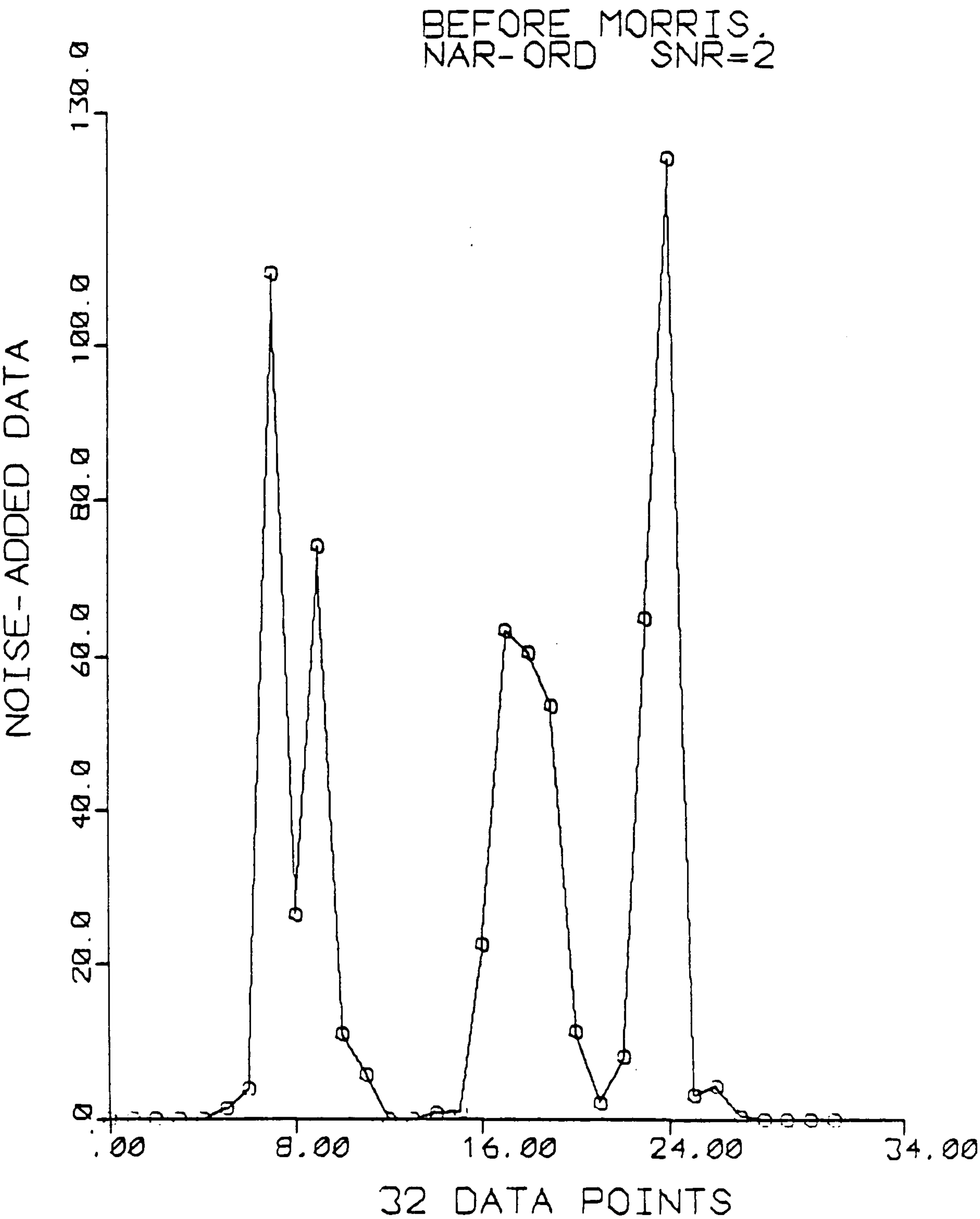

BEFORE MORRIS.
NAR-ORD SNR=2
NOISE-ADDED DATA
130.0
100.0
80.0
60.0
40.0
20.0
0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.3)

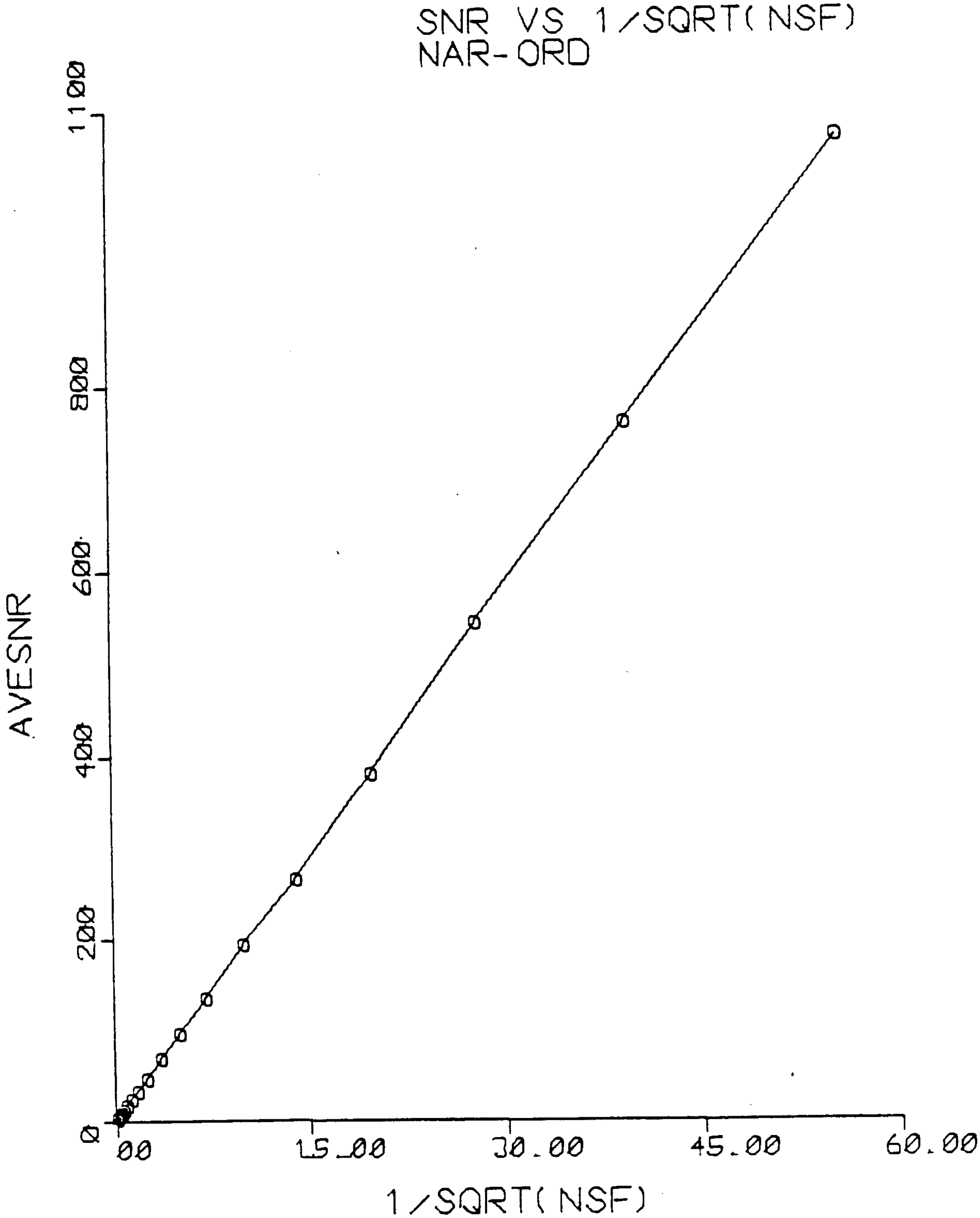

SNR VS 1/SQRT(NSF)
NAR-ORD
AVESNR
1100
800
600
400
200
0
.00
15.00
30.00
45.00
60.00
1/SQRT(NSF)

Figure (3.4)

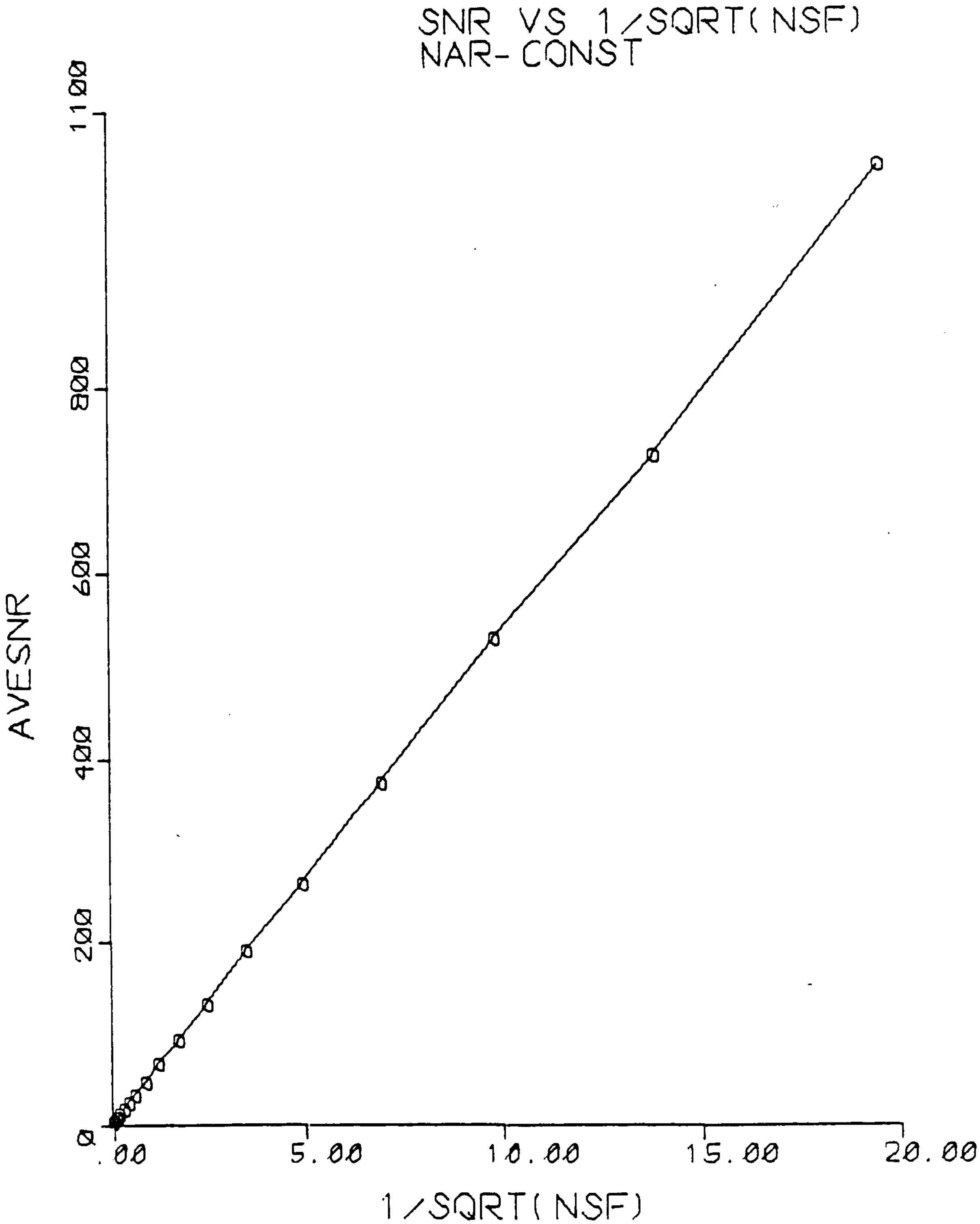

SNR VS 1/SQRT(NSF)
NAR-CONST
AVESNR
1100
800
600
400
200
0
.00
5.00
10.00
15.00
20.00
1/SQRT(NSF)

Figure (3.5)

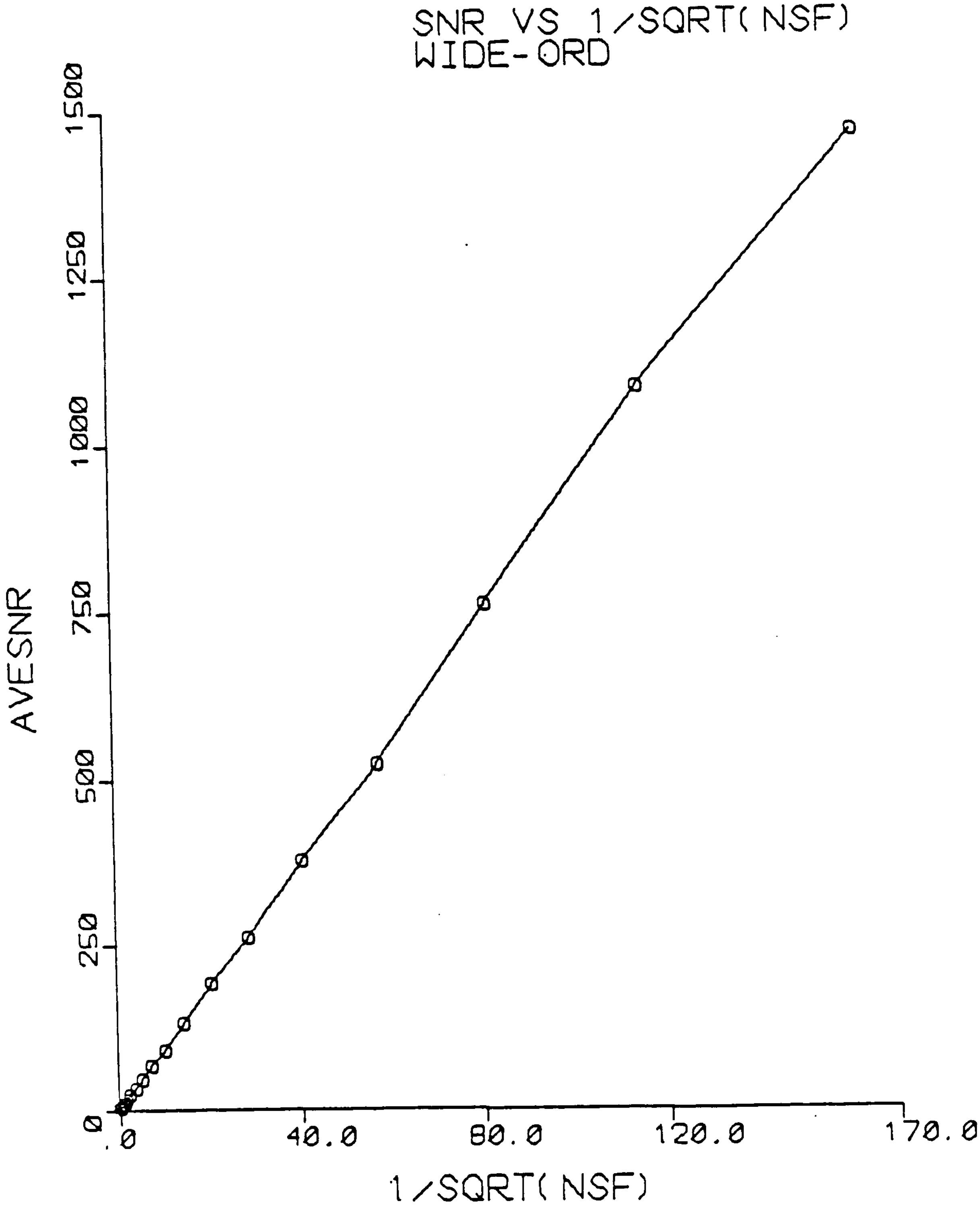

SNR VS 1/SQRT(NSF)
WIDE-ORD
AVESNR
1500
1250
1000
750
500
250
0
.0
40.0
80.0
120.0
170.0
1/SQRT(NSF)

Figure (3.6)

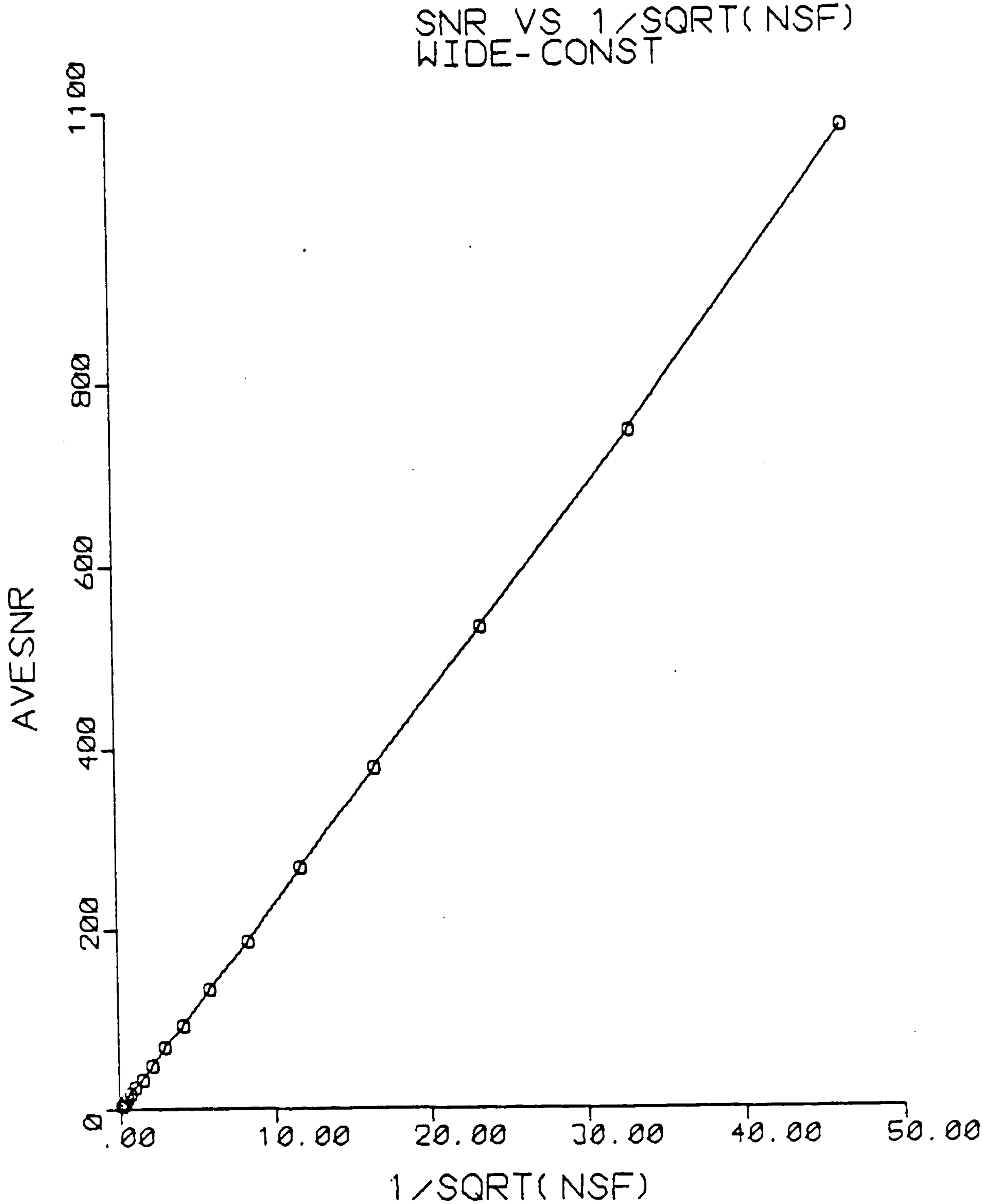
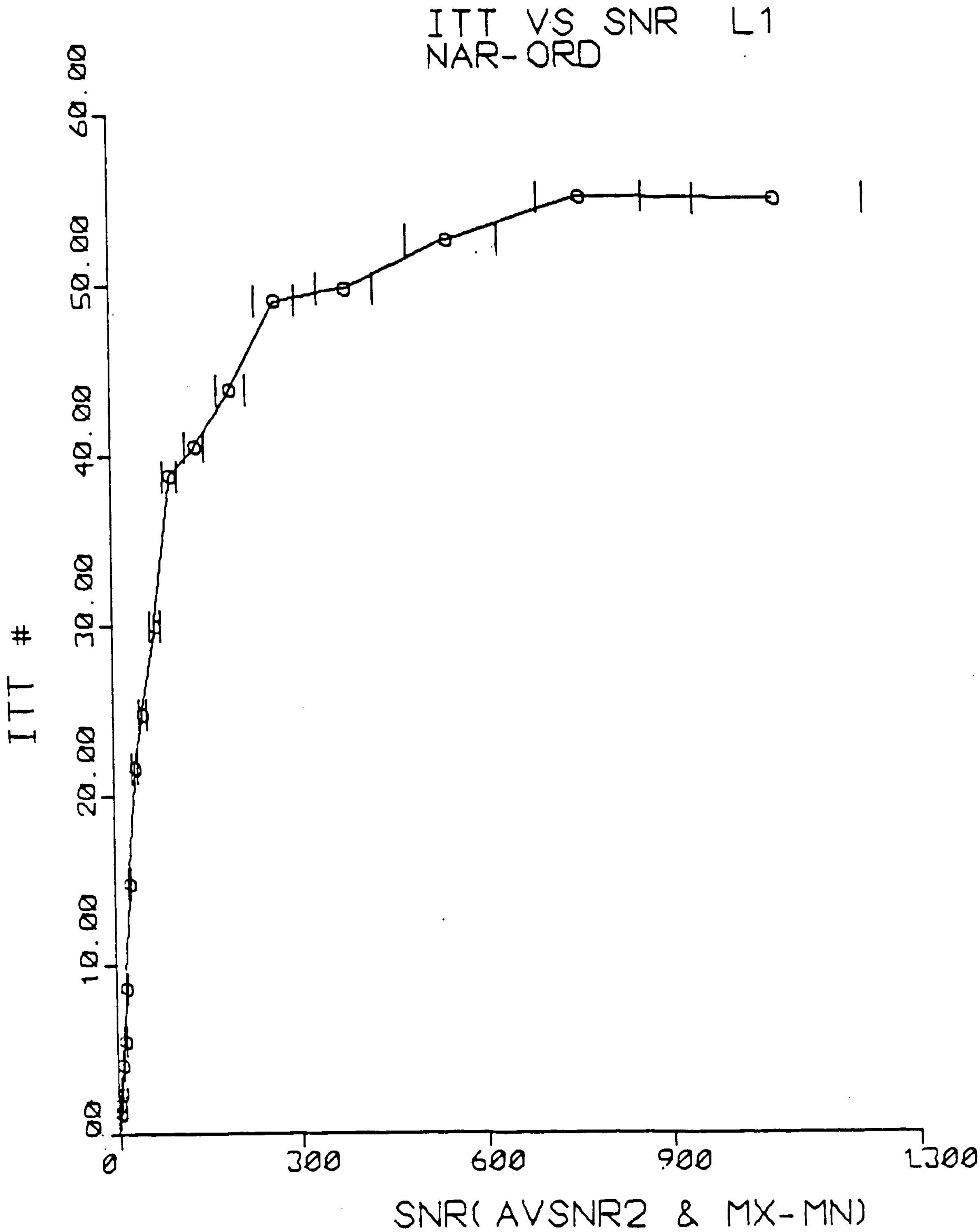

SNR VS 1/SQRT(NSF)
WIDE-CONST
AVESNR
1100
800
600
400
200
0
.00
10.00
20.00
30.00
40.00
50.00
1/SQRT(NSF)

Figure (3.7)



ITT VS SNR L1
NAR-ORD
ITT #
00
10.00
20.00
30.00
40.00
50.00
60.00
0
300
600
900
1300
SNR(AVSNR2 & MX-MN)

Figure (3.8)

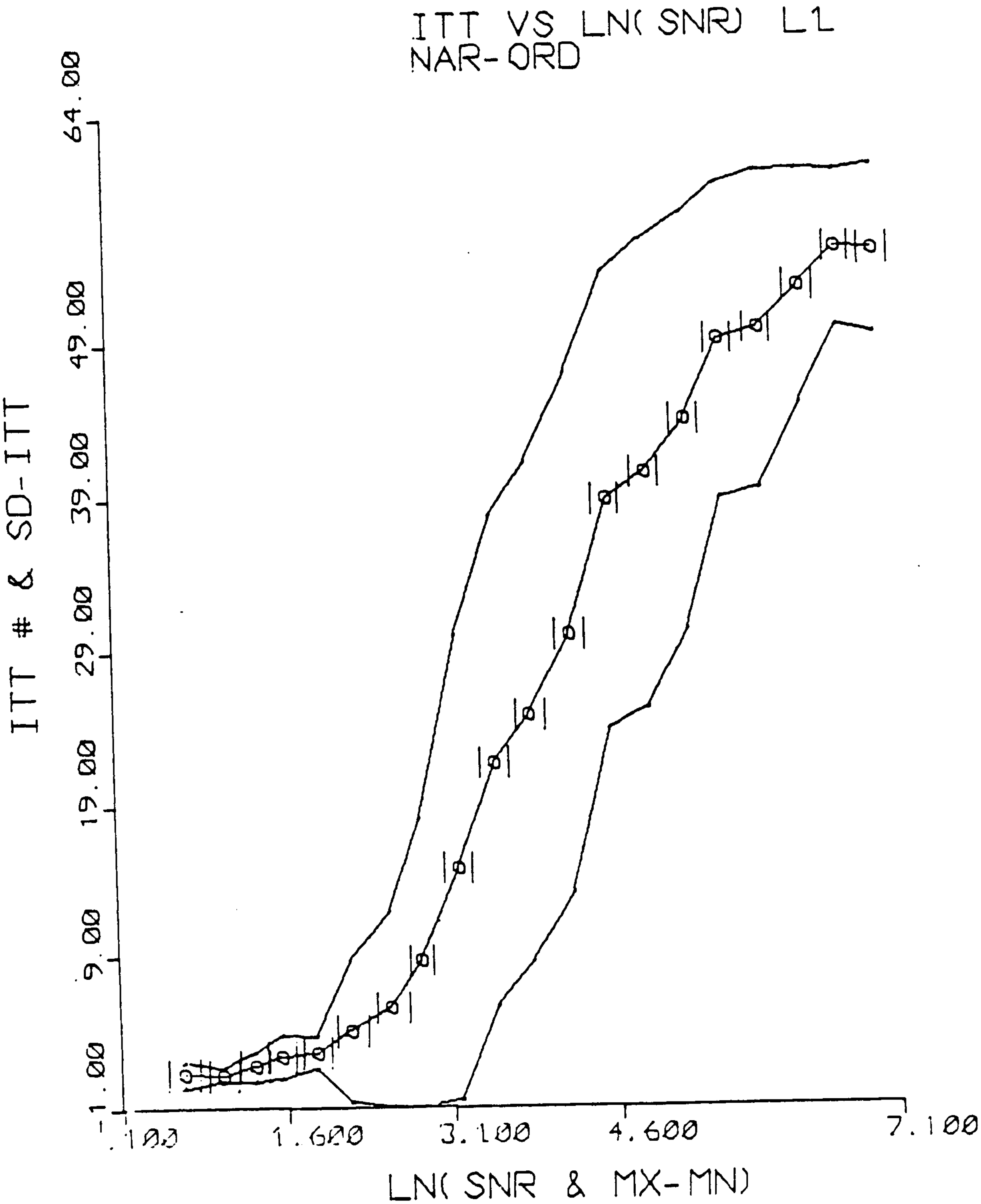

ITT VS LN(SNR) L1
NAR-ORD
ITT # & SD-ITT
64.00
49.00
39.00
29.00
19.00
9.00
1.00
-1
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (3.9)

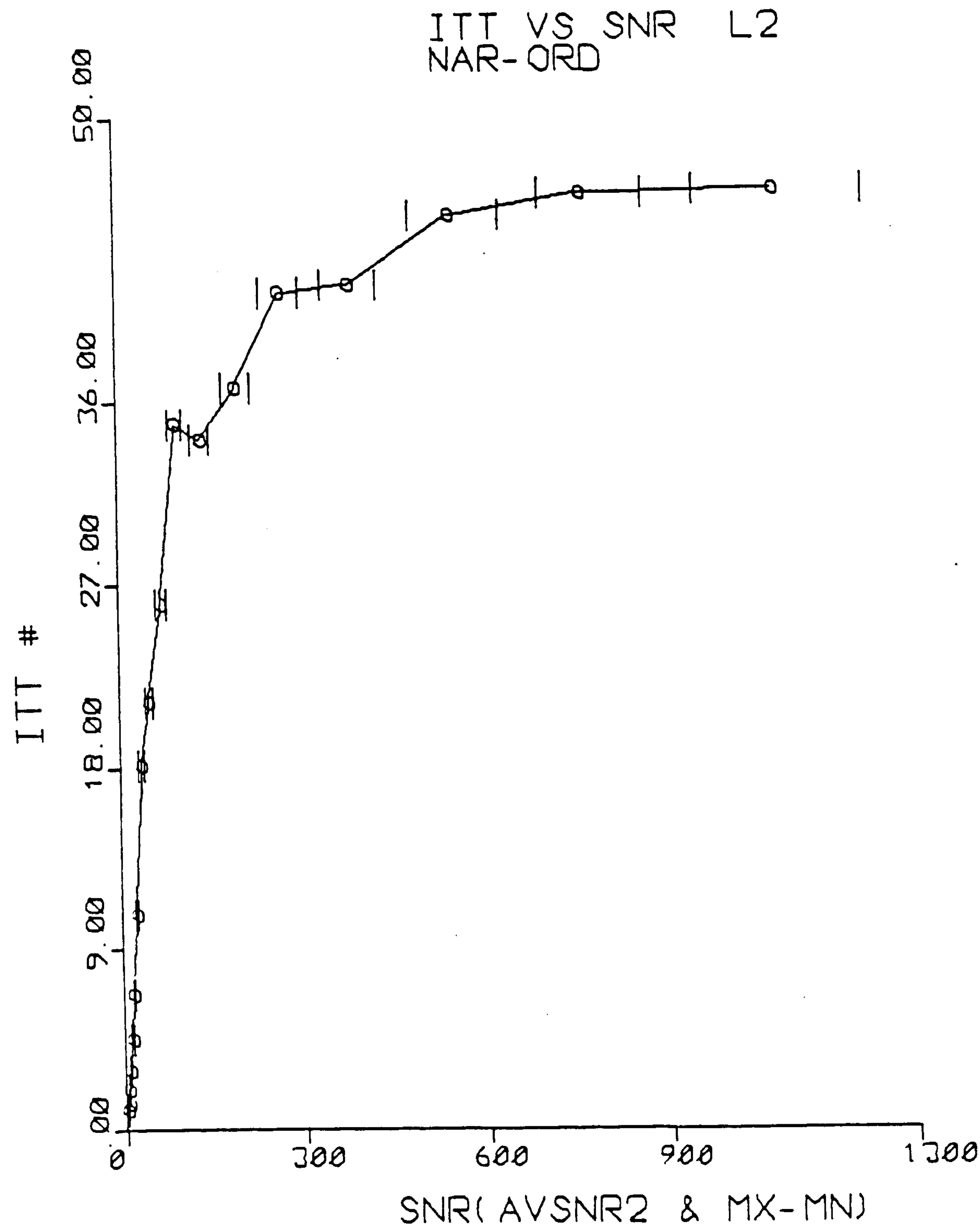

ITT VS SNR L2
NAR-ORD
50.00
36.00
27.00
18.00
9.00
.00
ITT #
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.10)

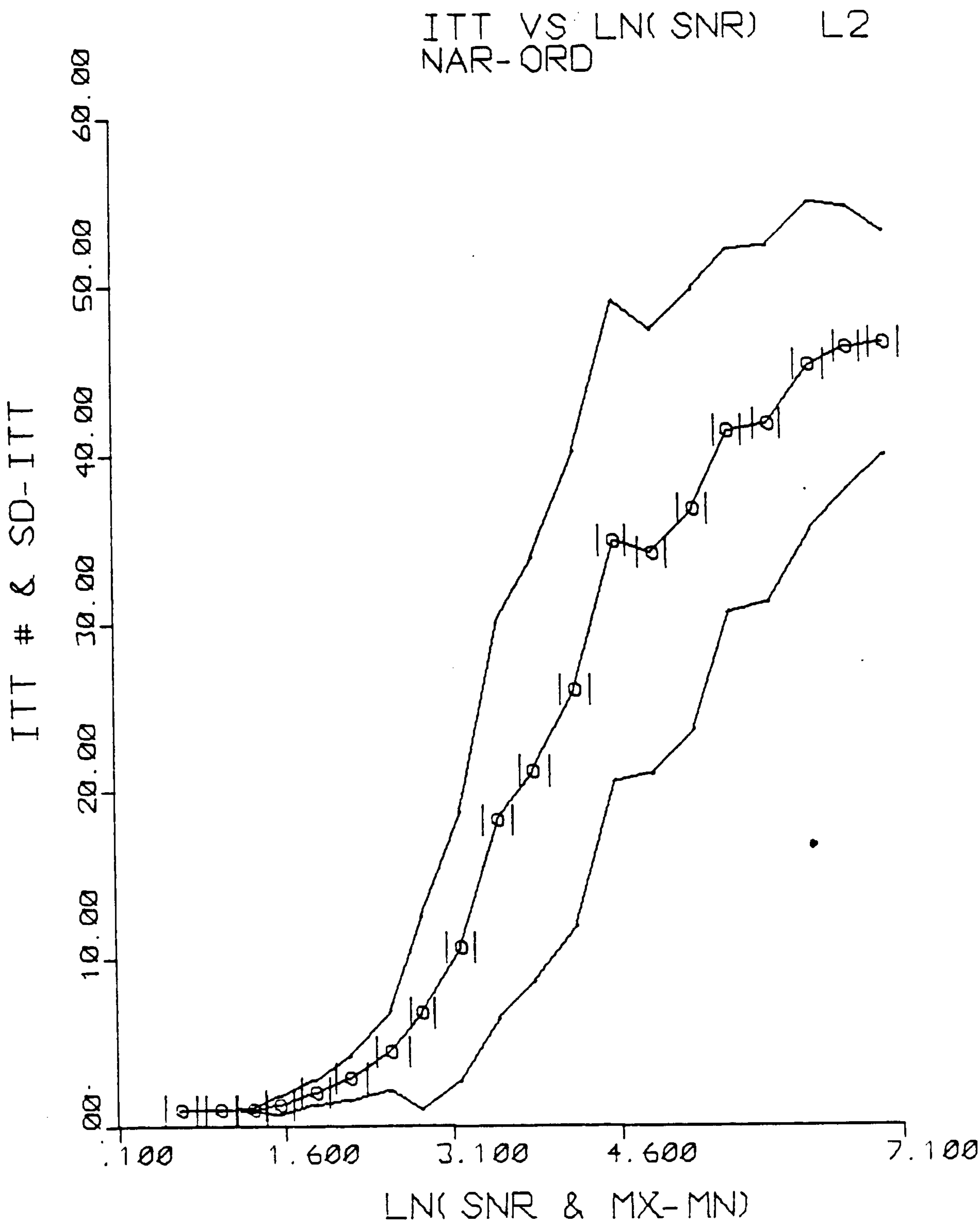

ITT VS LN(SNR) L2
NAR-ORD
ITT # & SD-ITT
60.00
50.00
40.00
30.00
20.00
10.00
.00
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (3.11)

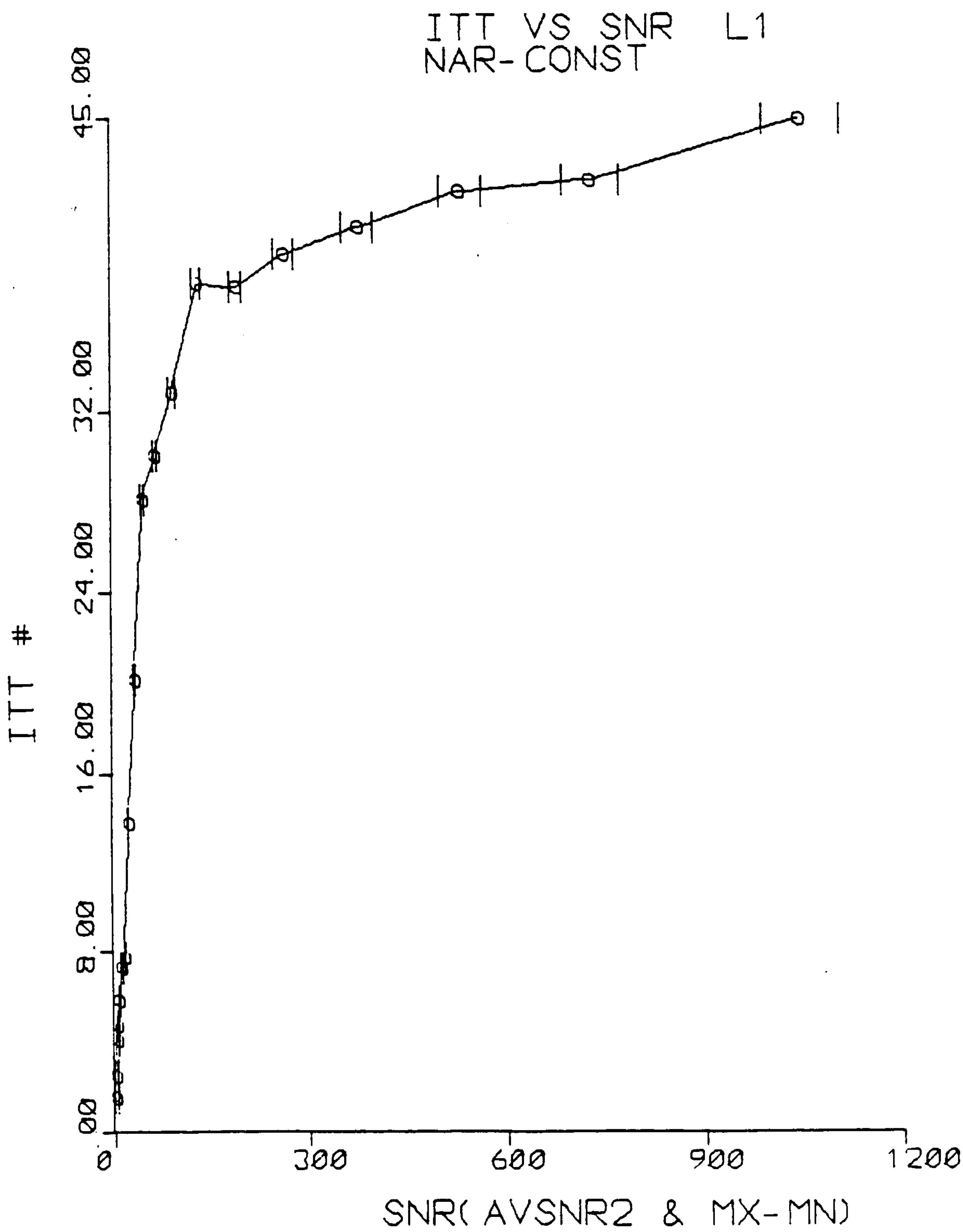

ITT VS SNR L1
NAR-CONST
ITT #
45.00
32.00
24.00
16.00
8.00
00
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.12)

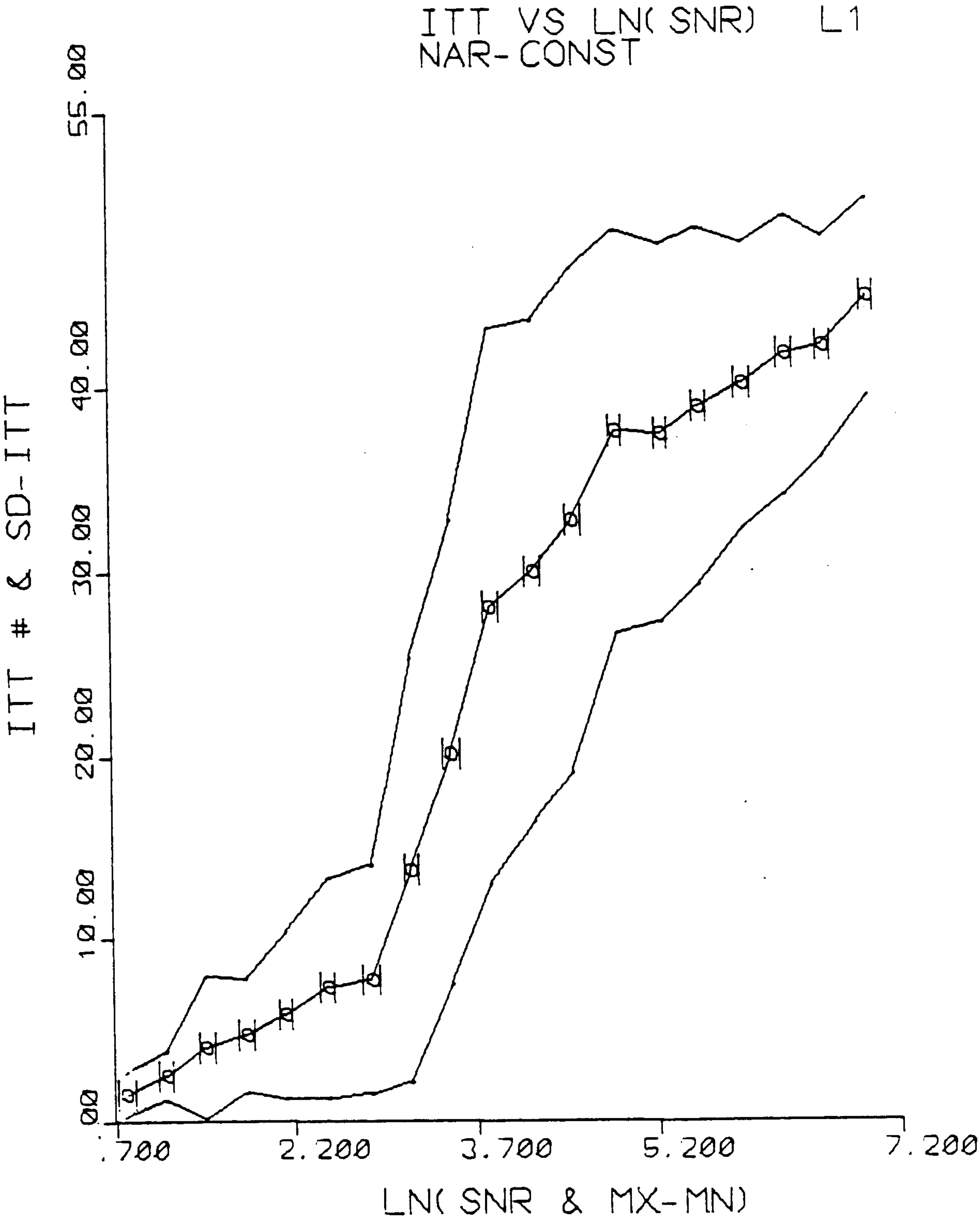

ITT VS LN(SNR) L1
NAR- CONST
ITT # & SD- ITT
55.00
40.00
30.00
20.00
10.00
00
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (3.13)

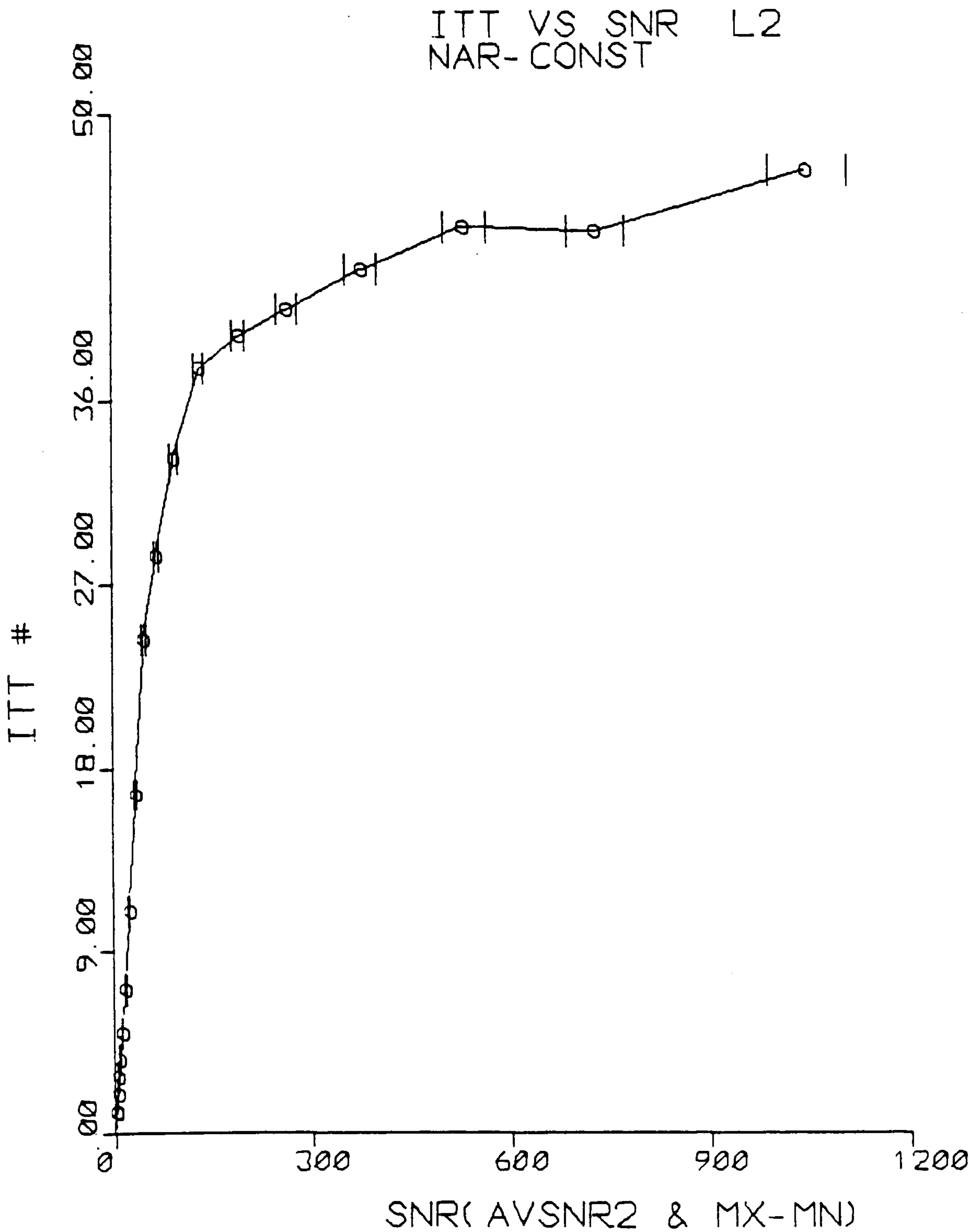

ITT VS SNR L2
NAR-CONST
50.00
36.00
27.00
18.00
9.00
00
ITT #
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.14)

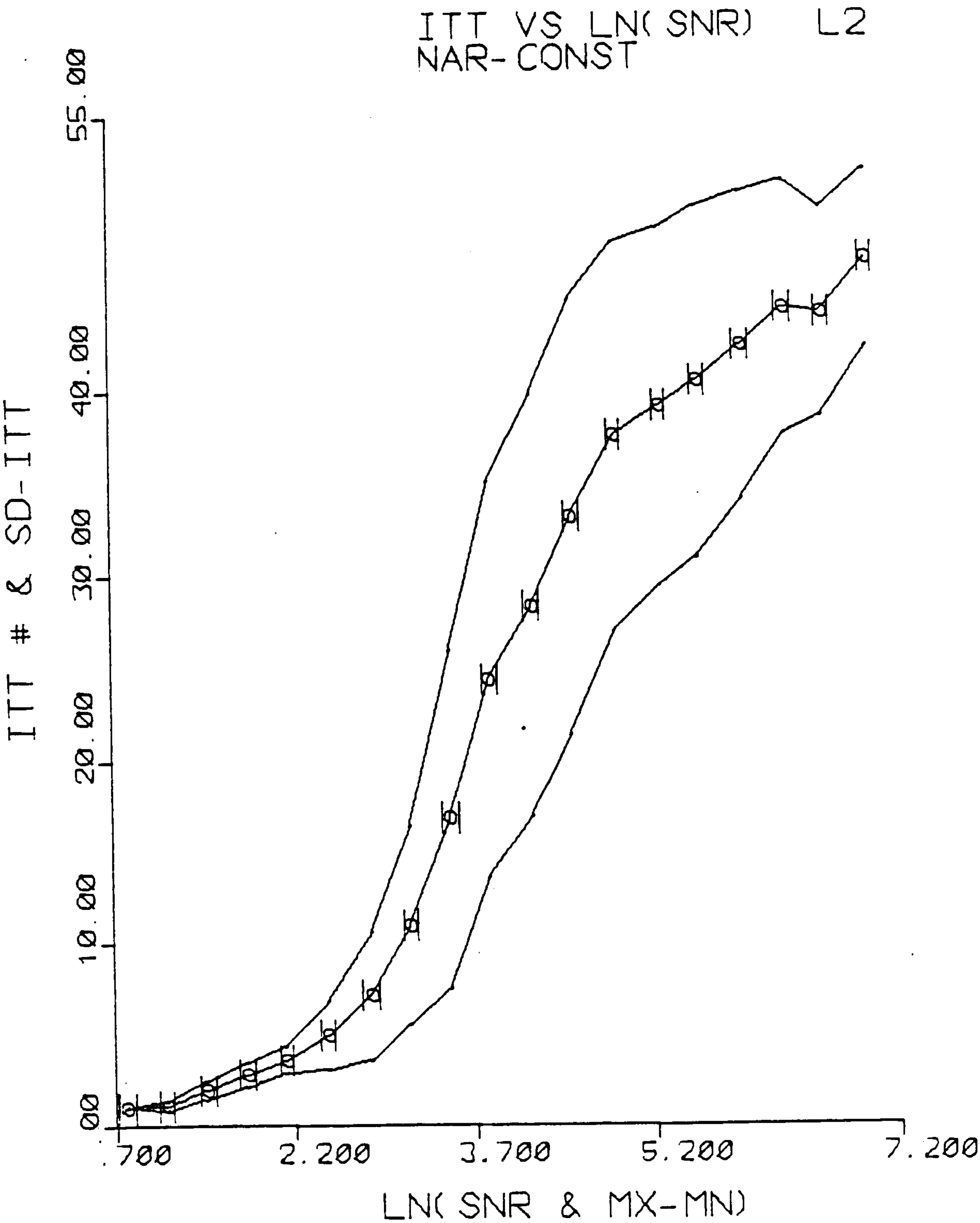

ITT VS LN(SNR) L2
NAR-CONST
ITT # & SD-ITT
55.00
40.00
30.00
20.00
10.00
00
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (3.15)

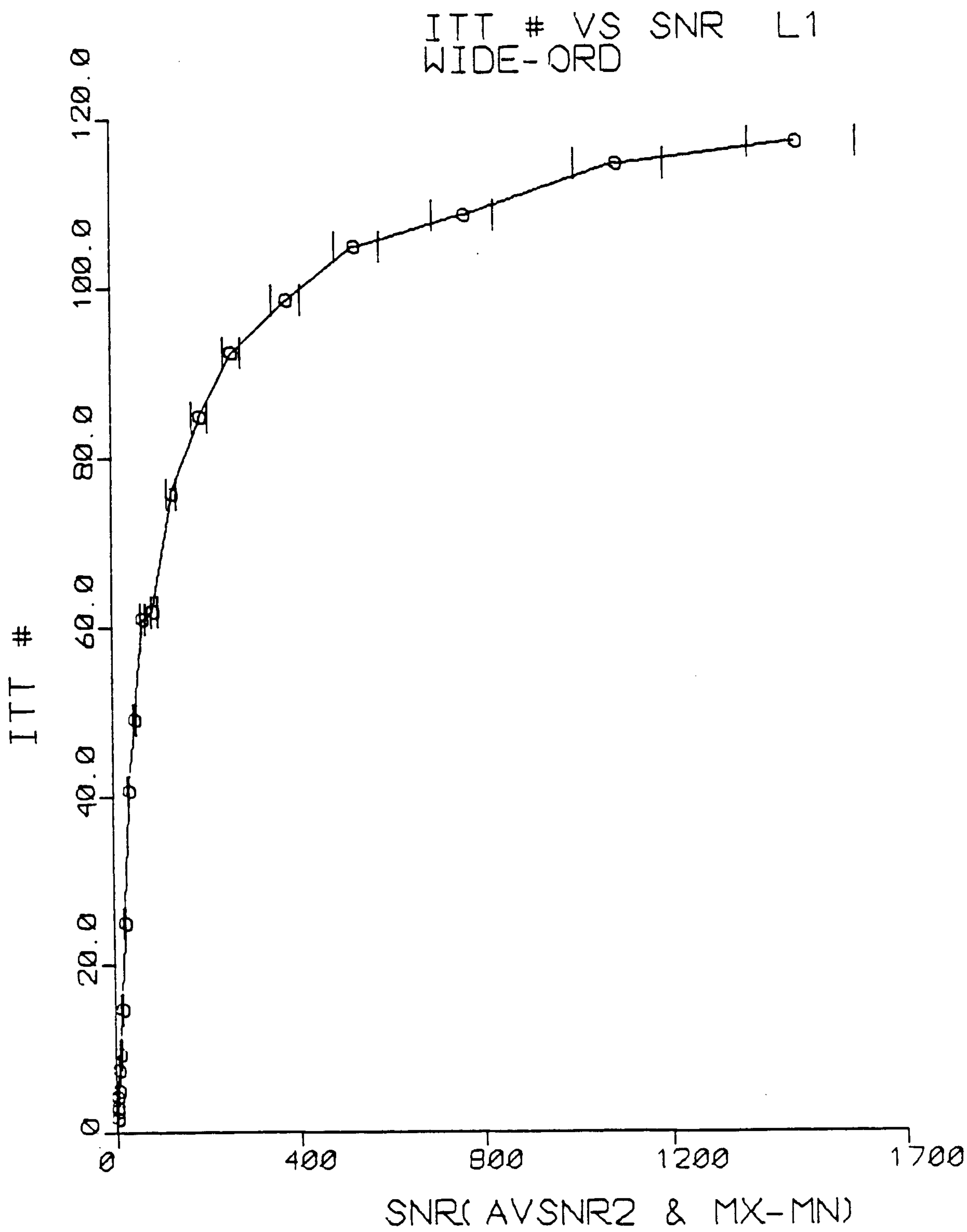

ITT # VS SNR L1
WIDE-ORD
ITT #
120.0
100.0
80.0
60.0
40.0
20.0
0
0
400
800
1200
1700
SNR(AVSNR2 & MX-MN)

Figure (3.16)

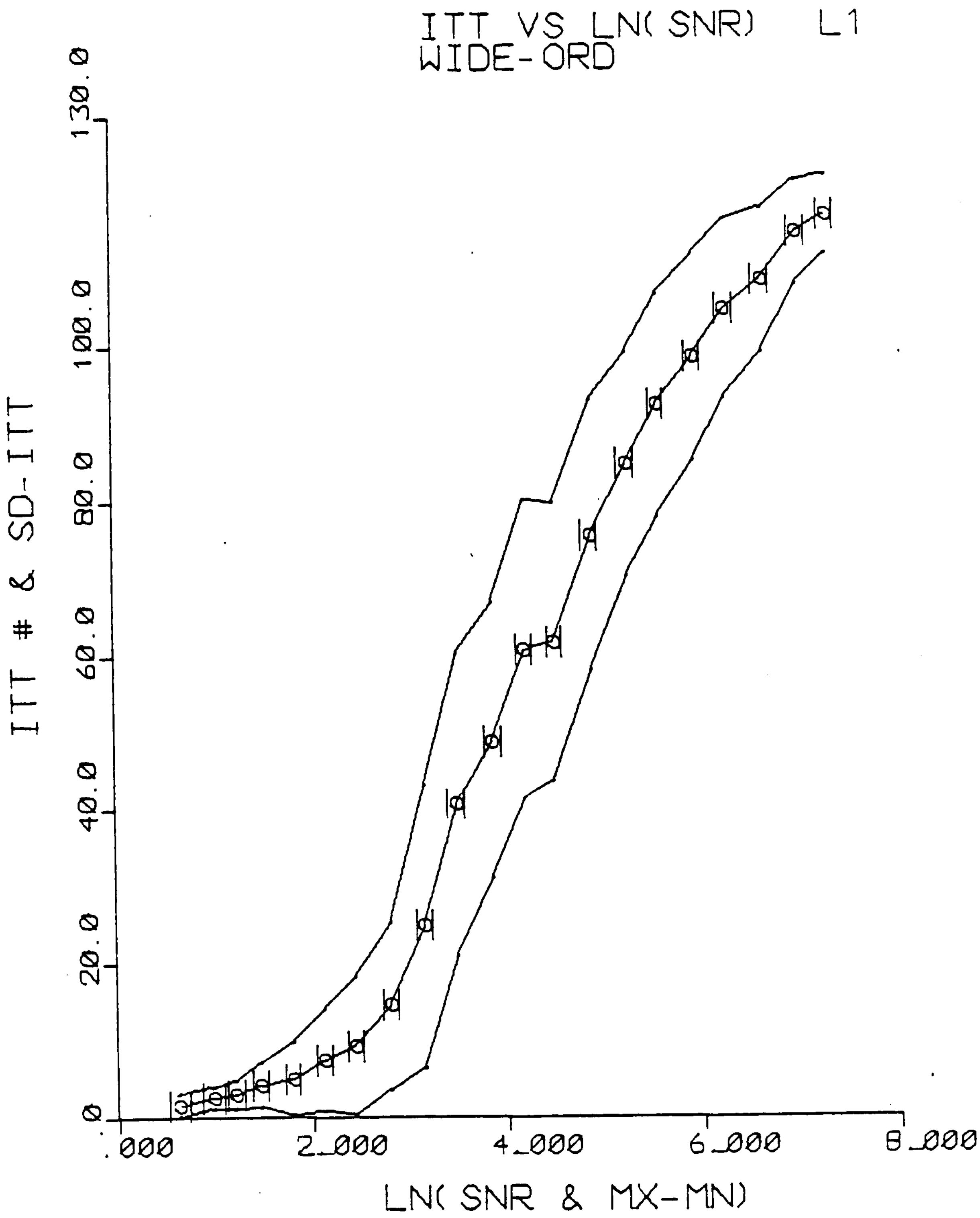

ITT VS LN(SNR) L1
WIDE-ORD
ITT # & SD-ITT
130.0
100.0
80.0
60.0
40.0
20.0
0
.000
2.000
4.000
6.000
8.000
LN(SNR & MX-MN)

Figure (3.17)

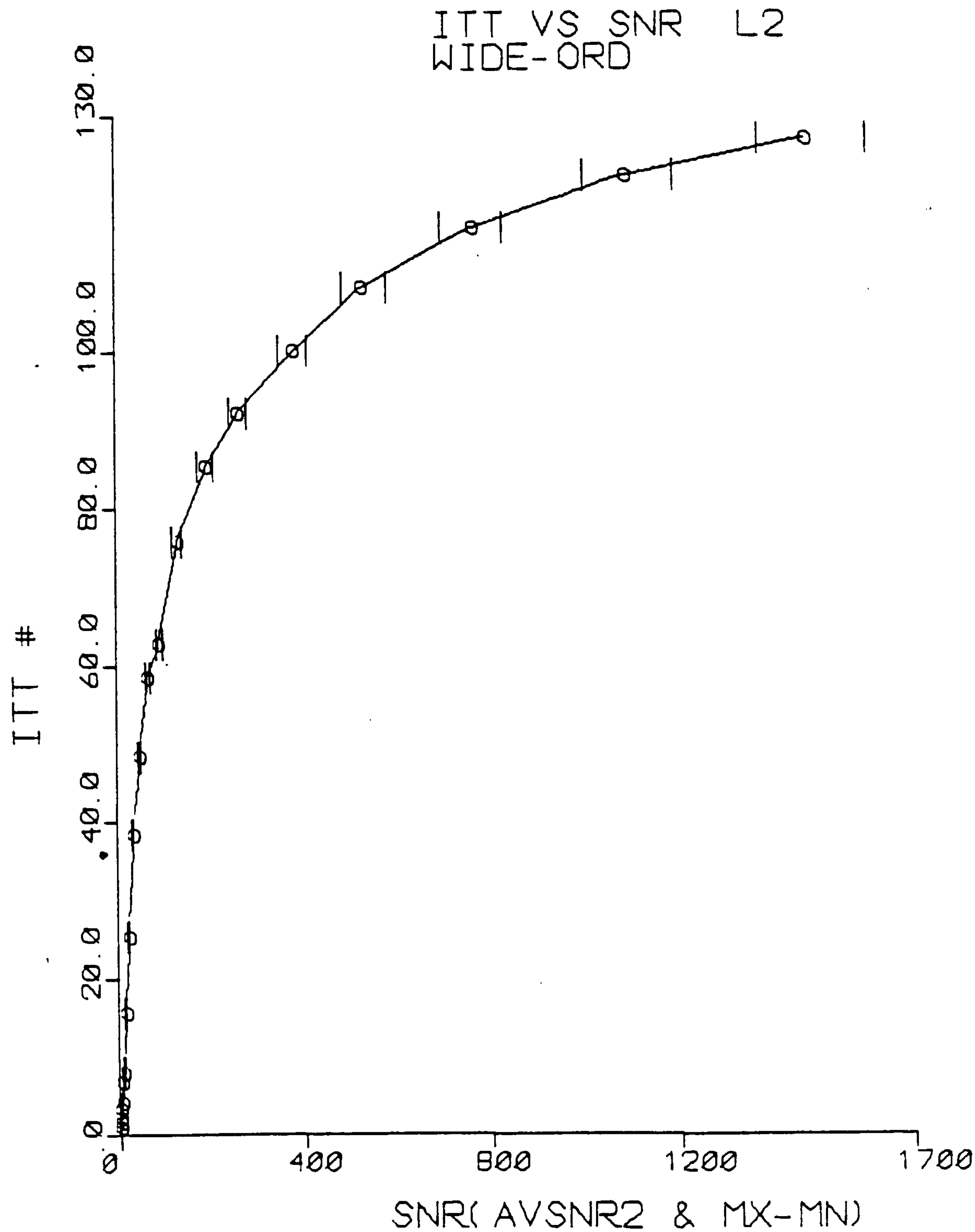

ITT VS SNR L2
WIDE-ORD
130.0
100.0
80.0
60.0
40.0
20.0
0
ITT #
0
400
800
1200
1700
SNR(AVSNR2 & MX-MN)

Figure (3.18)

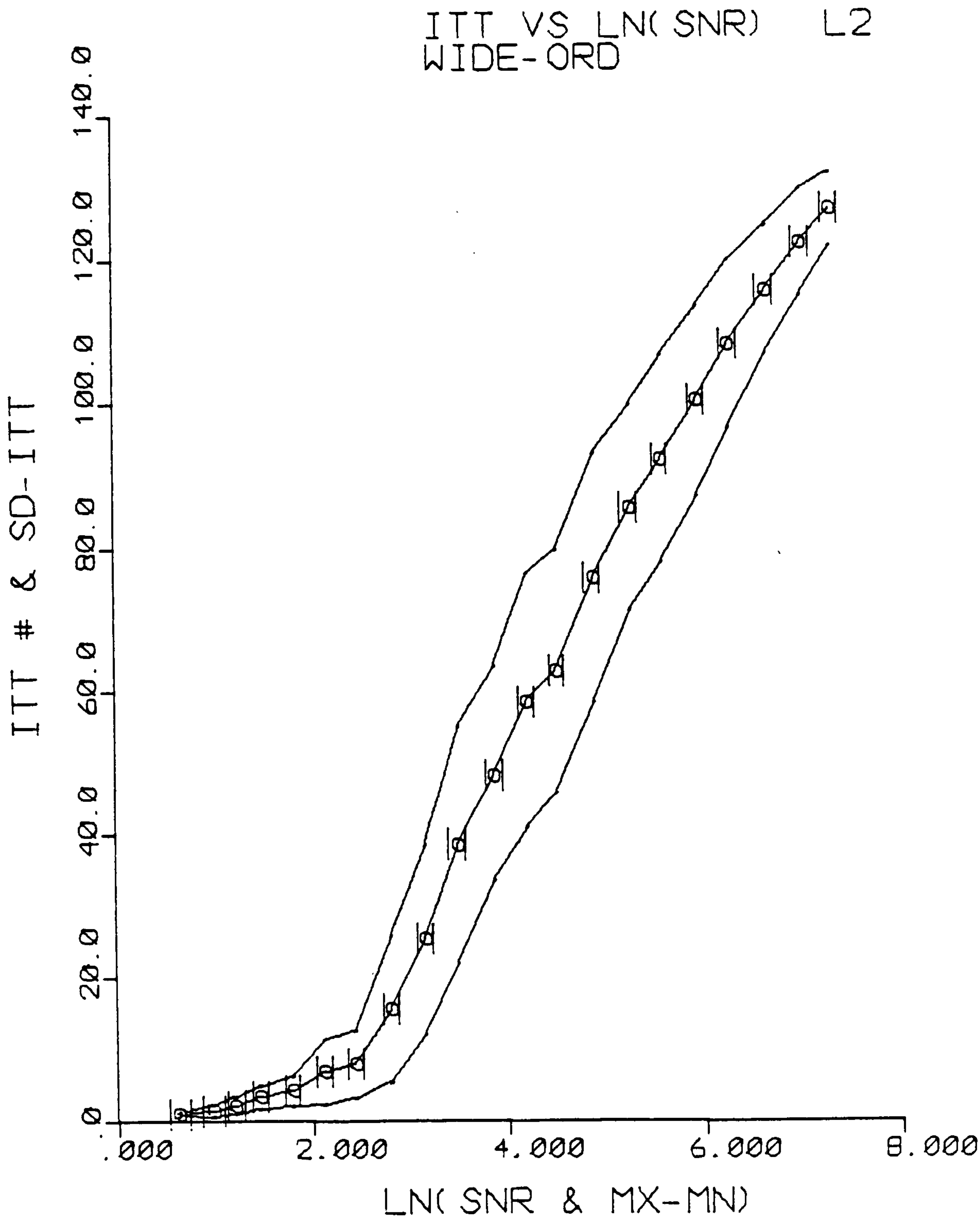

ITT VS LN(SNR) L2
WIDE-ORD
ITT # & SD-ITT
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0
.000
2.000
4.000
6.000
8.000
LN(SNR & MX-MN)

Figure (3.19)

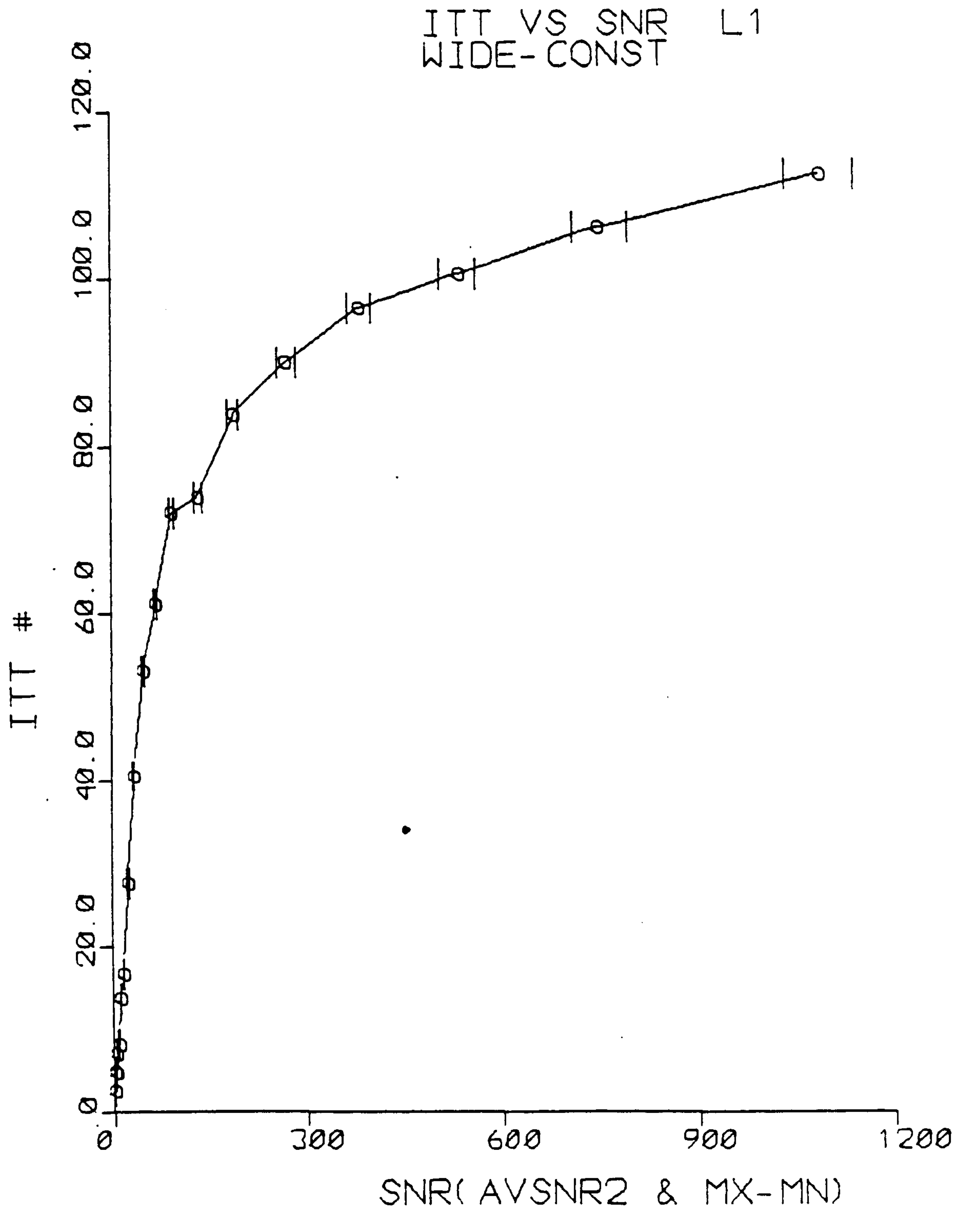

ITT VS SNR L1
WIDE-CONST
120.0
100.0
80.0
60.0
40.0
20.0
0
ITT #
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.20)

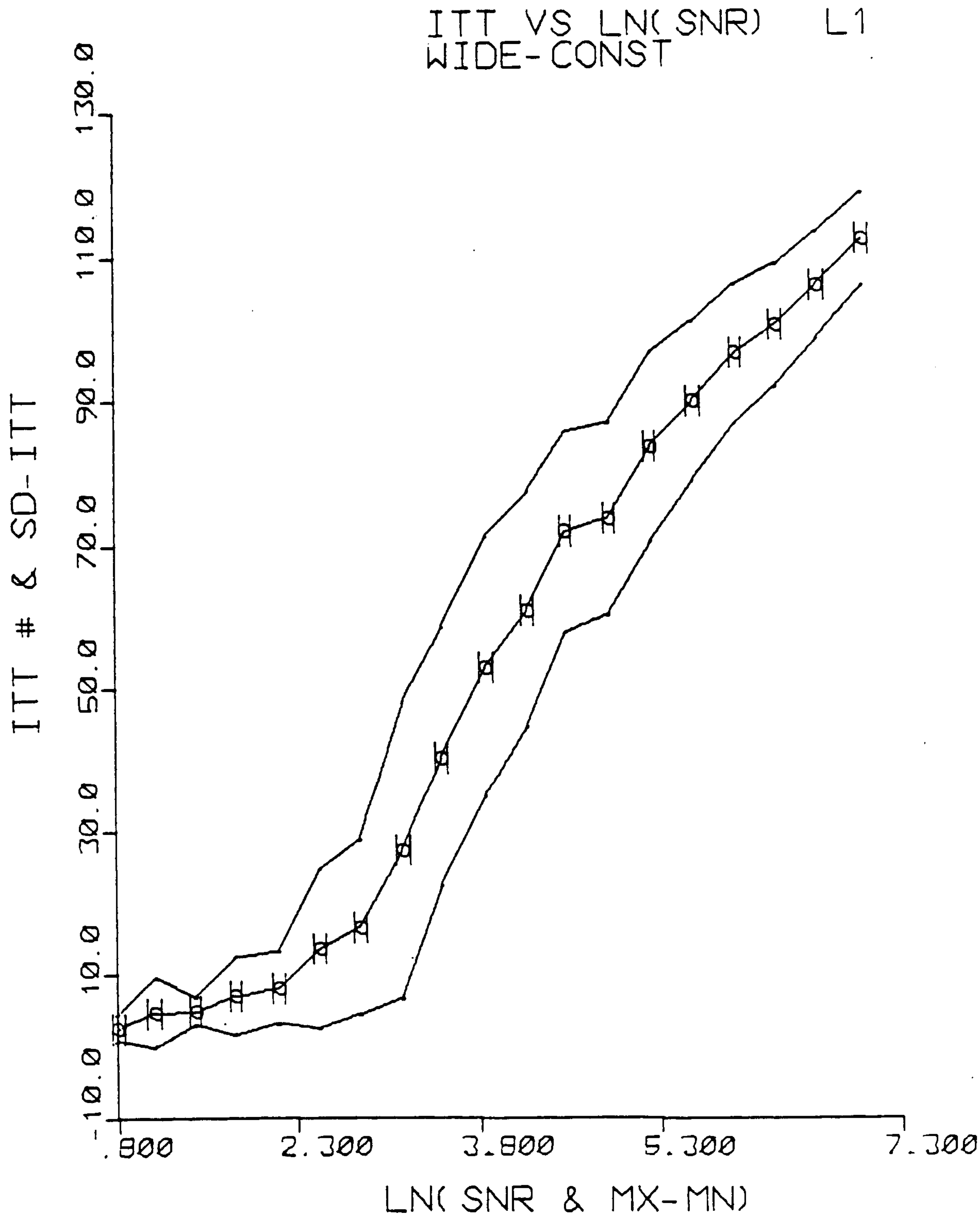

ITT VS LN(SNR) L1
WIDE-CONST
ITT # & SD-ITT
130.0
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.800
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (3.21)

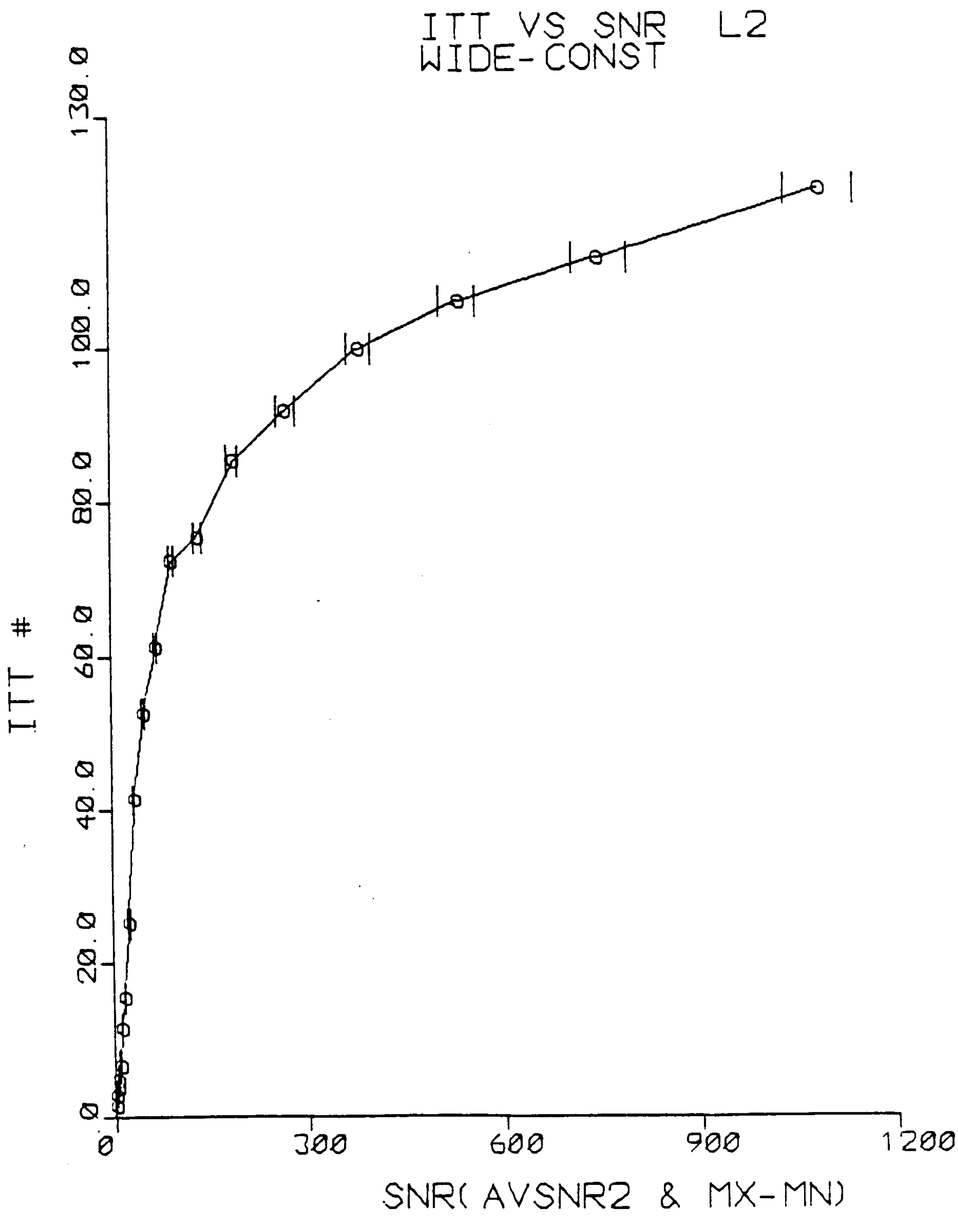

ITT VS SNR L2
WIDE-CONST
ITT #
130.0
100.0
80.0
60.0
40.0
20.0
0
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.22)

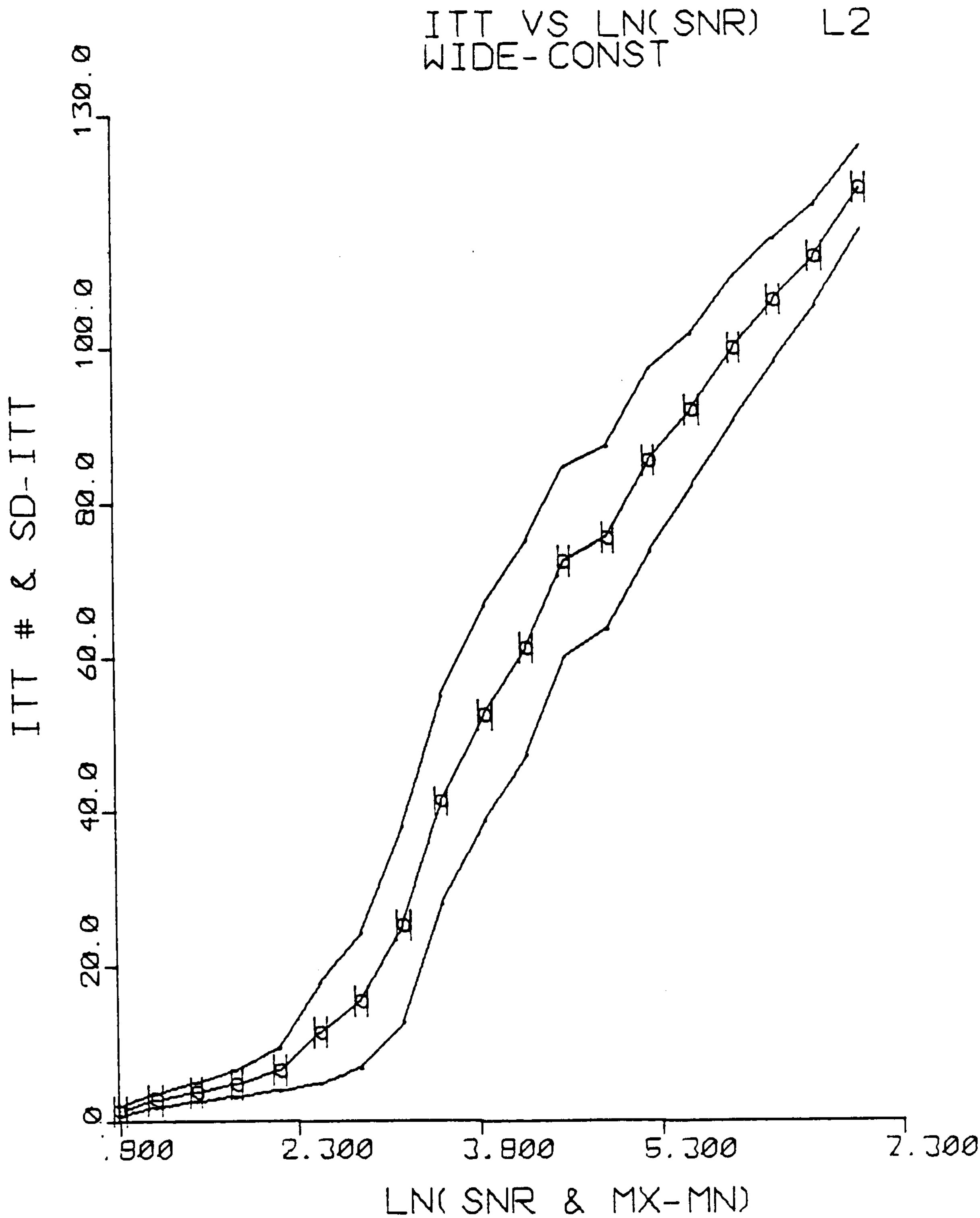

ITT VS LN(SNR) L2
WIDE-CONST
ITT # & SD-ITT
130.0
100.0
80.0
60.0
40.0
20.0
0
.900
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (3.23)

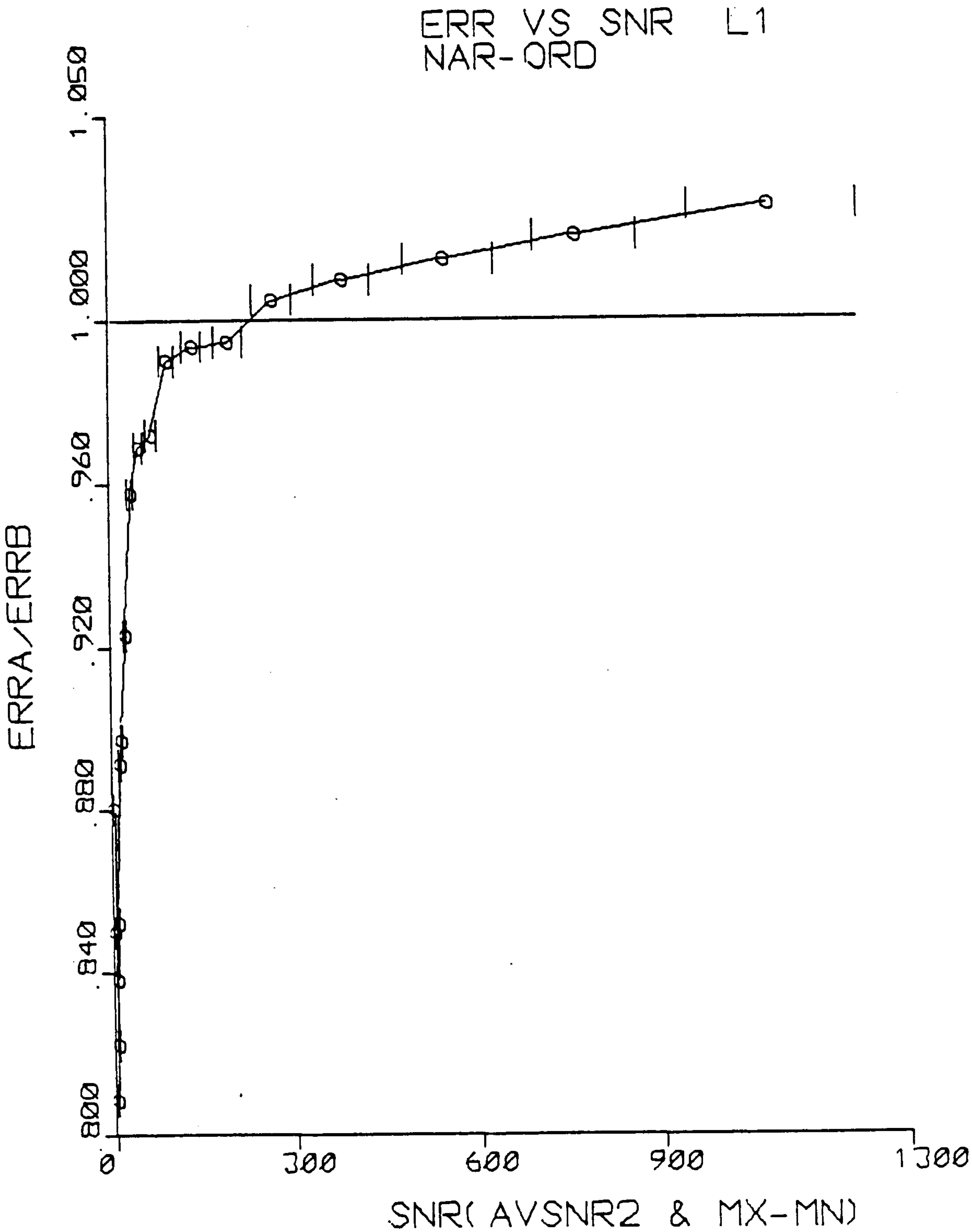
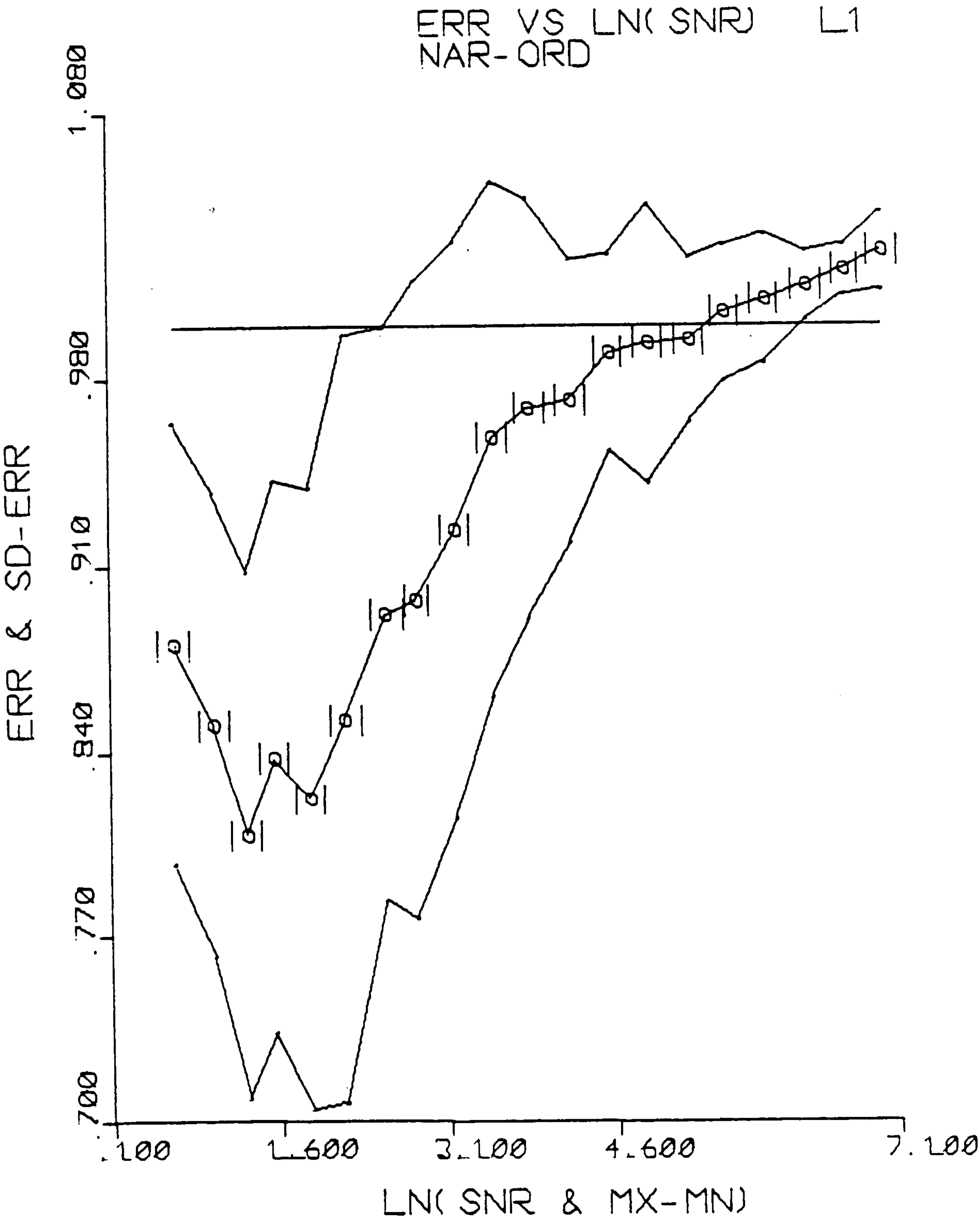

ERR VS SNR L1
NAR-ORD
1.050
1.000
.960
.920
.880
.840
.800
ERRA/ERRB
0
300
600
900
1300
SNR(AVSNR2 & MX-MN)

Figure (3.24)



ERR VS LN(SNR) L1
NAR-ORD
ERR & SD-ERR
1.080
.980
.910
.840
.770
.700
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (3.25)

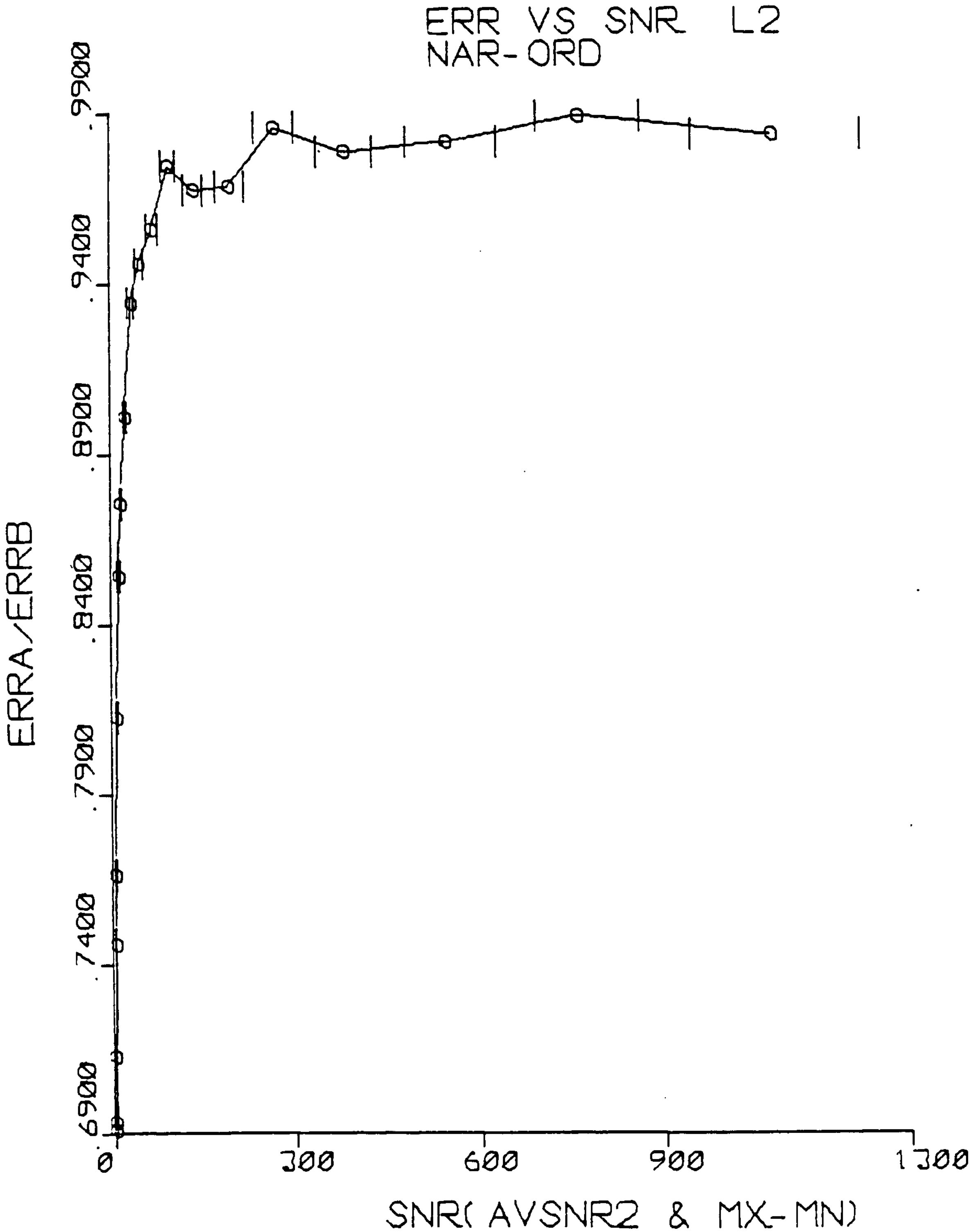

ERR VS SNR L2
NAR-ORD
ERRA/ERRB
.9900
.9400
.8900
.8400
.7900
.7400
.6900
0
300
600
900
1300
SNR(AVSNR2 & MX-MN)

Figure (3.26)

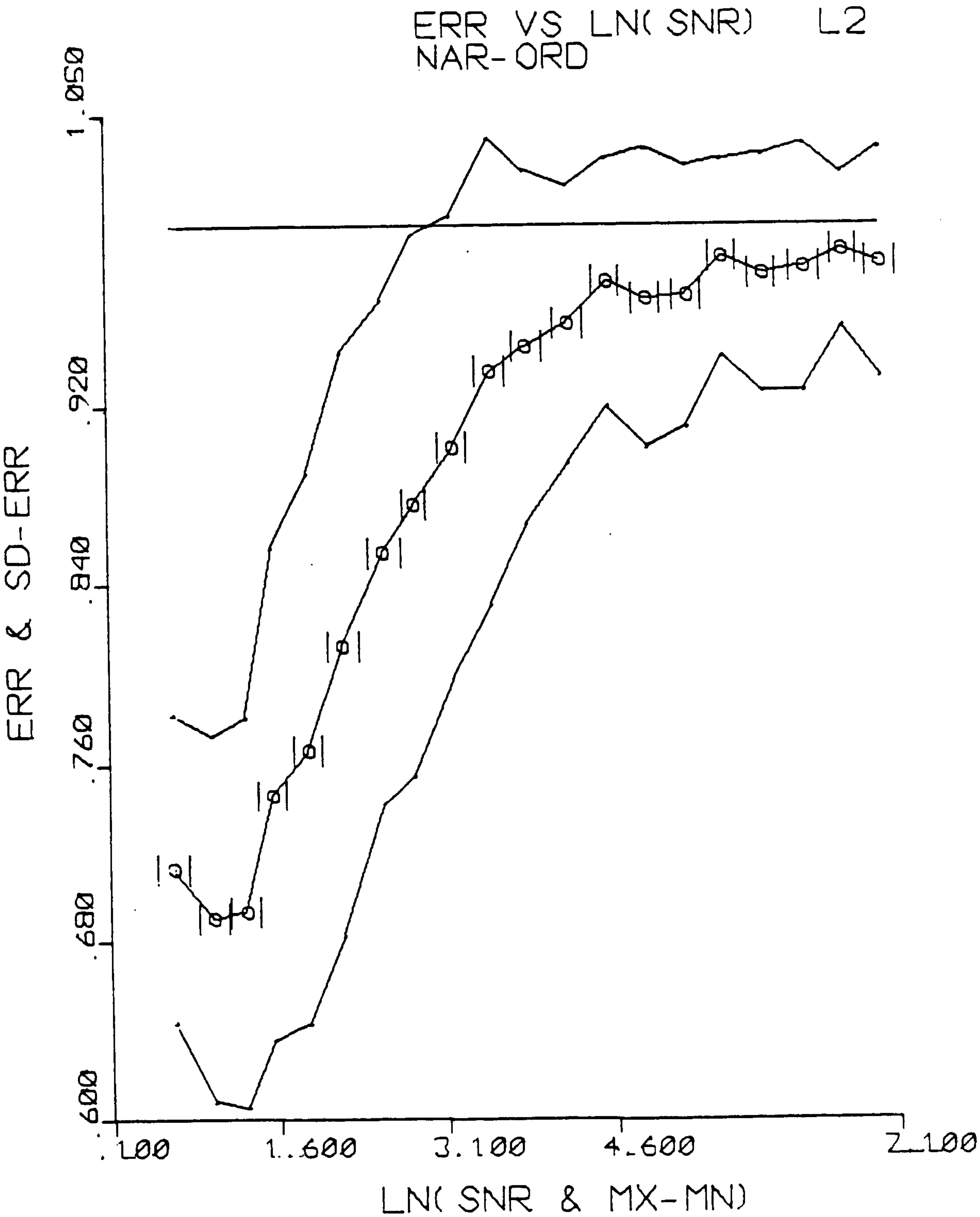

ERR VS LN(SNR) L2
NAR-ORD
ERR & SD-ERR
1.050
.920
.840
.760
.680
.600
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (3.27)

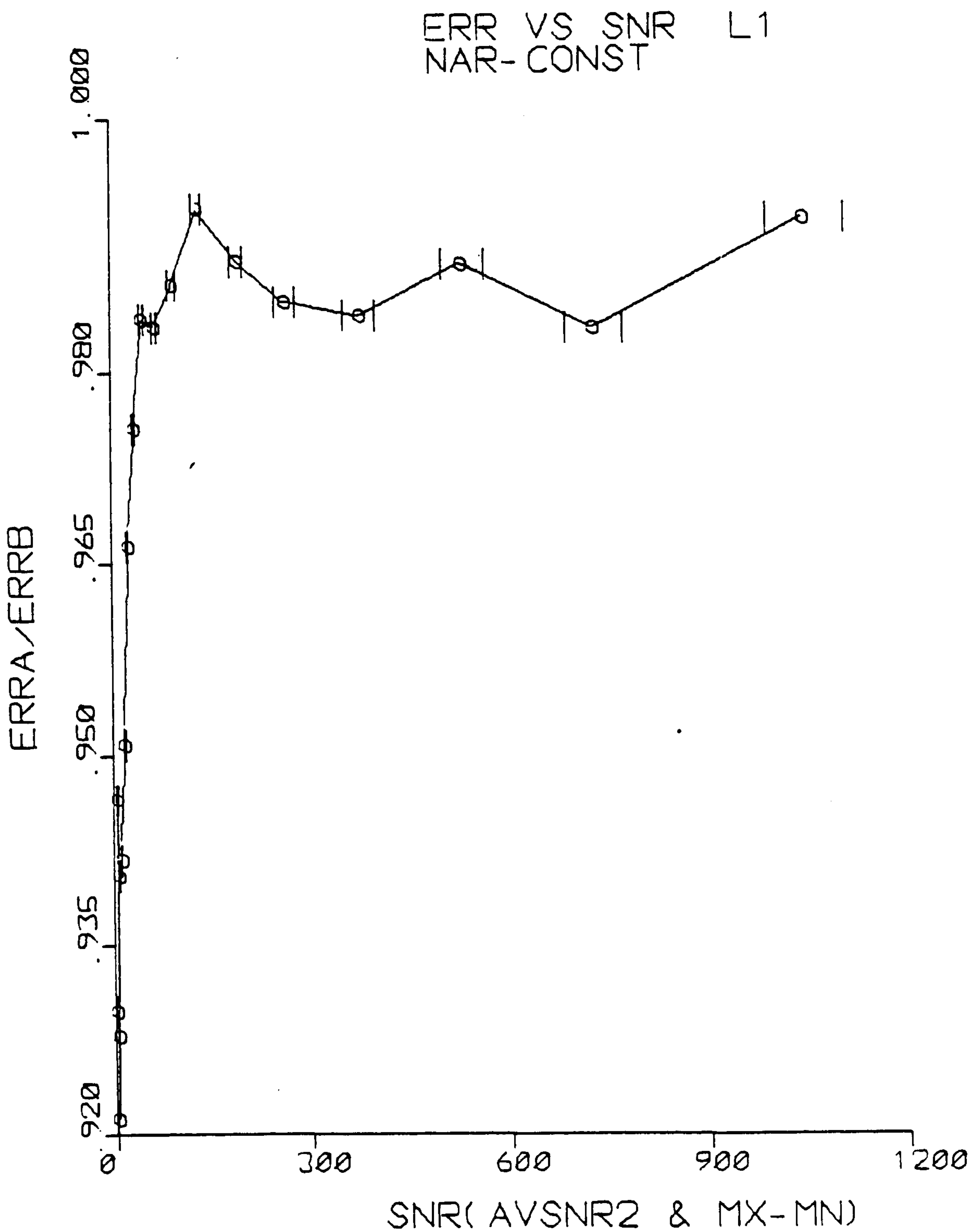

ERR VS SNR L1
NAR-CONST
ERRA/ERRB
1.000
.980
.965
.950
.935
.920
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.28)

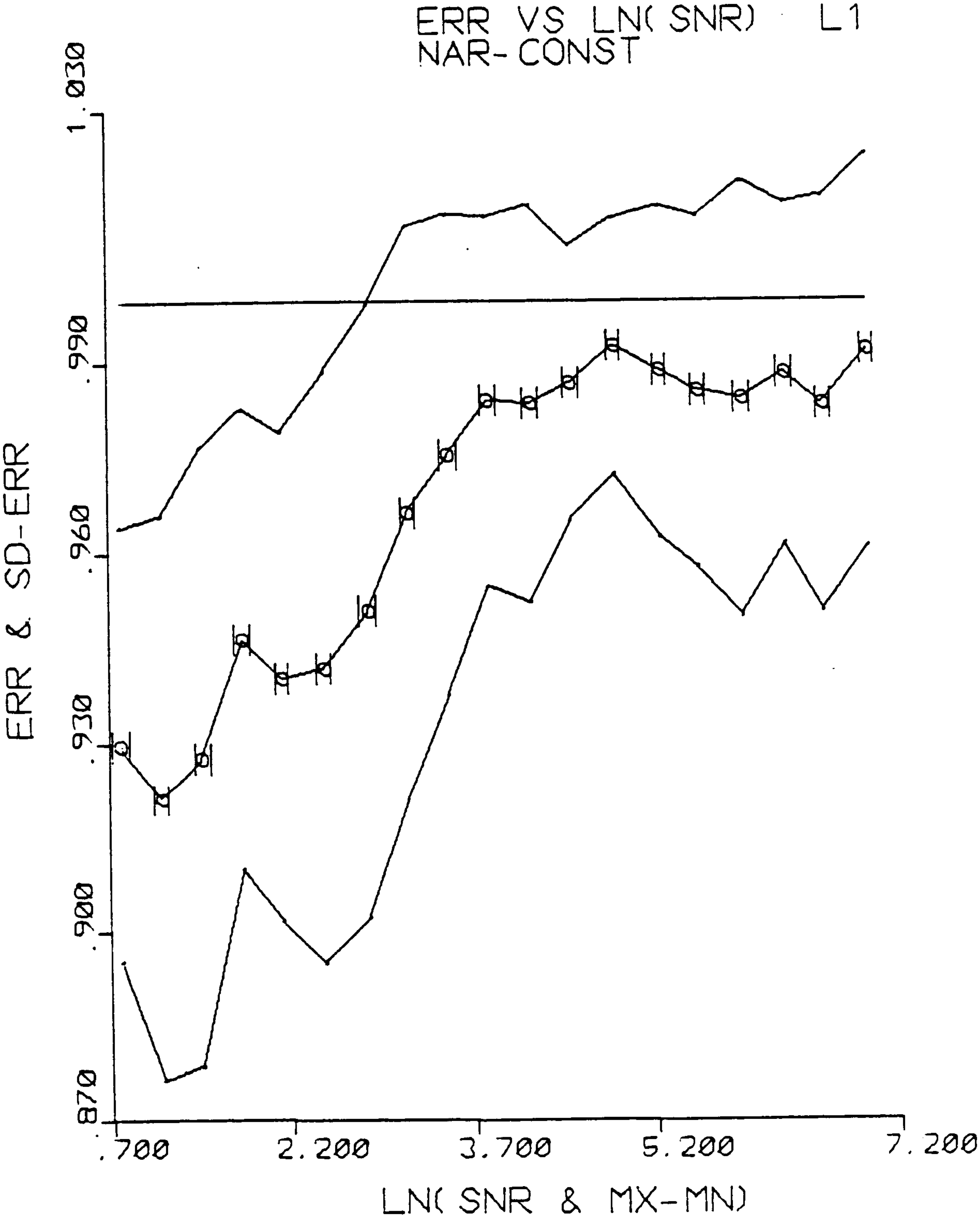

ERR VS LN(SNR) L1
NAR- CONST
ERR & SD-ERR
1.030
.990
.960
.930
.900
.870
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (3.29)

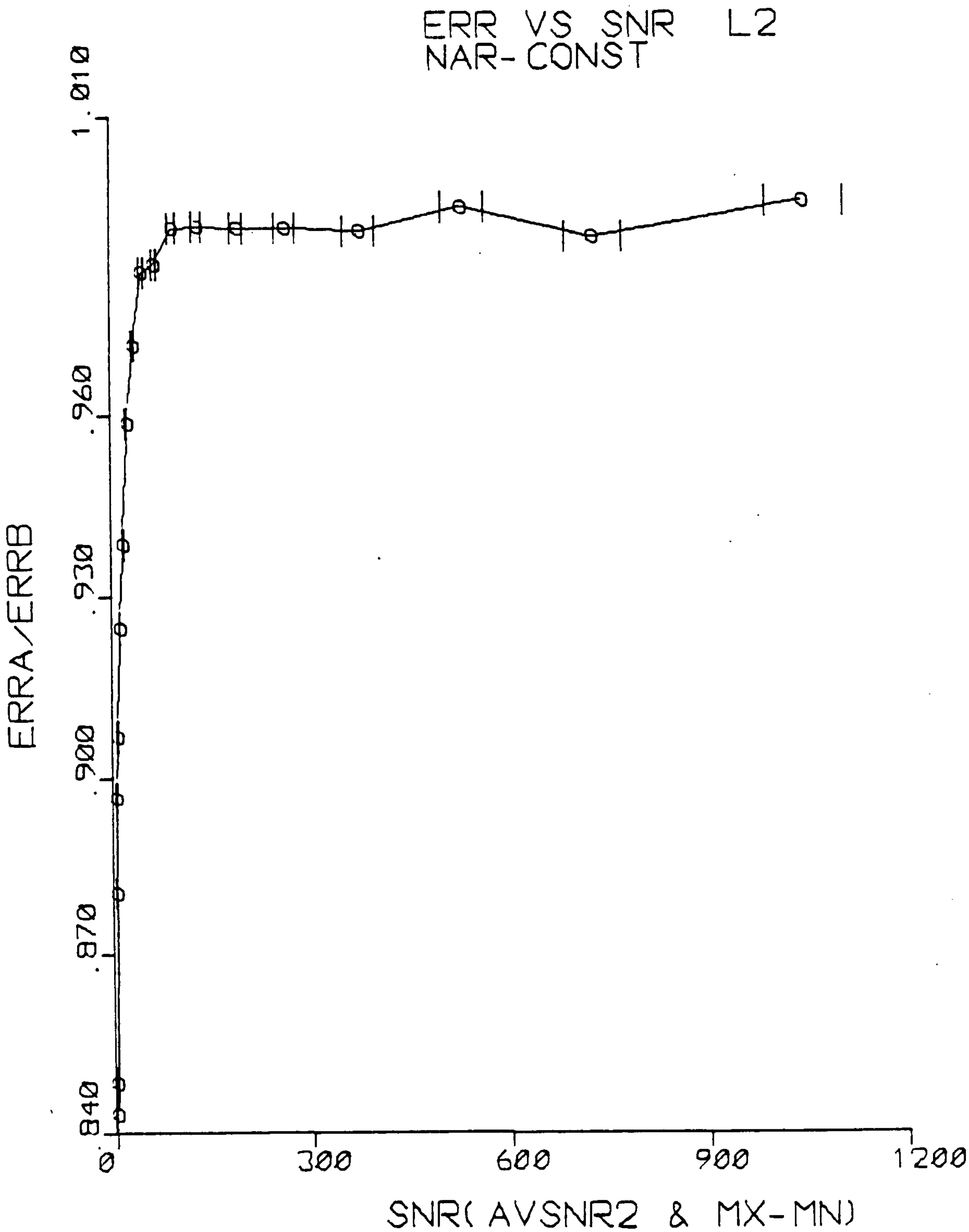

ERR VS SNR L2
NAR-CONST
ERRA/ERRB
1.010
.960
.930
.900
.870
.840
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.30)

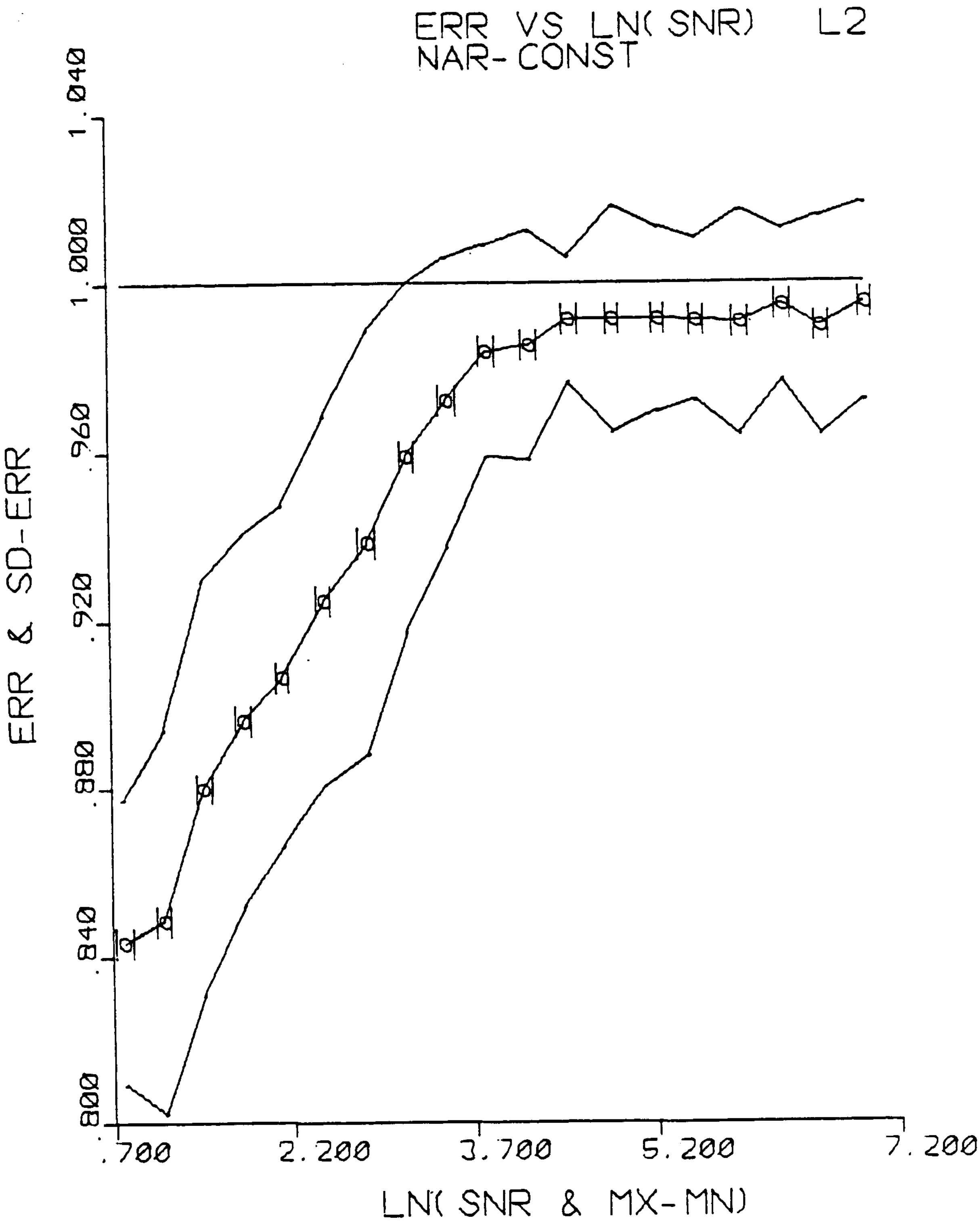

ERR VS LN(SNR) L2
NAR-CONST
ERR & SD-ERR
1.040
1.000
.960
.920
.880
.840
.800
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (3.31)

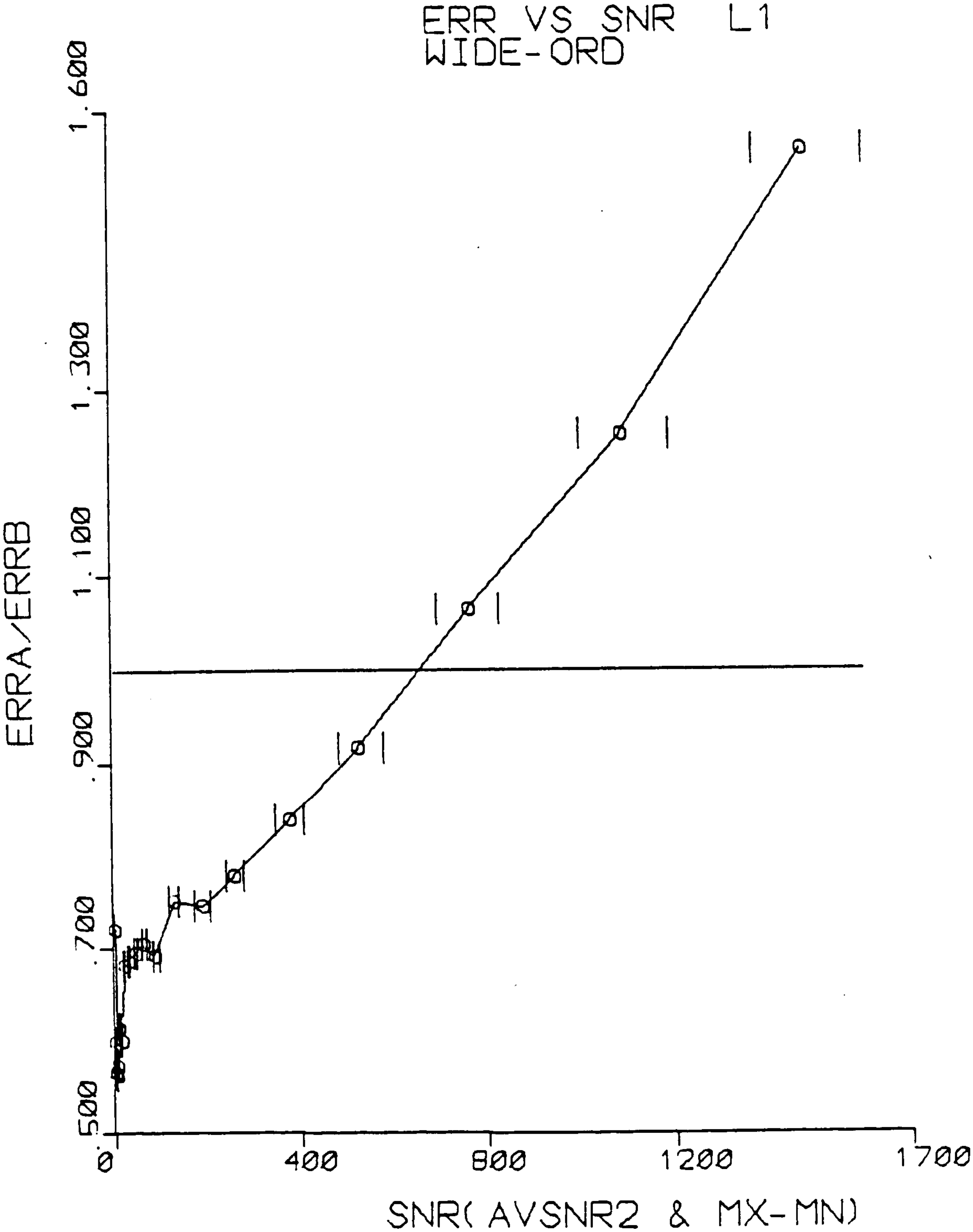

ERR VS SNR L1
WIDE-ORD
ERRA/ERRB
1.600
1.300
1.100
.900
.700
.500
0
400
800
1200
1700
SNR(AVSNR2 & MX-MN)

Figure (3.32)

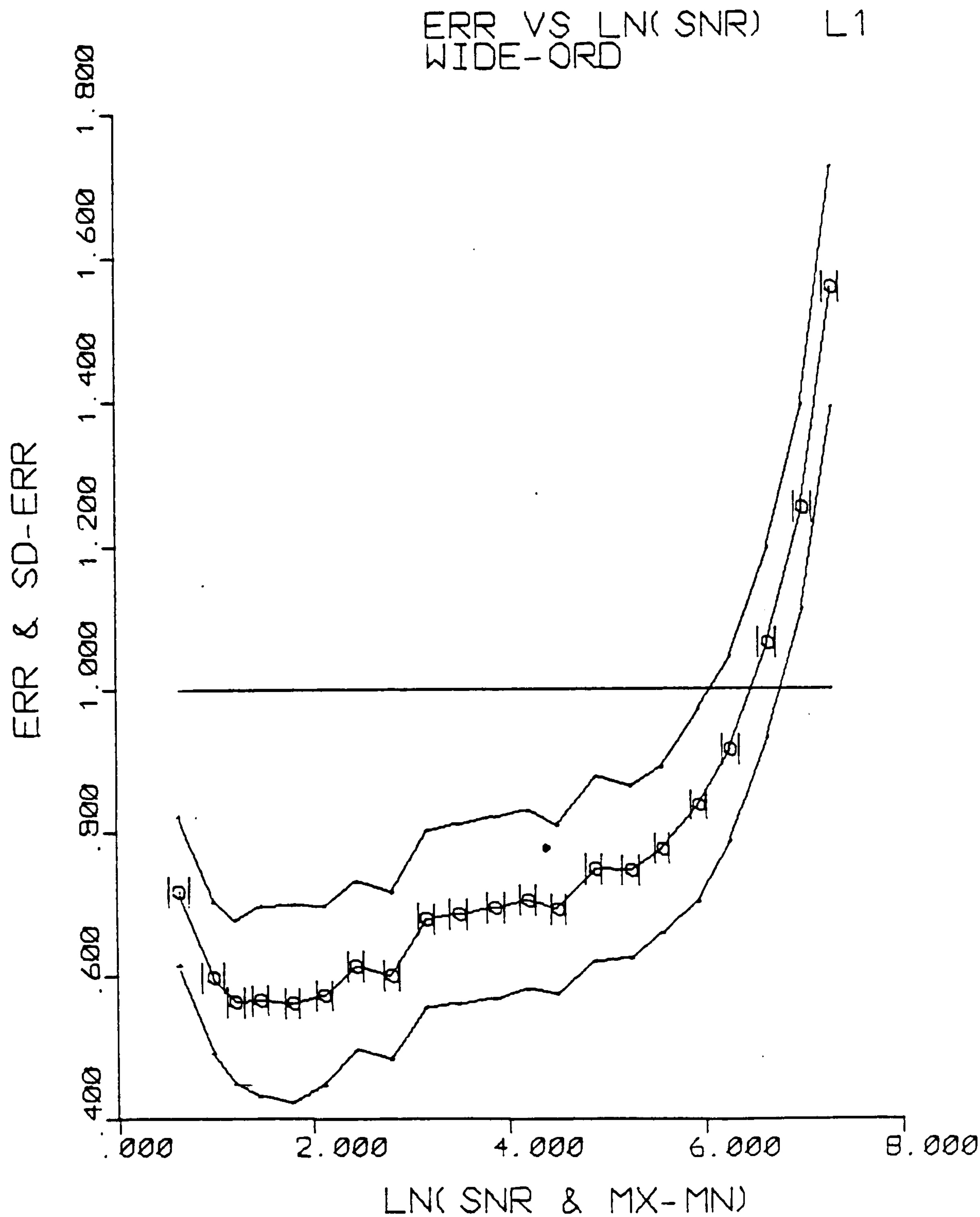

ERR VS LN(SNR) L1
WIDE-ORD
ERR & SD-ERR
1.800
1.600
1.400
1.200
1.000
.800
.600
.400
.000
2.000
4.000
6.000
8.000
LN(SNR & MX-MN)

Figure (3.33)

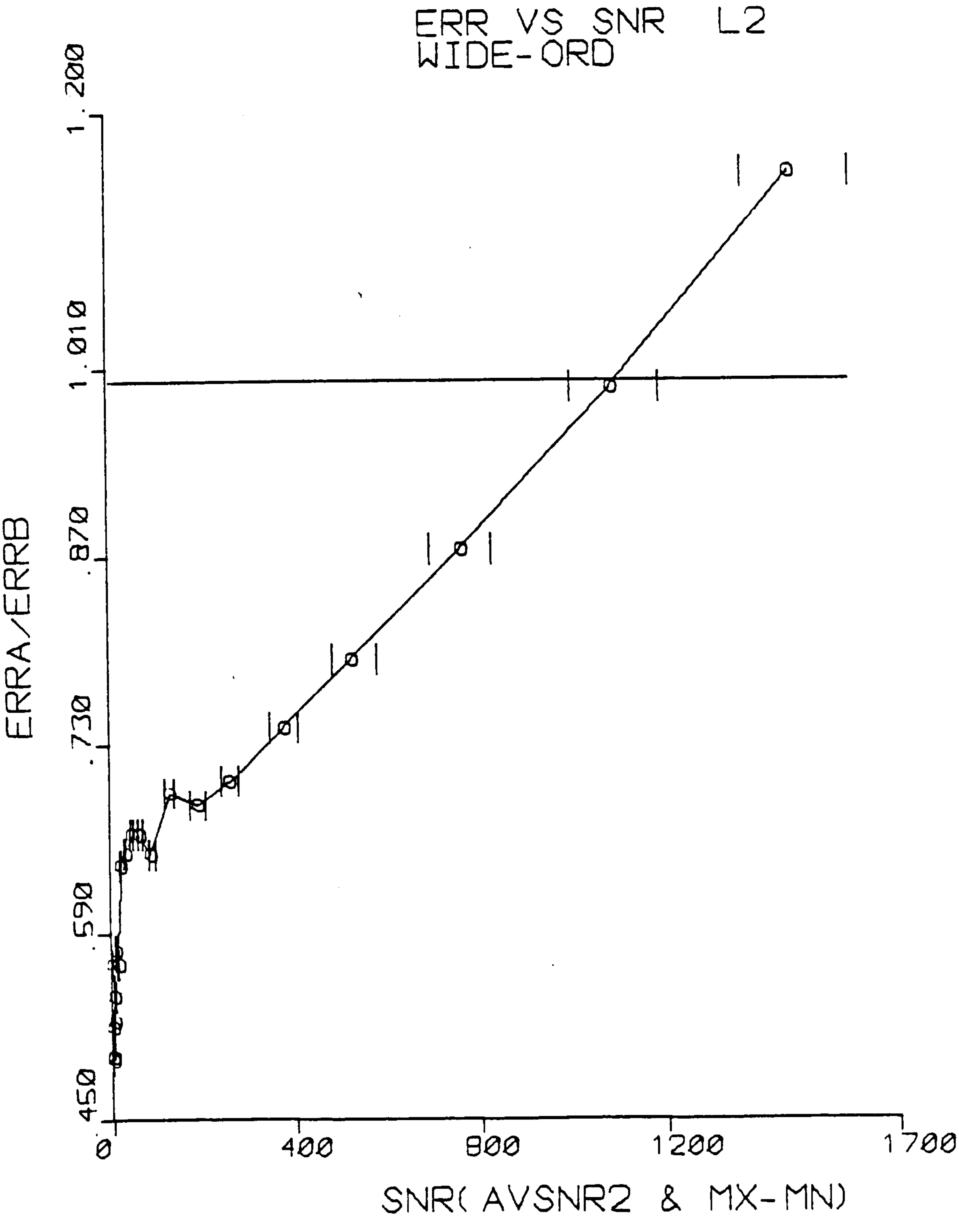

ERR VS SNR L2
WIDE-ORD
ERRA/ERRB
1.200
1.010
.870
.730
.590
.450
0
400
800
1200
1700
SNR(AVSNR2 & MX-MN)

Figure (3.34)

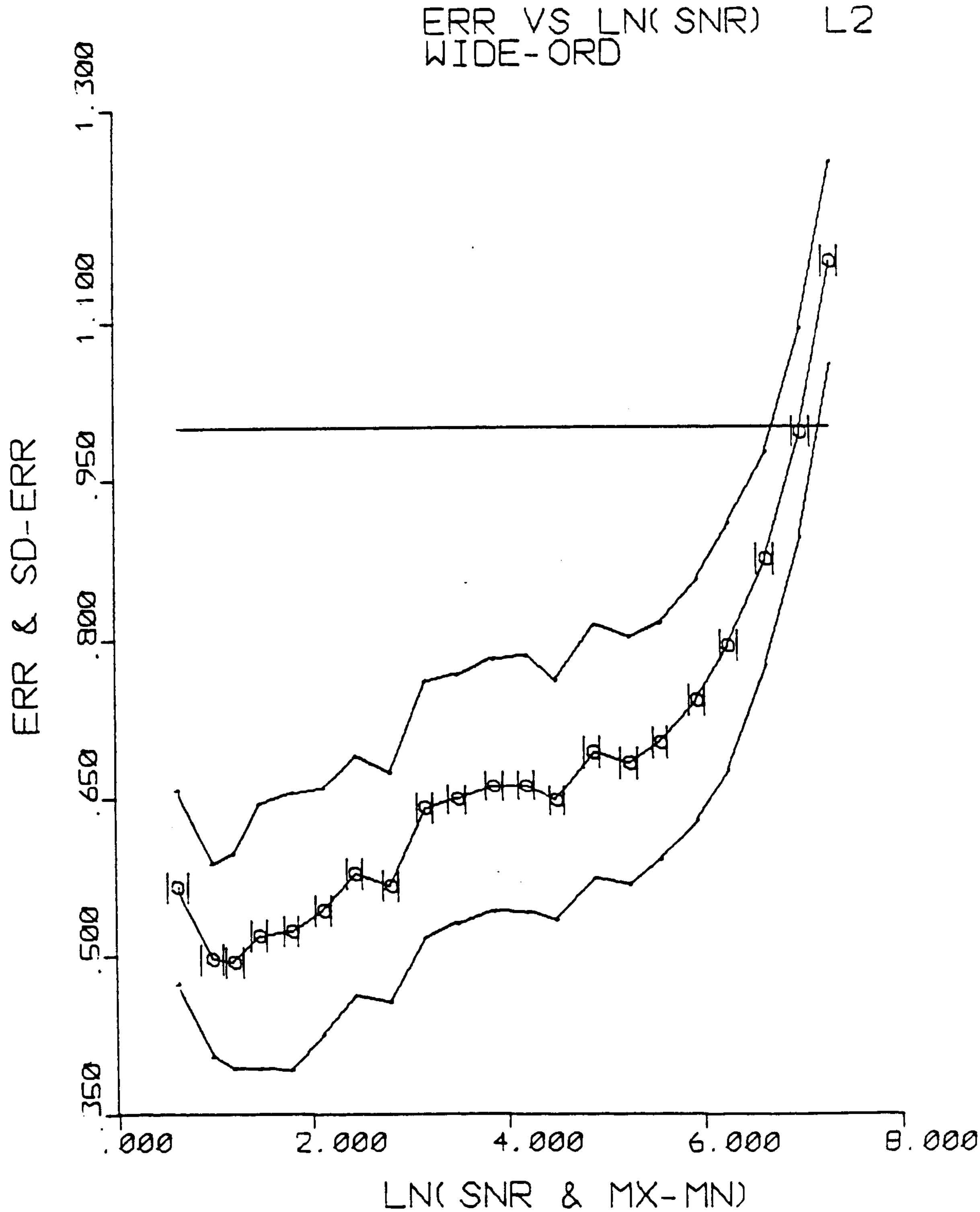
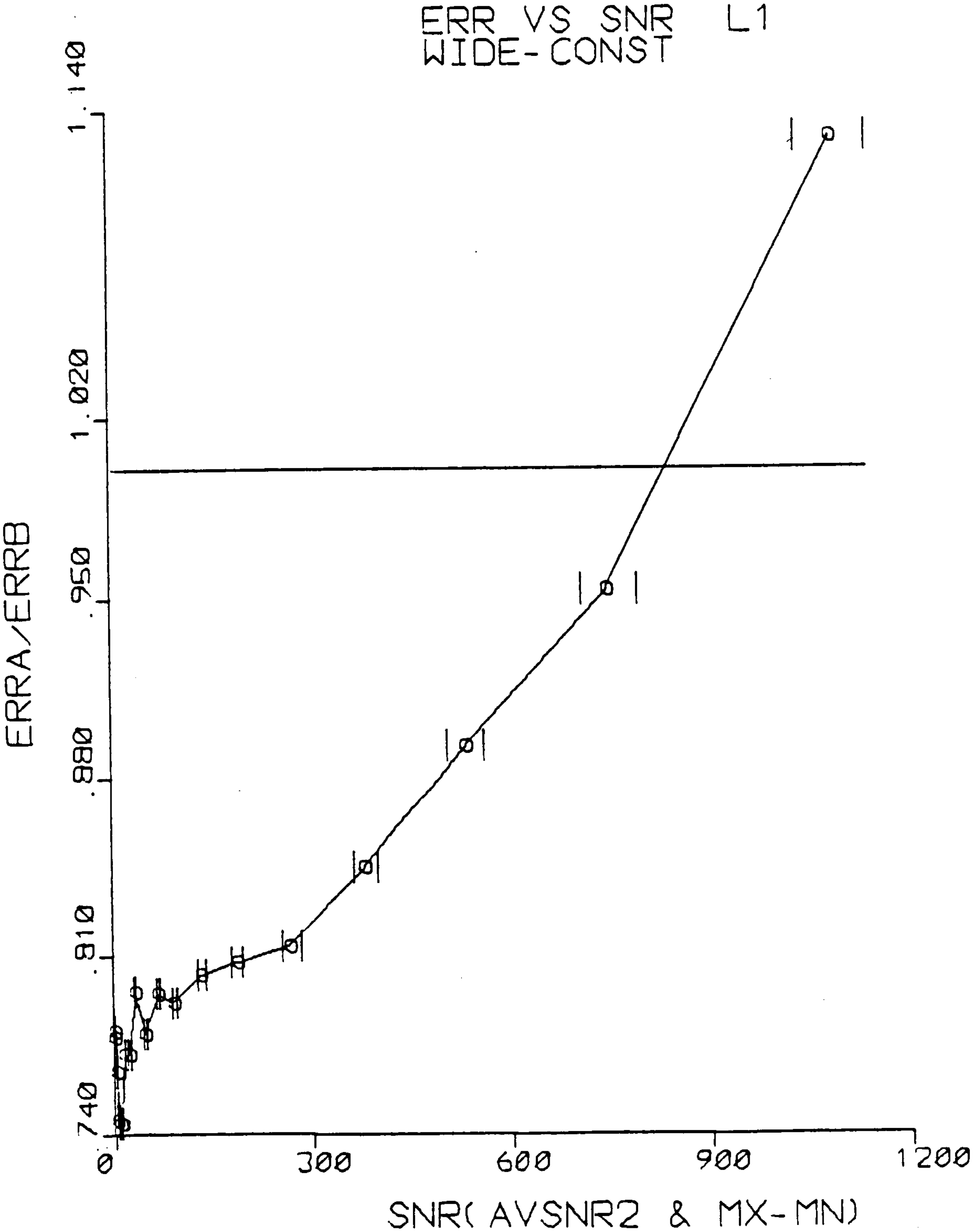

ERR VS LN(SNR) L2
WIDE-ORD
ERR & SD-ERR
1.300
1.100
.950
.800
.650
.500
.350
.000
2.000
4.000
6.000
8.000
LN(SNR & MX-MN)

Figure (3.35)



c-3

Figure (3.36)

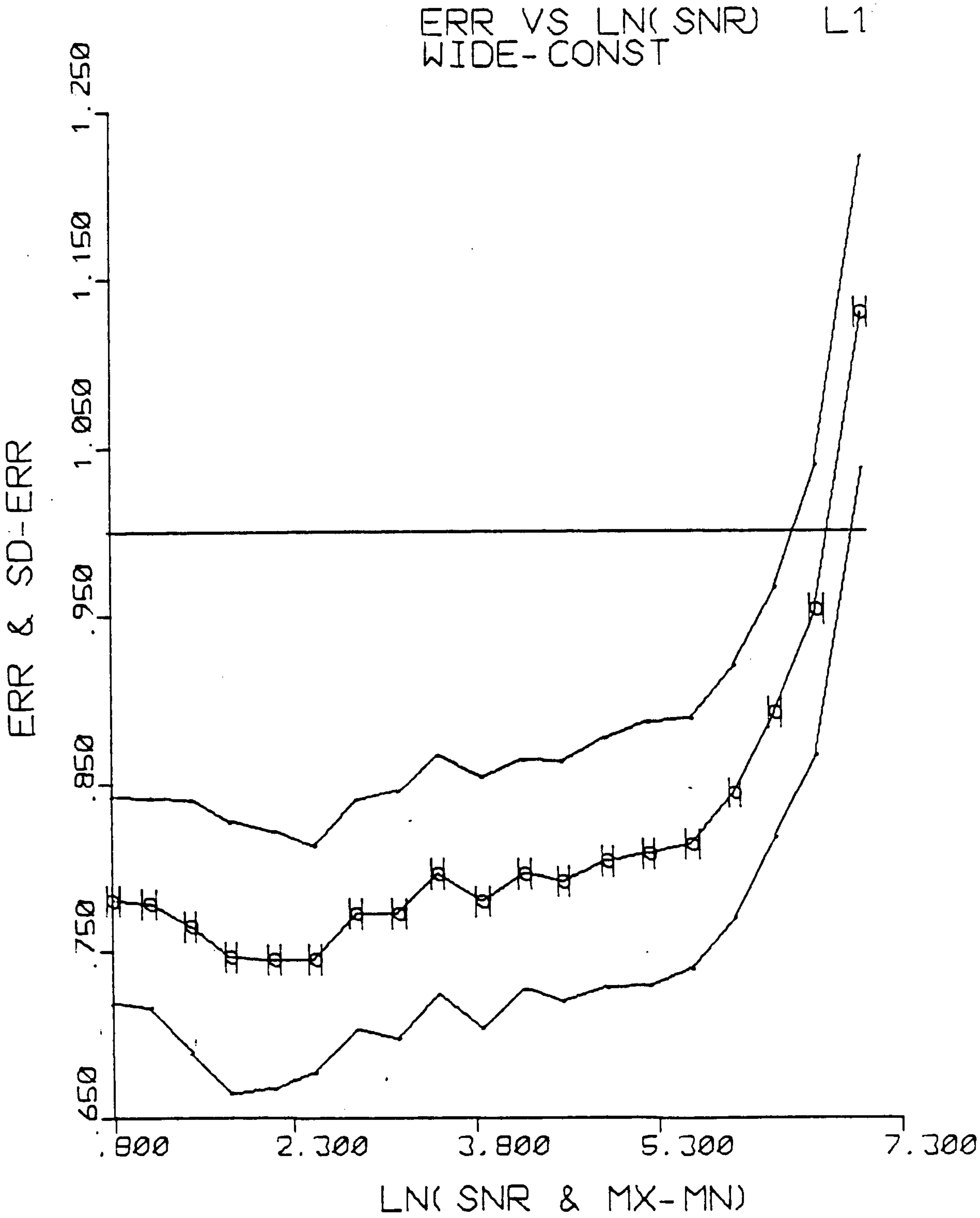

ERR VS LN(SNR) L1
WIDE-CONST
ERR & SD-ERR
1.250
1.150
1.050
.950
.850
.750
.650
.800
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (3.37)

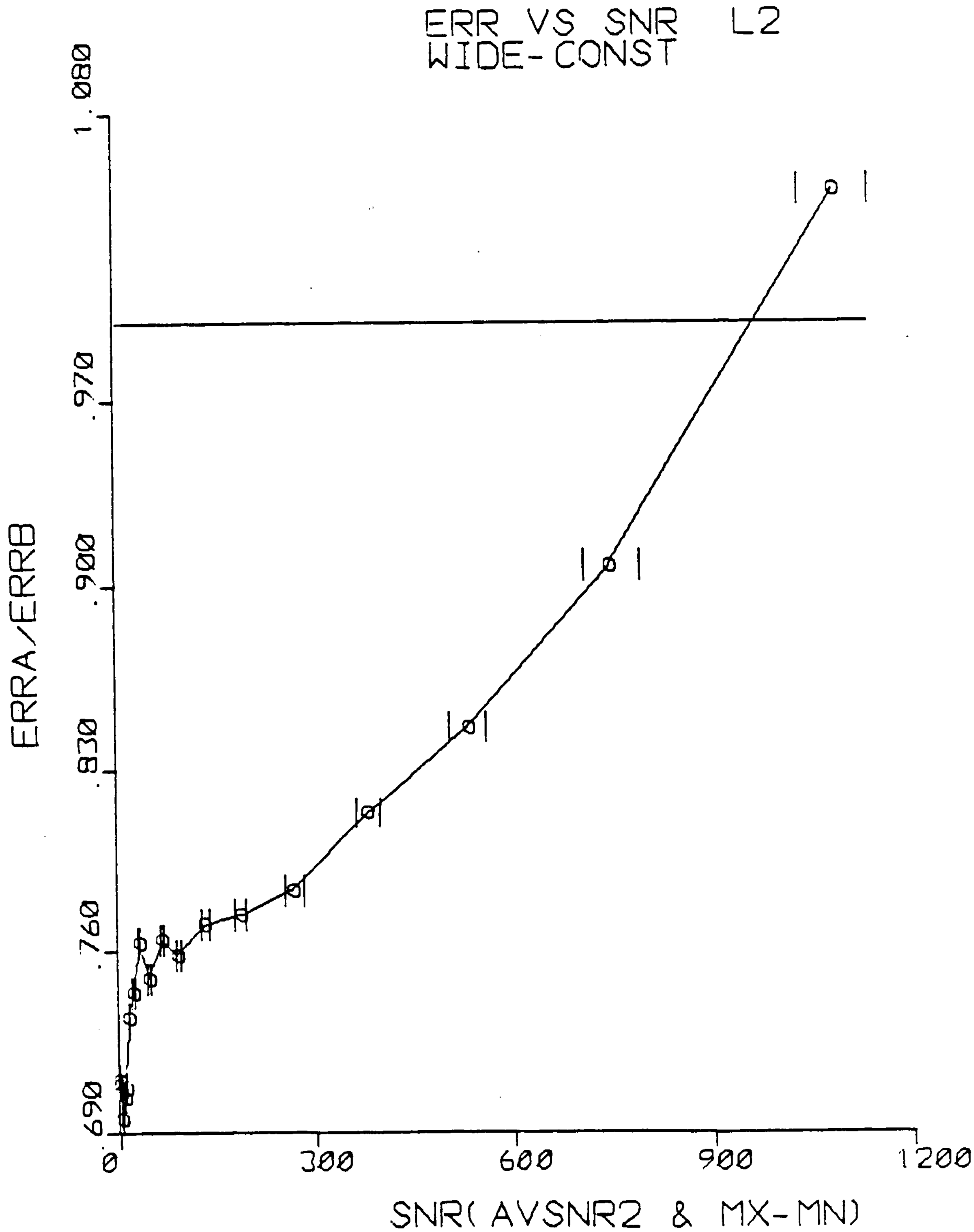

ERR VS SNR L2
WIDE-CONST
ERRA/ERRB
1.080
.970
.900
.830
.760
.690
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (3.38)

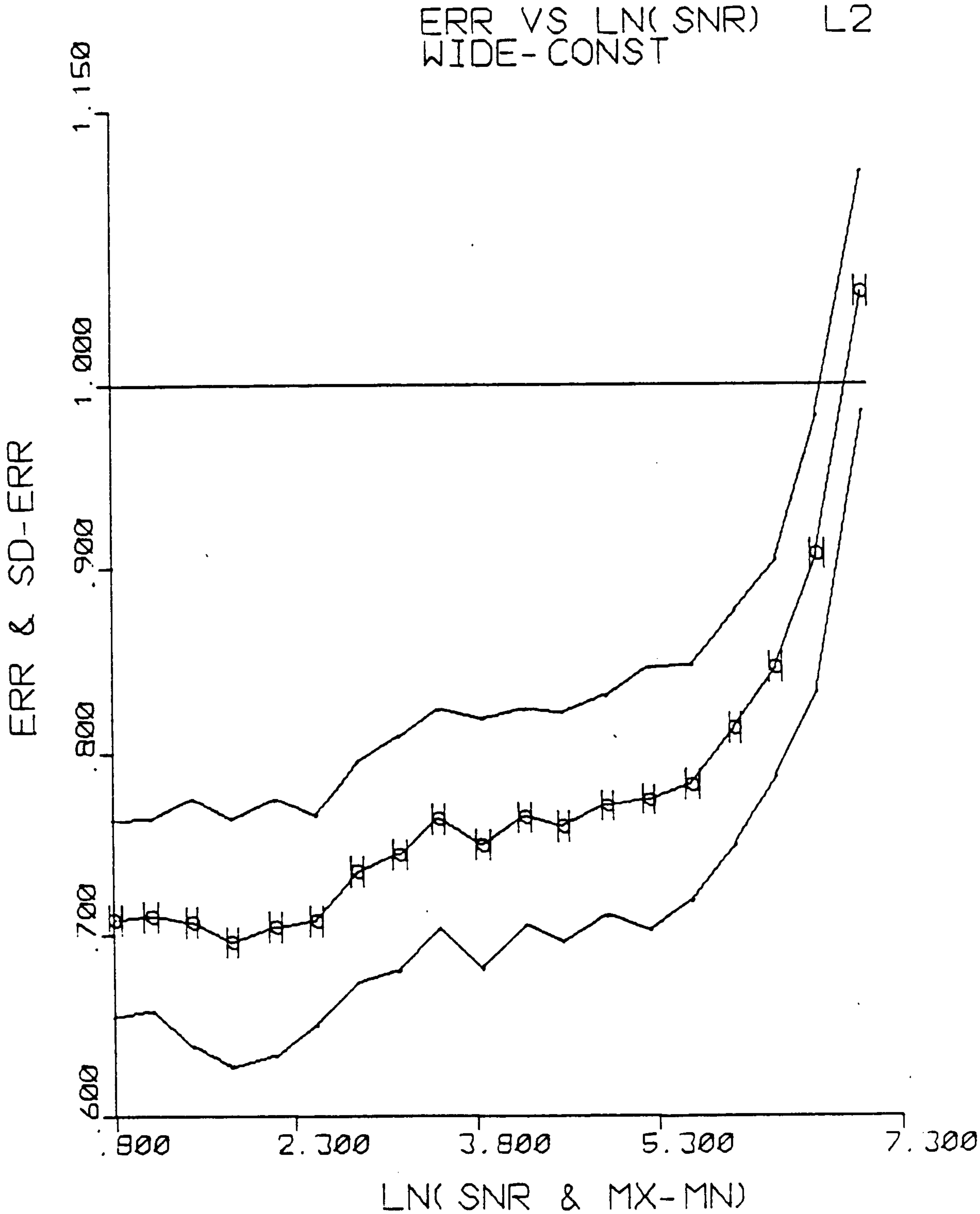

ERR VS LN(SNR) L2
WIDE-CONST
ERR & SD-ERR
.600
.700
.800
.900
1.000
1.150
.800
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (3.39)

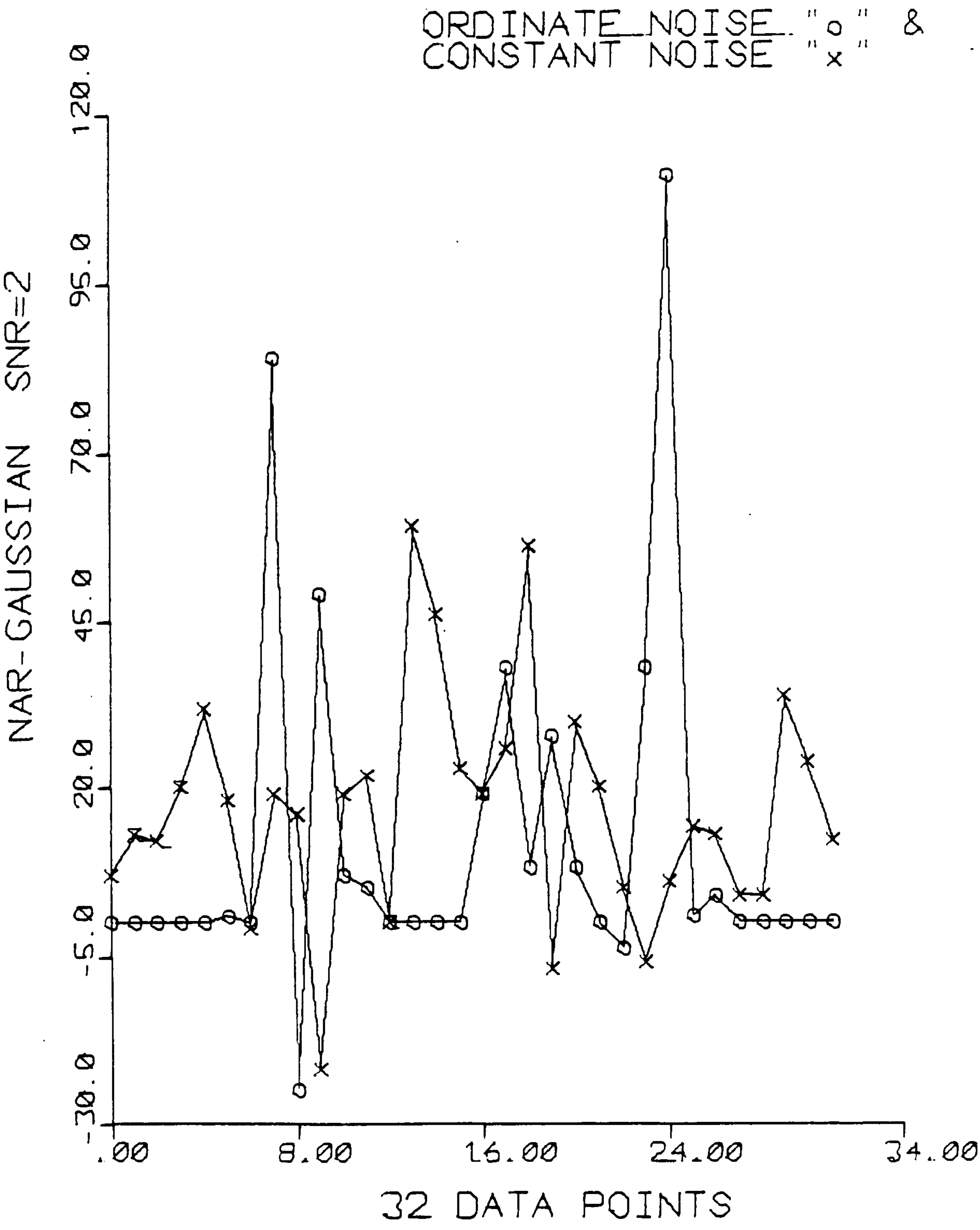

ORDINATE NOISE "o" &
CONSTANT NOISE "x"
NAR-GAUSSIAN SNR=2
120.0
95.0
70.0
45.0
20.0
-5.0
-30.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.40)

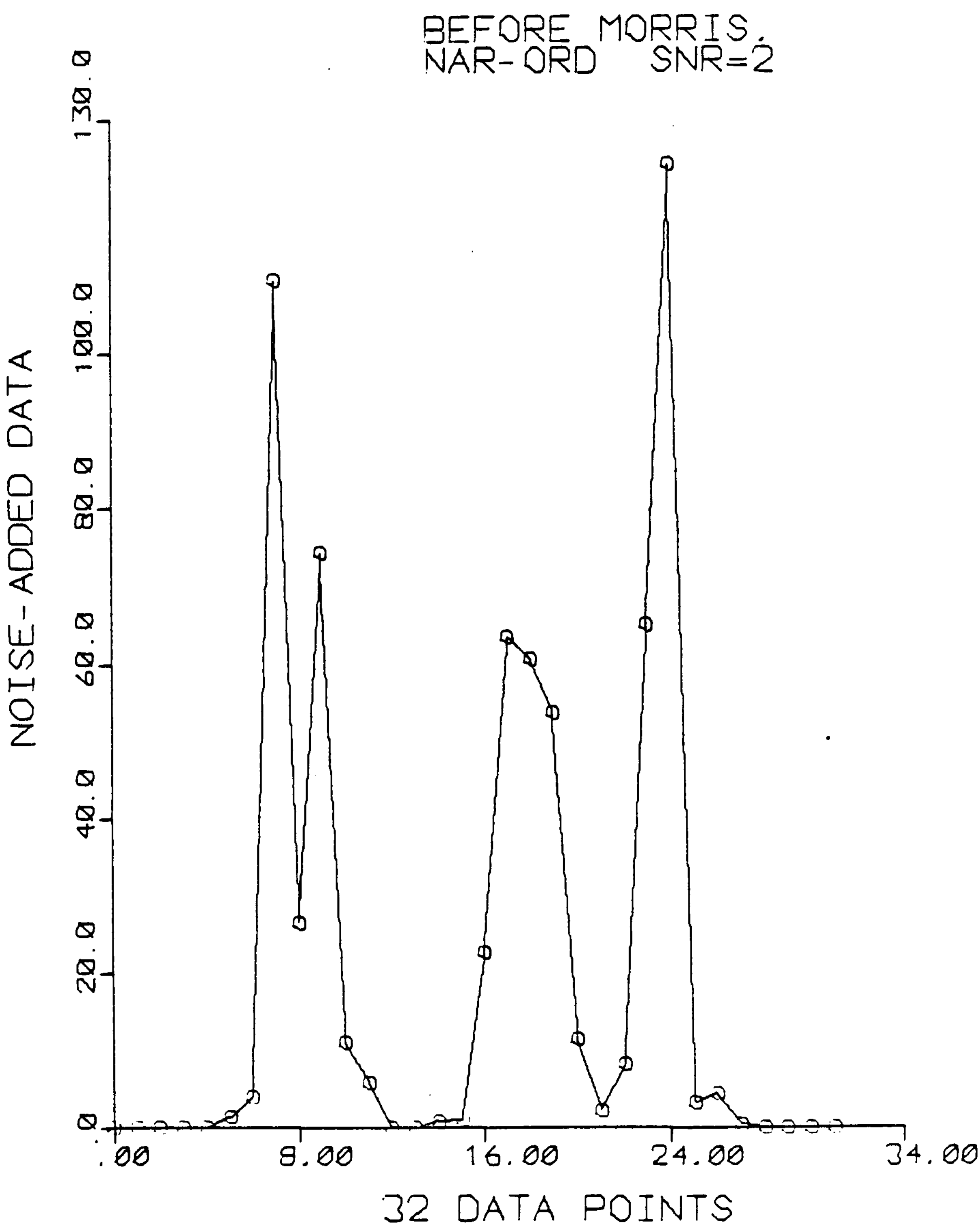

BEFORE MORRIS,
NAR-ORD SNR=2
NOISE-ADDED DATA
130.0
100.0
80.0
60.0
40.0
20.0
0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure 3.41)

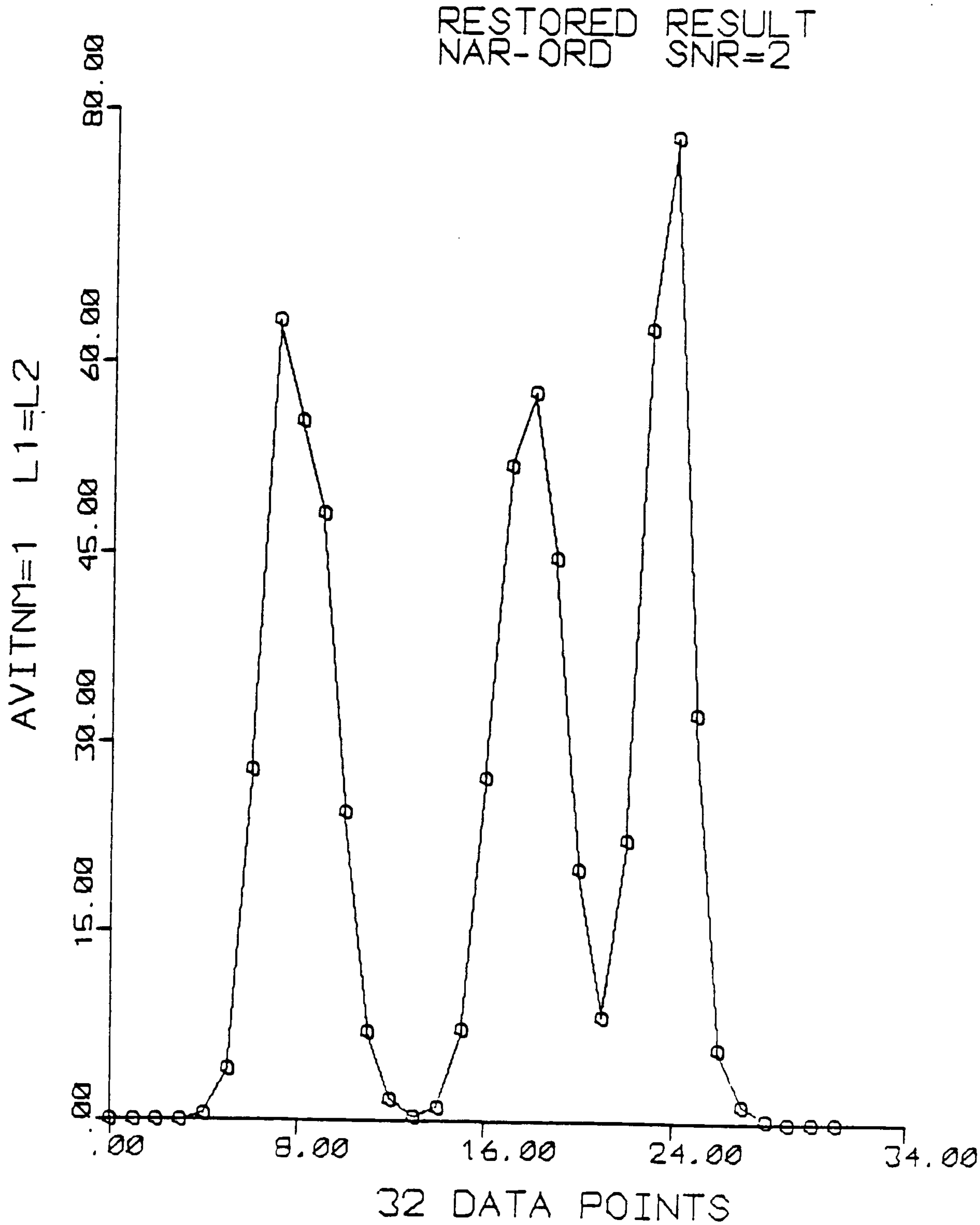

RESTORED RESULT
NAR-ORD SNR=2
AVITNM=1 L1=L2
80.00
60.00
45.00
30.00
15.00
.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.42)

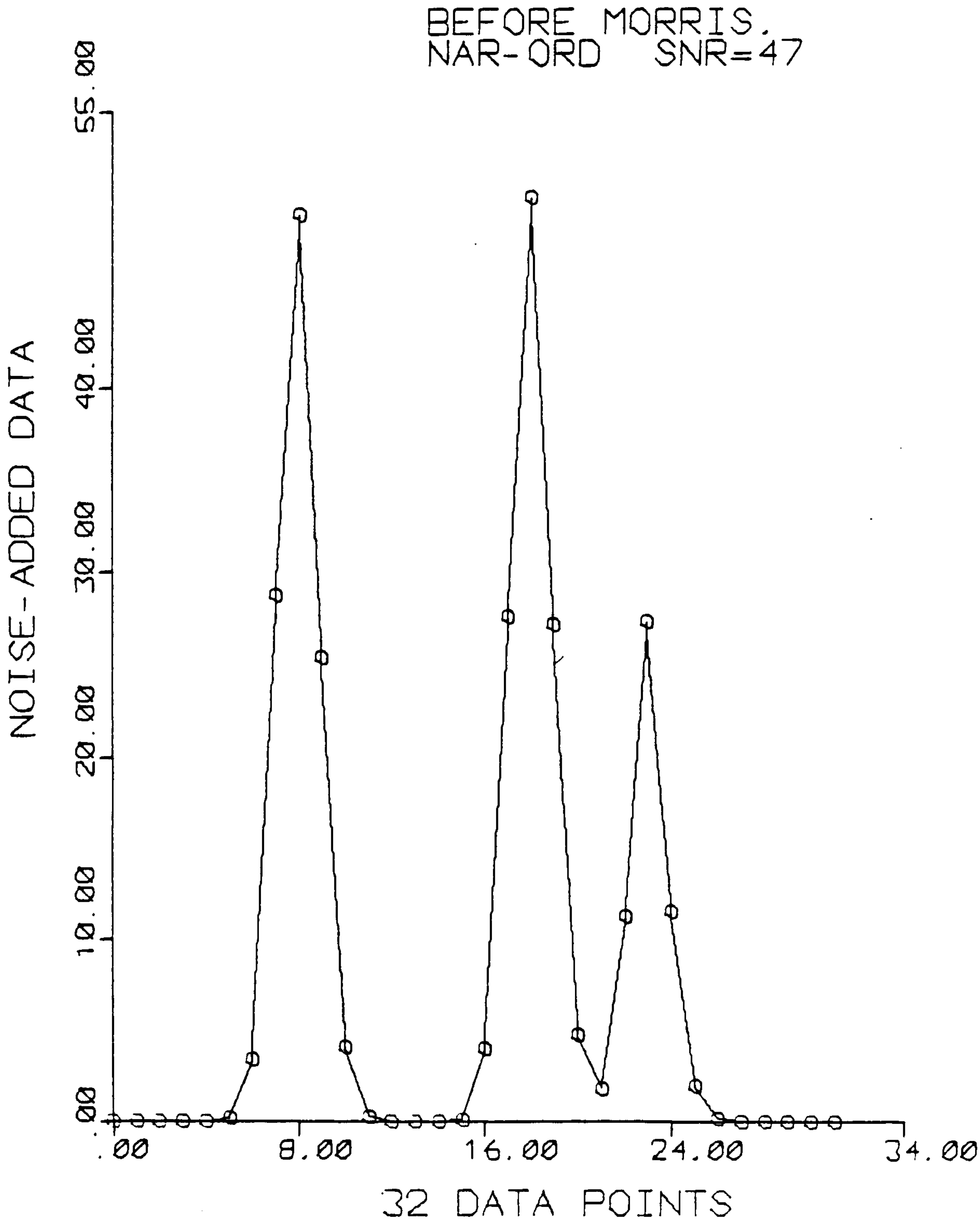

BEFORE MORRIS.
NAR-ORD SNR=47
NOISE-ADDED DATA
55.00
40.00
30.00
20.00
10.00
.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.43)

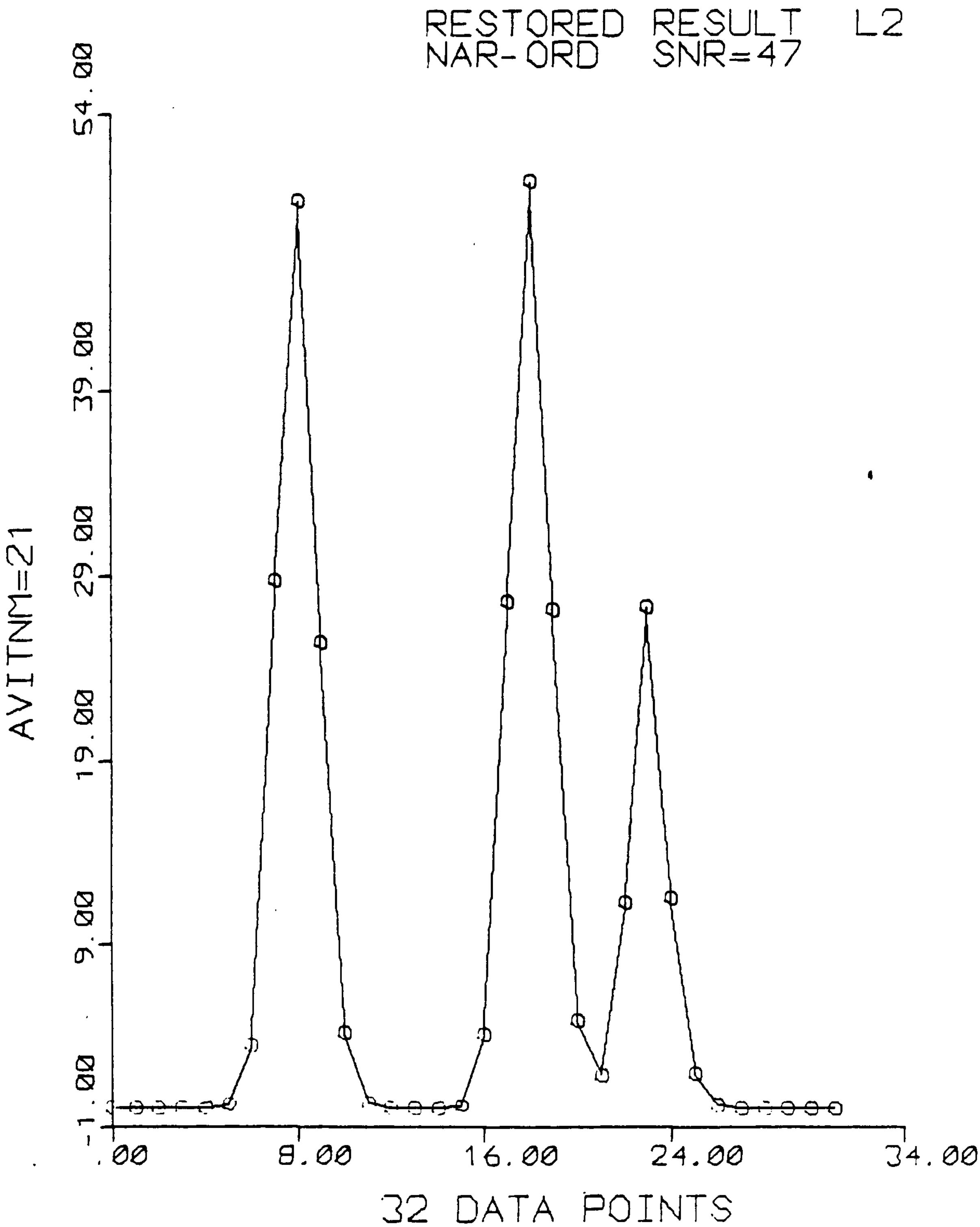

RESTORED RESULT L2
NAR-ORD SNR=47
AVITNM=21
54.00
39.00
29.00
19.00
9.00
-1.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.44)

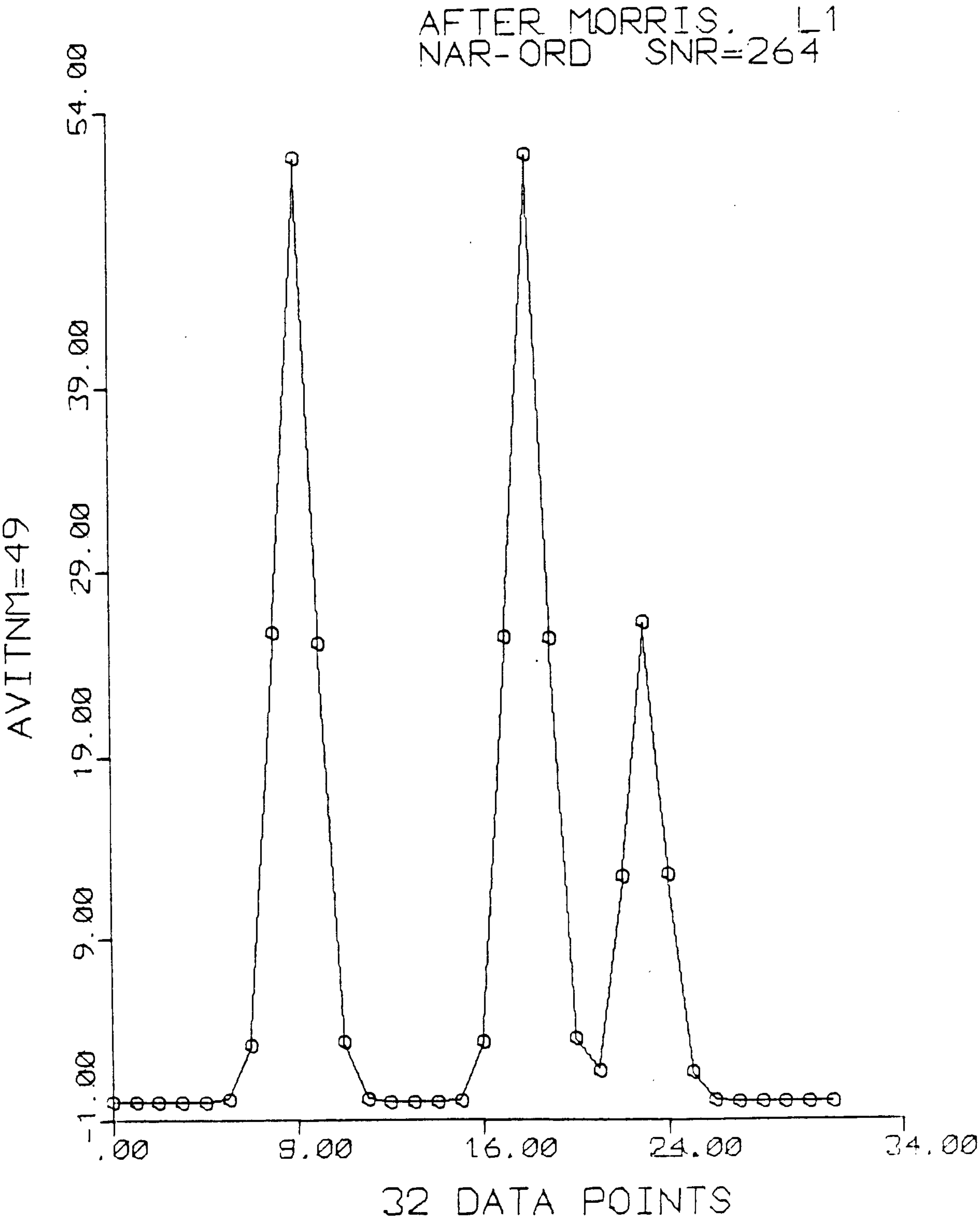

AFTER MORRIS, L1
NAR-ORD SNR=264
AVITNM=49
54.00
39.00
29.00
19.00
9.00
-1.00
.00
9.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.45)

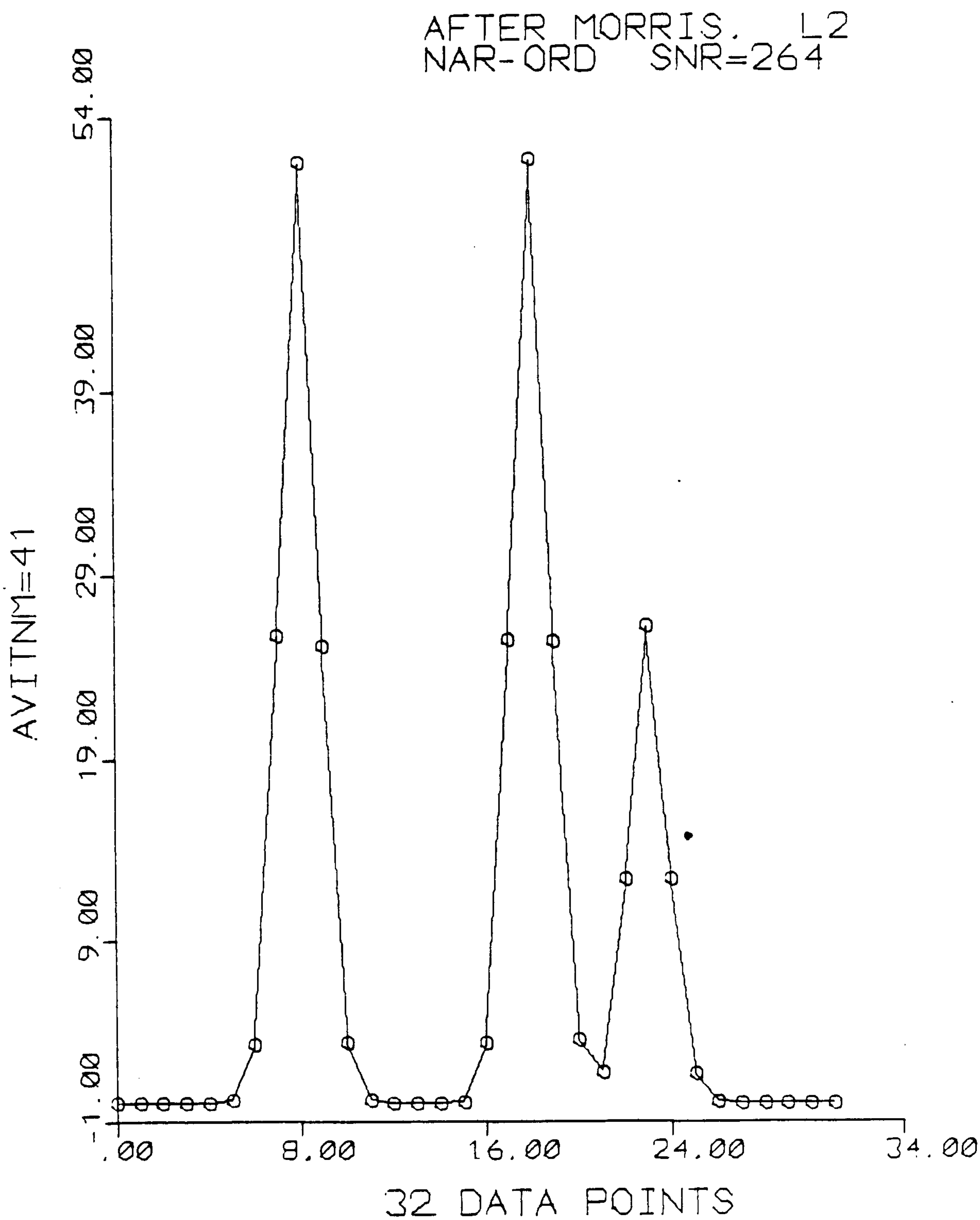

AFTER MORRIS. L2
NAR-ORD SNR=264
AVITNM=41
54.00
39.00
29.00
19.00
9.00
-1.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.46)

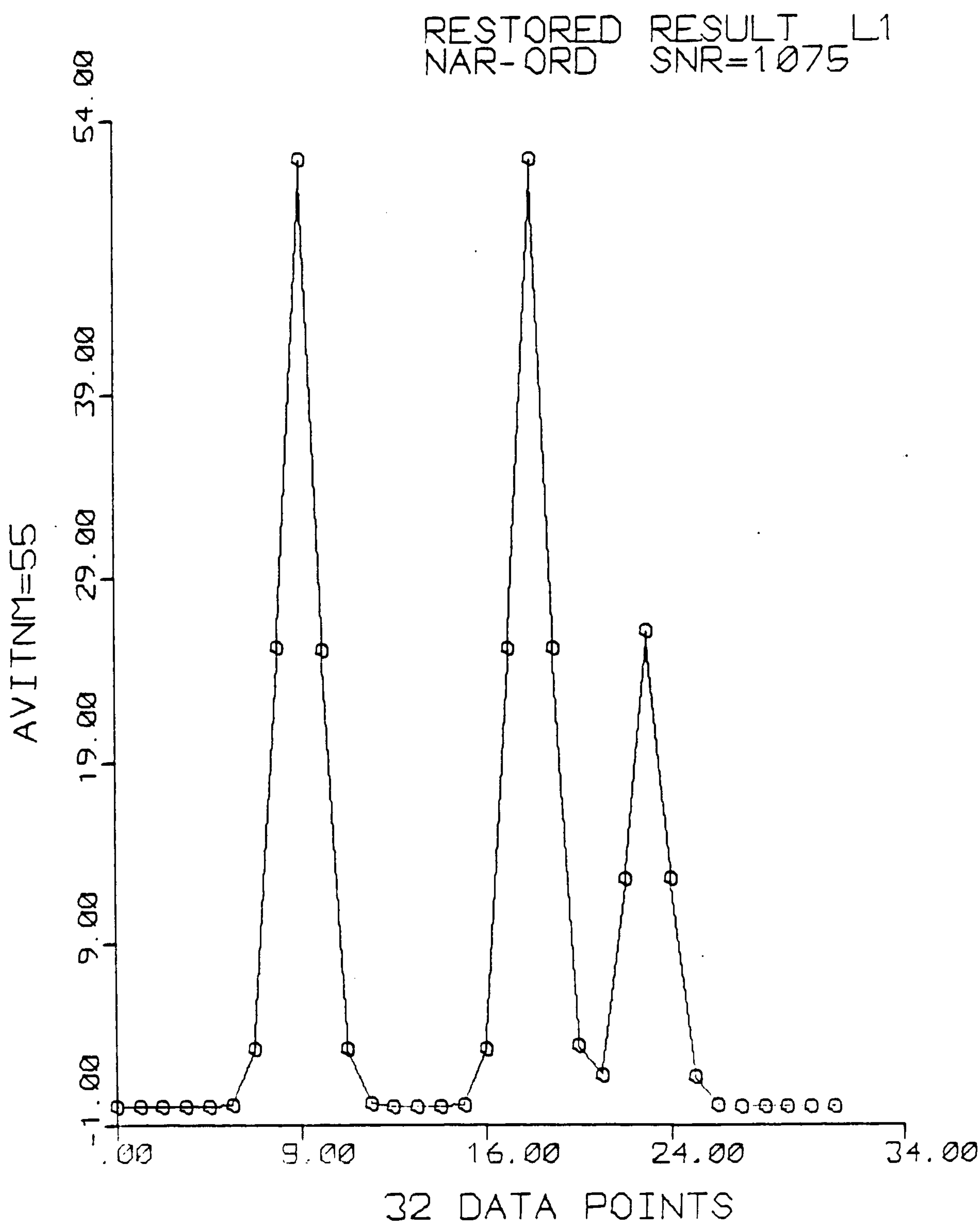

RESTORED RESULT L1
NAR-ORD SNR=1075
54.00
39.00
29.00
19.00
9.00
-1.00
AVITNM=55
.00
9.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.47)

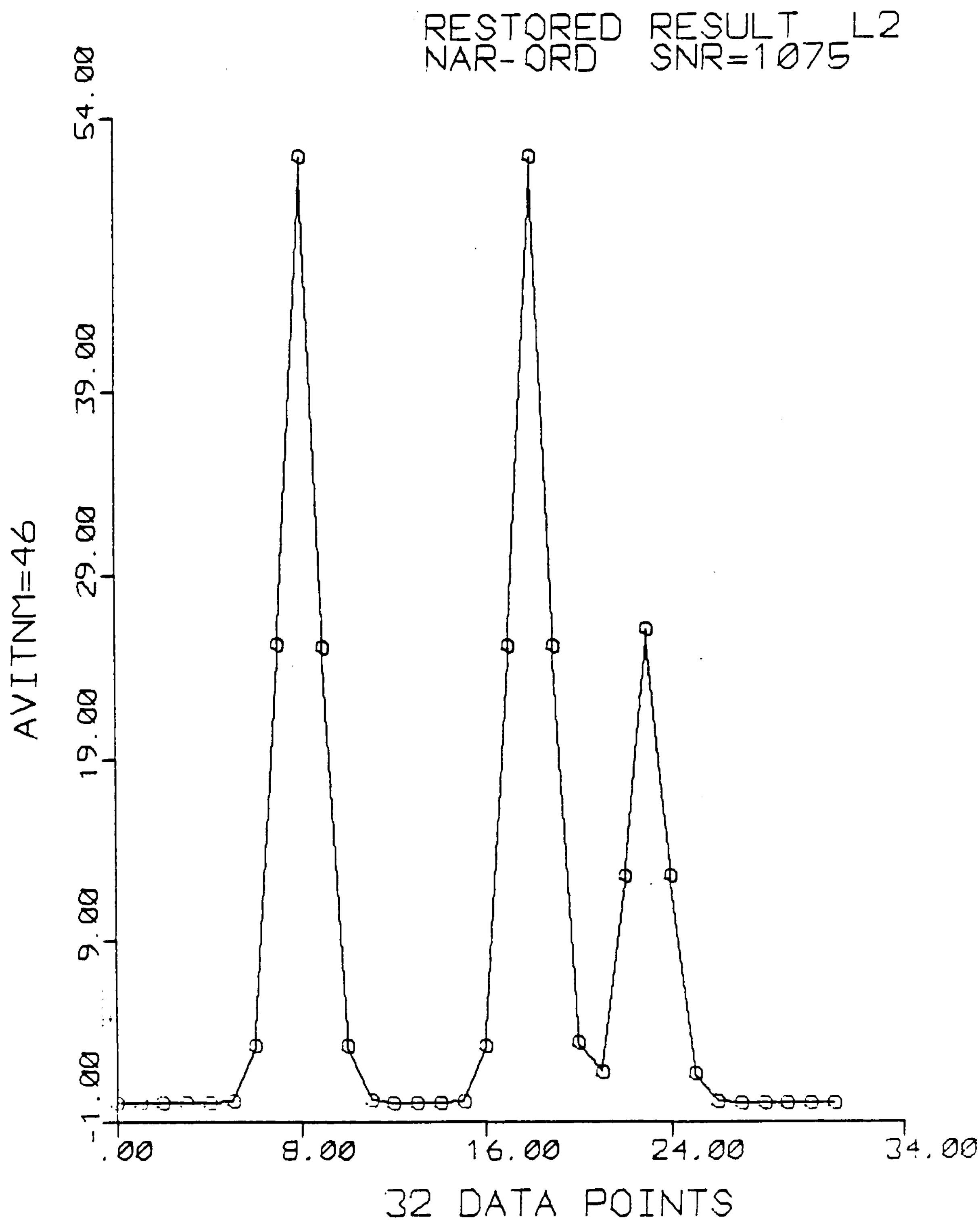

RESTORED RESULT L2
NAR-ORD SNR=1075
54.00
39.00
29.00
19.00
9.00
1.00
-1.
AVITNM=46
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.48)

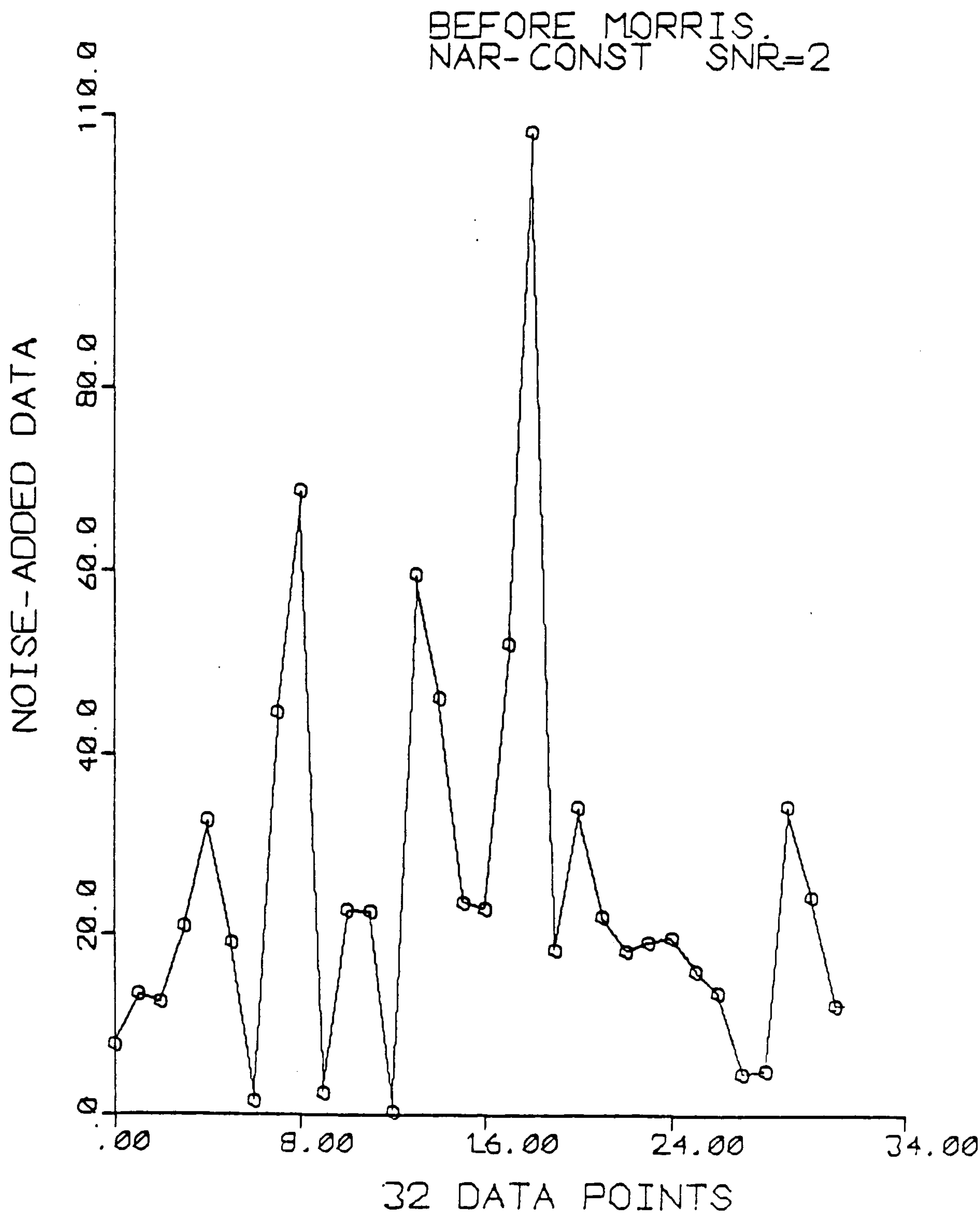

BEFORE MORRIS.
NAR-CONST SNR=2
NOISE-ADDED DATA
110.0
80.0
60.0
40.0
20.0
0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.49)

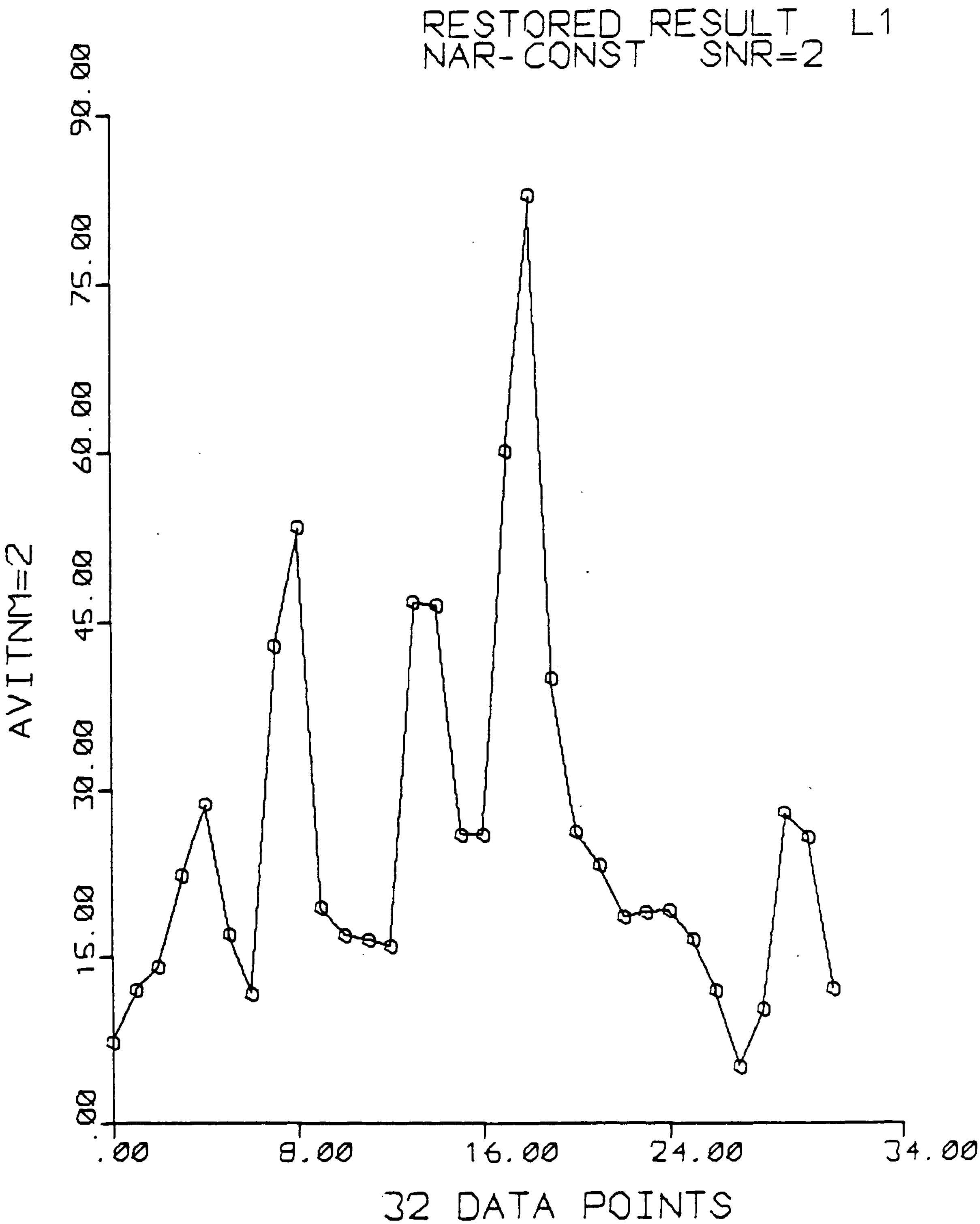

RESTORED RESULT L1
NAR-CONST SNR=2
AVITNM=2
90.00
75.00
60.00
45.00
30.00
15.00
.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.50)

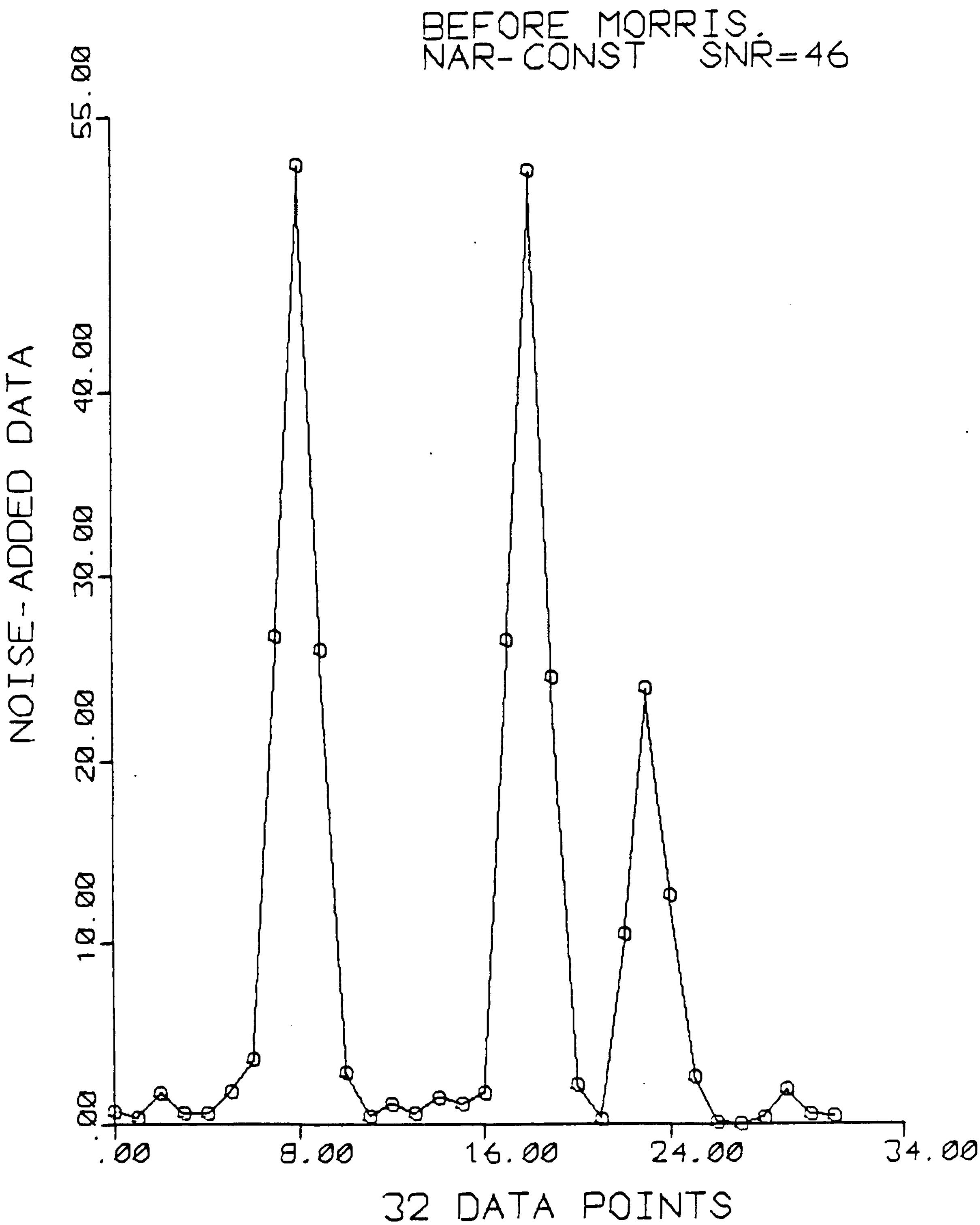

BEFORE MORRIS.
NAR-CONST SNR=46
NOISE-ADDED DATA
55.00
40.00
30.00
20.00
10.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.51)

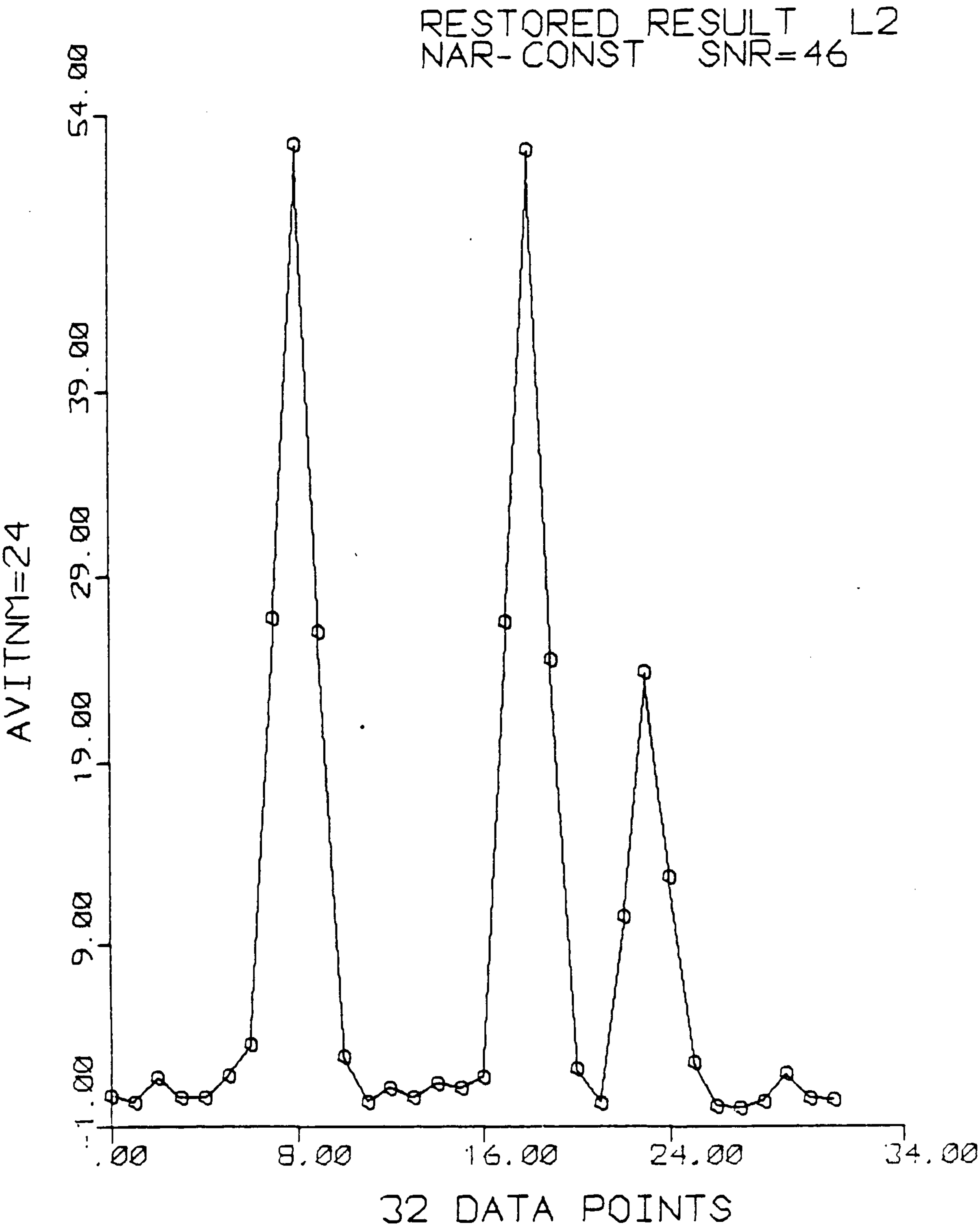

RESTORED RESULT L2
NAR-CONST SNR=46
AVITNM=24
54.00
39.00
29.00
19.00
9.00
1.00
-1.
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.52)

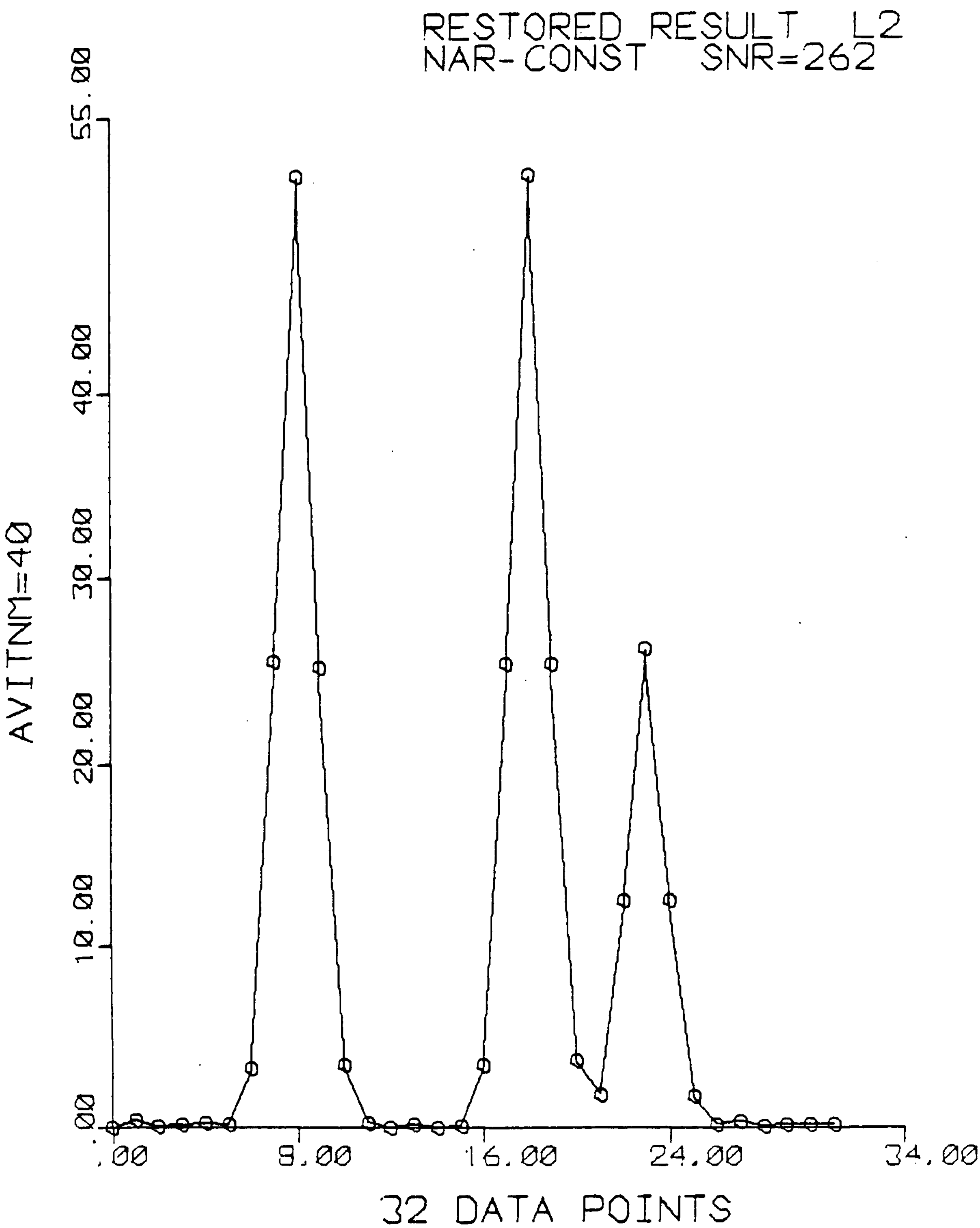

RESTORED RESULT L2
NAR-CONST SNR=262
AVITNM=40
55.00
40.00
30.00
20.00
10.00
.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.53)

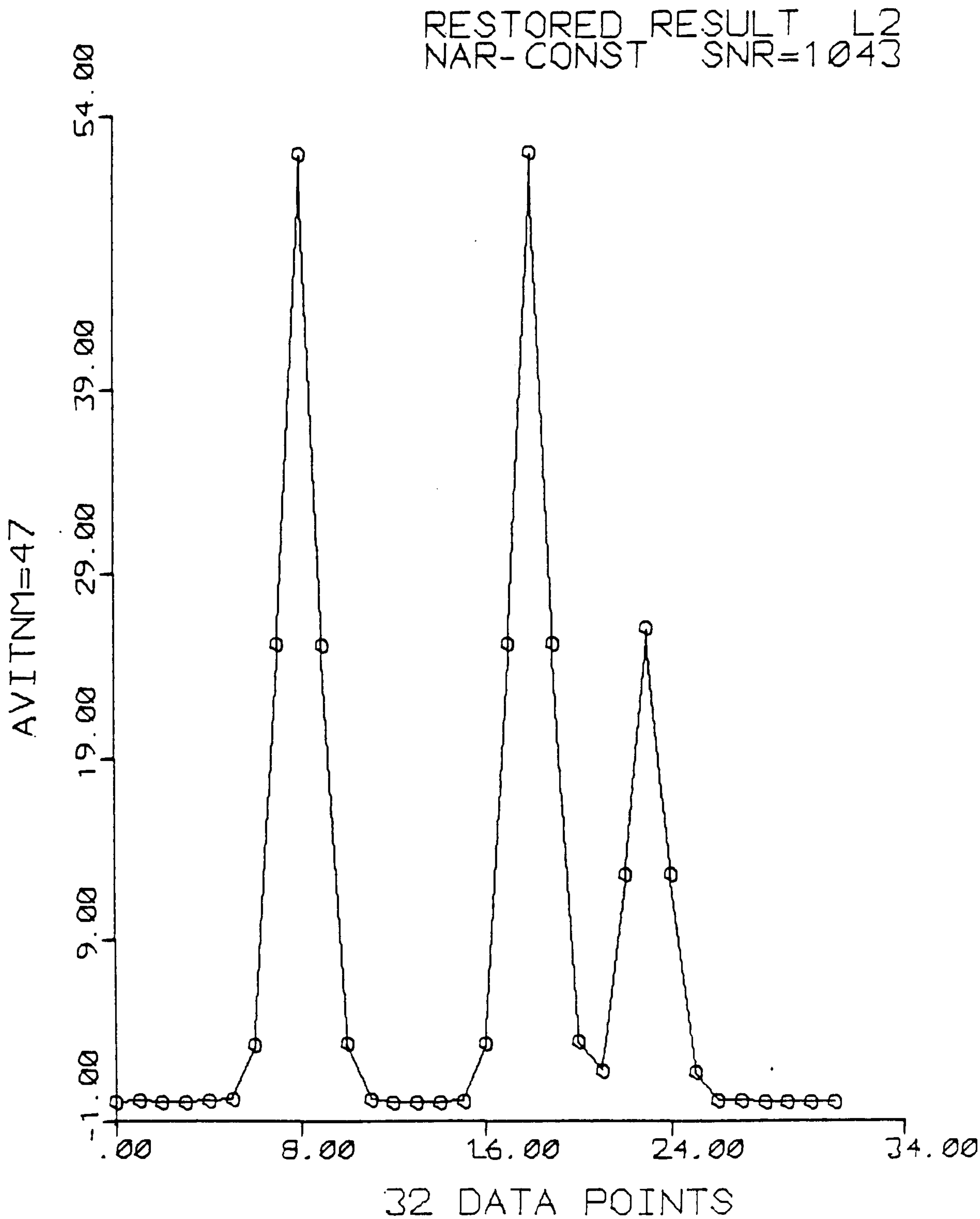

RESTORED RESULT L2
NAR-CONST SNR=1043
AVITNM=47
54.00
39.00
29.00
19.00
9.00
-1.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (3.54)

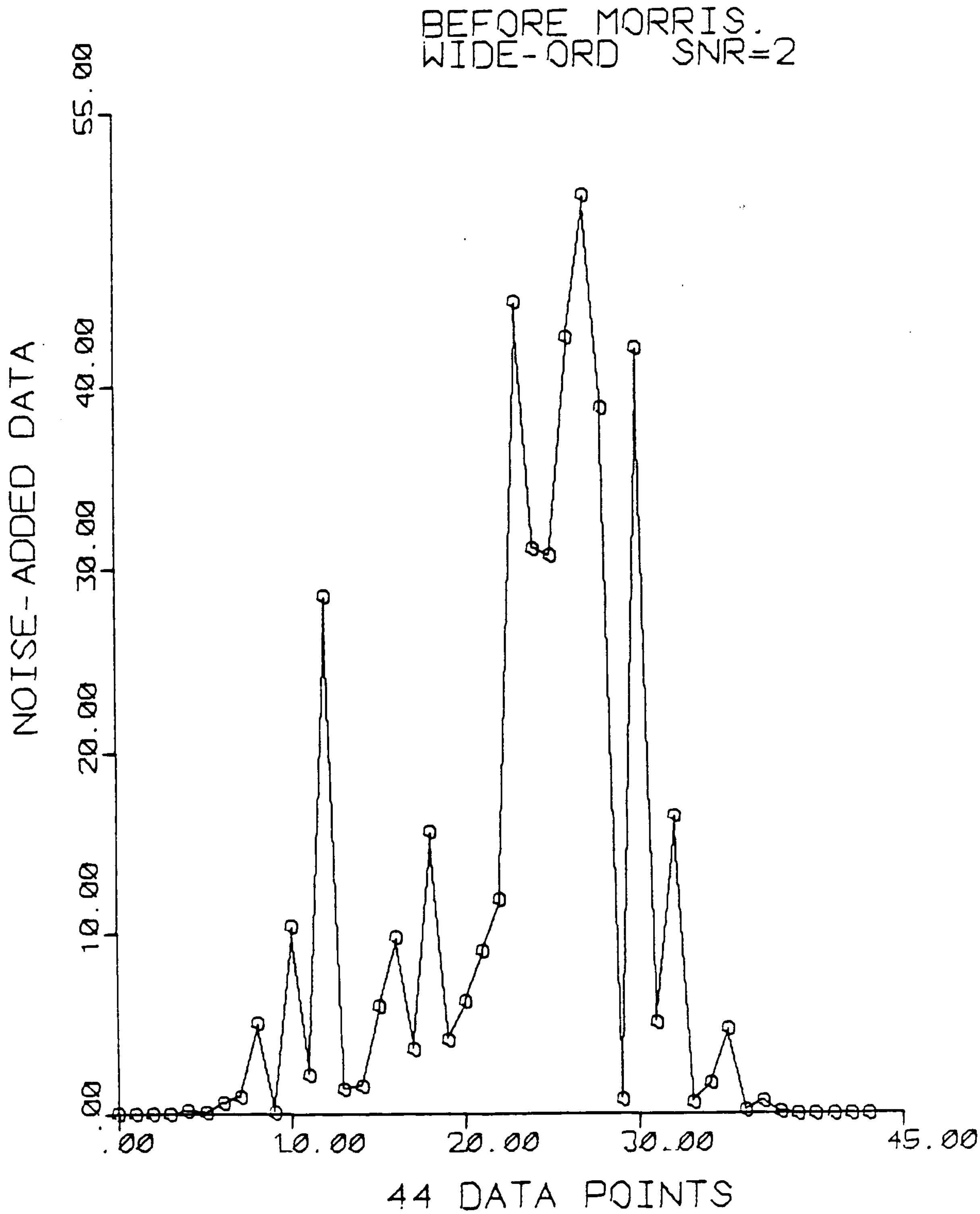

BEFORE MORRIS.
WIDE-ORD SNR=2
NOISE-ADDED DATA
55.00
40.00
30.00
20.00
10.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.55)

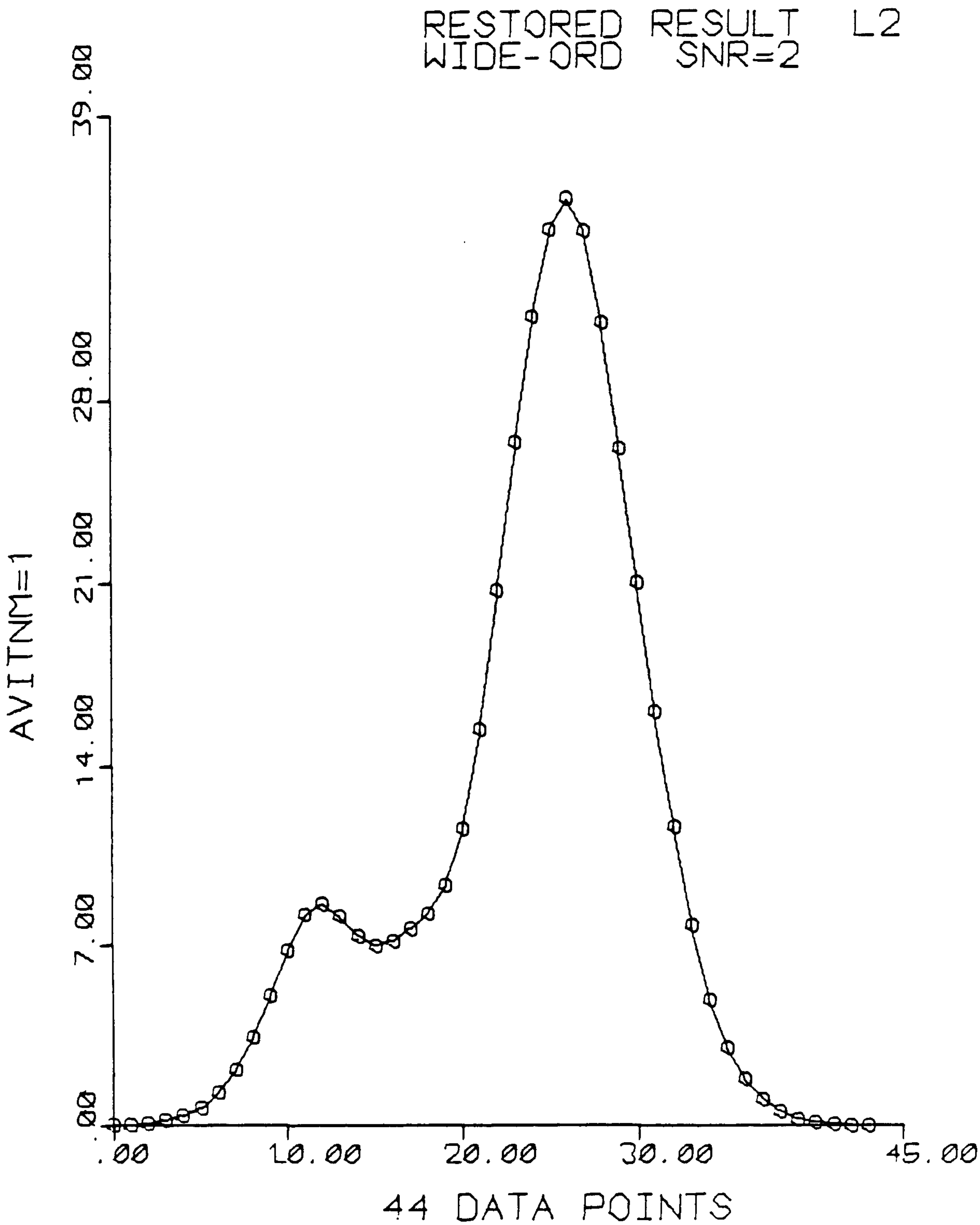

RESTORED RESULT L2
WIDE-ORD SNR=2
AVITNM=1
39.00
28.00
21.00
14.00
7.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.56)

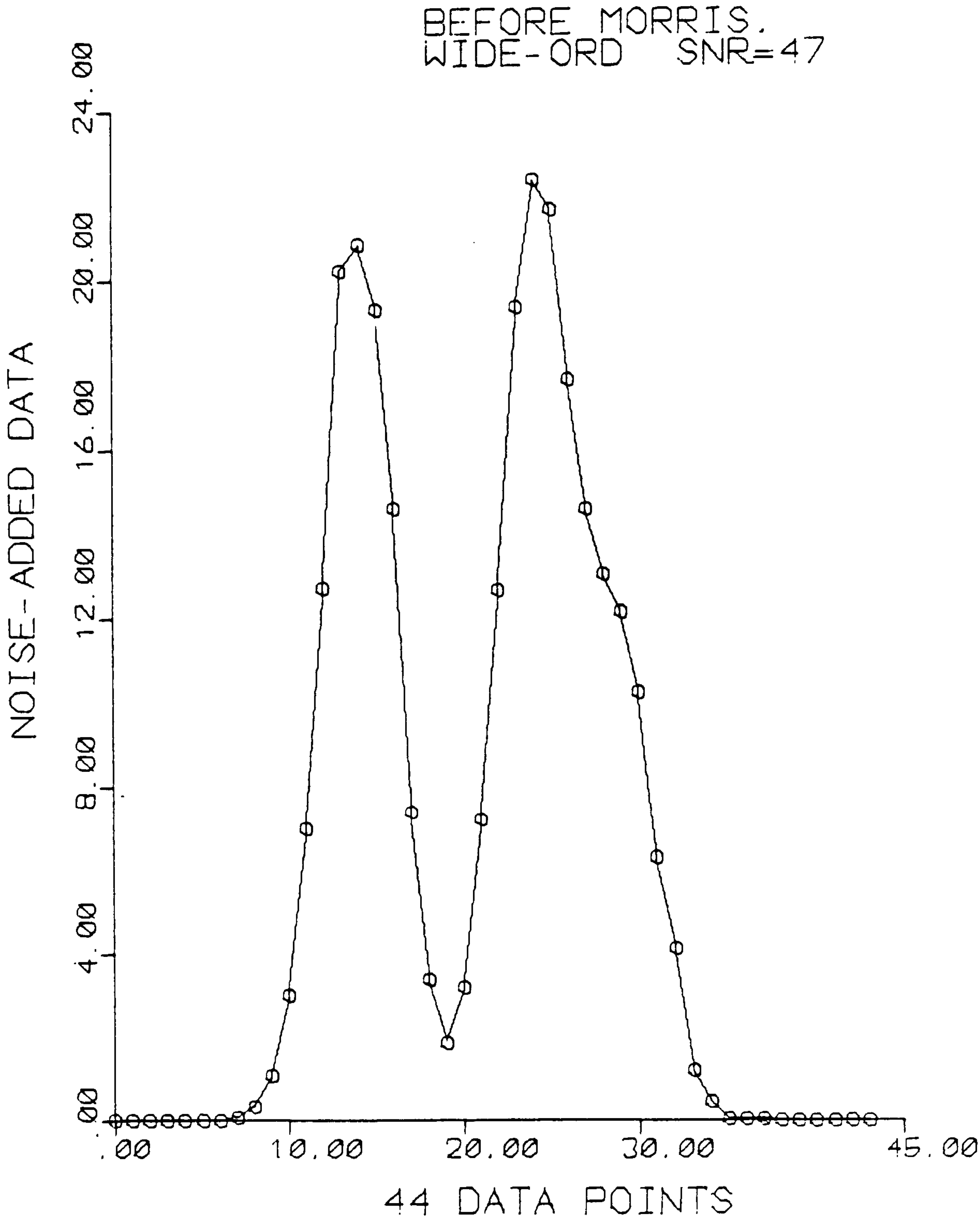

BEFORE MORRIS.
WIDE-ORD SNR=47
NOISE-ADDED DATA
24.00
20.00
16.00
12.00
8.00
4.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.57)

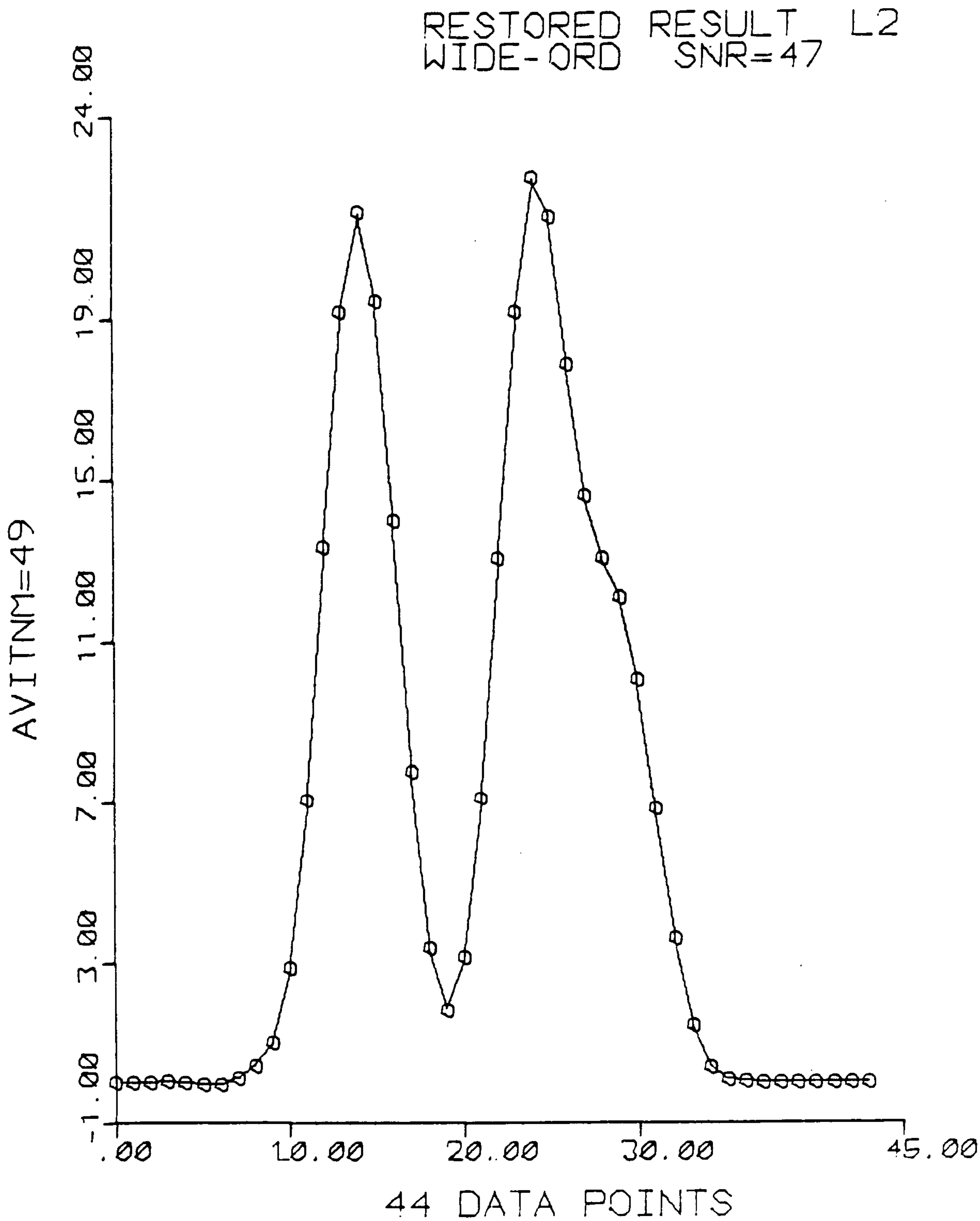

RESTORED RESULT L2
WIDE-ORD SNR=47
AVITNM=49
24.00
19.00
15.00
11.00
7.00
3.00
-1.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.58)

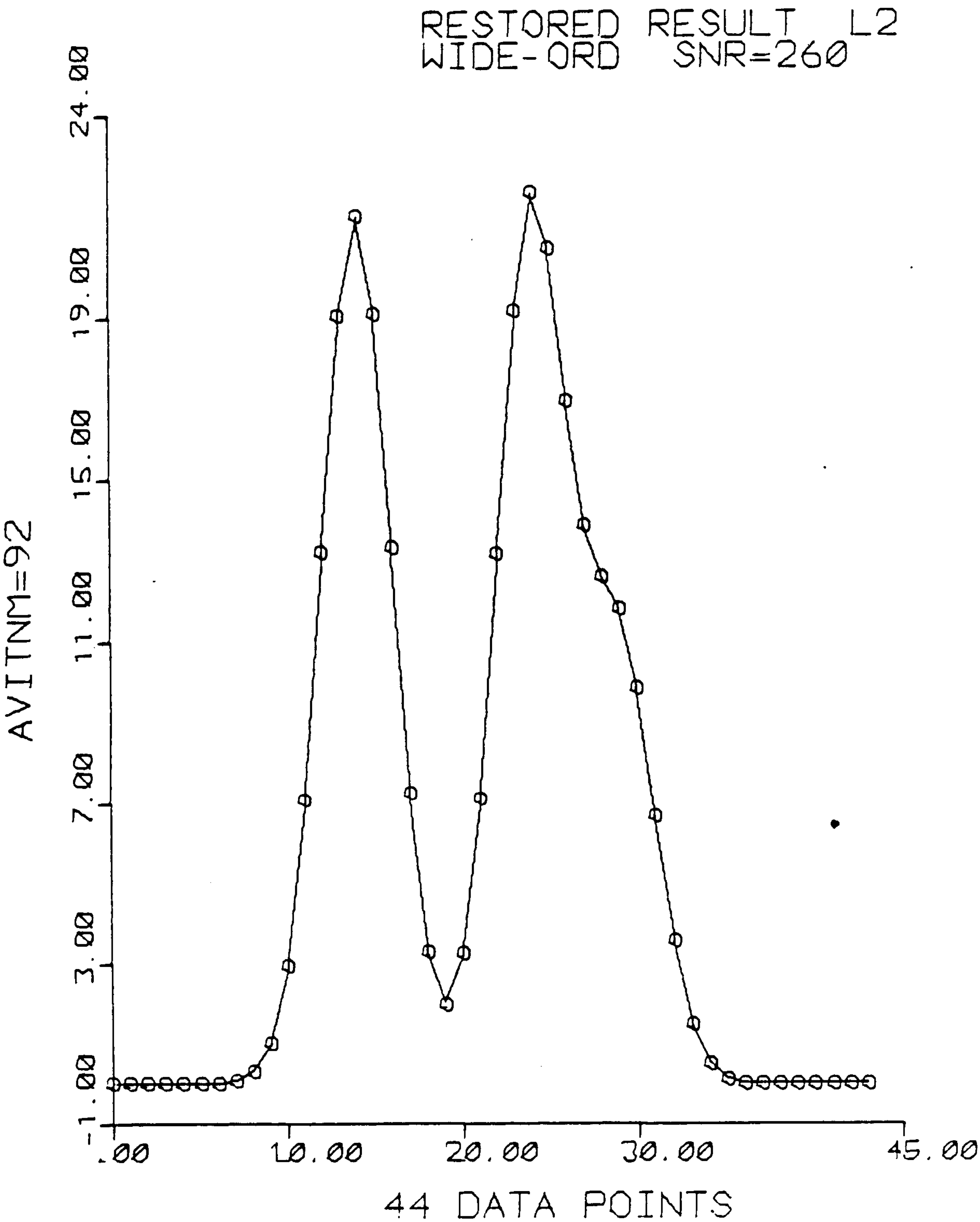

RESTORED RESULT L2
WIDE-ORD SNR=260
AVITNM=92
24.00
19.00
15.00
11.00
7.00
3.00
-1.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.59)

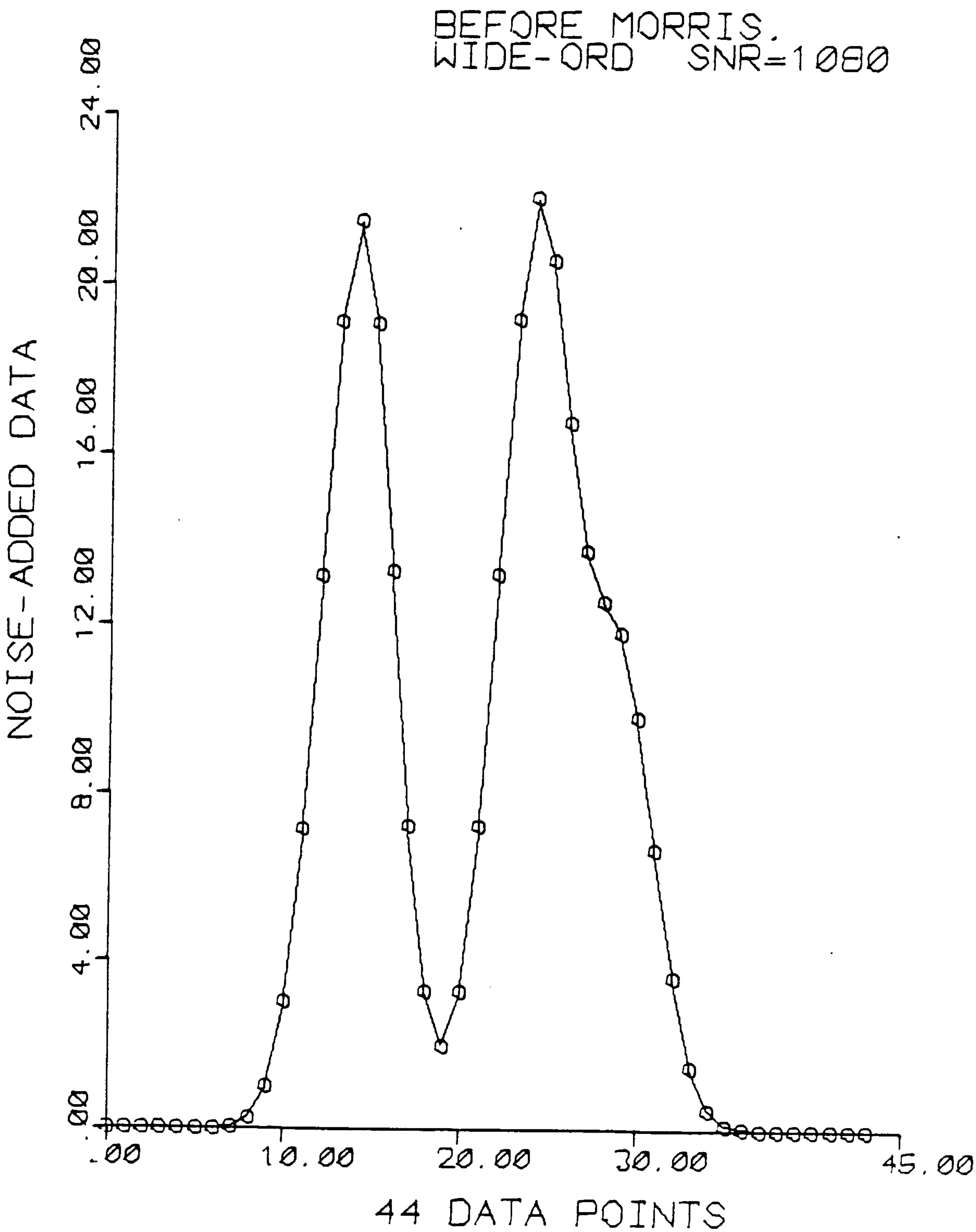

BEFORE MORRIS.
WIDE-ORD SNR=1080
NOISE-ADDED DATA
24.00
20.00
16.00
12.00
8.00
4.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.60)

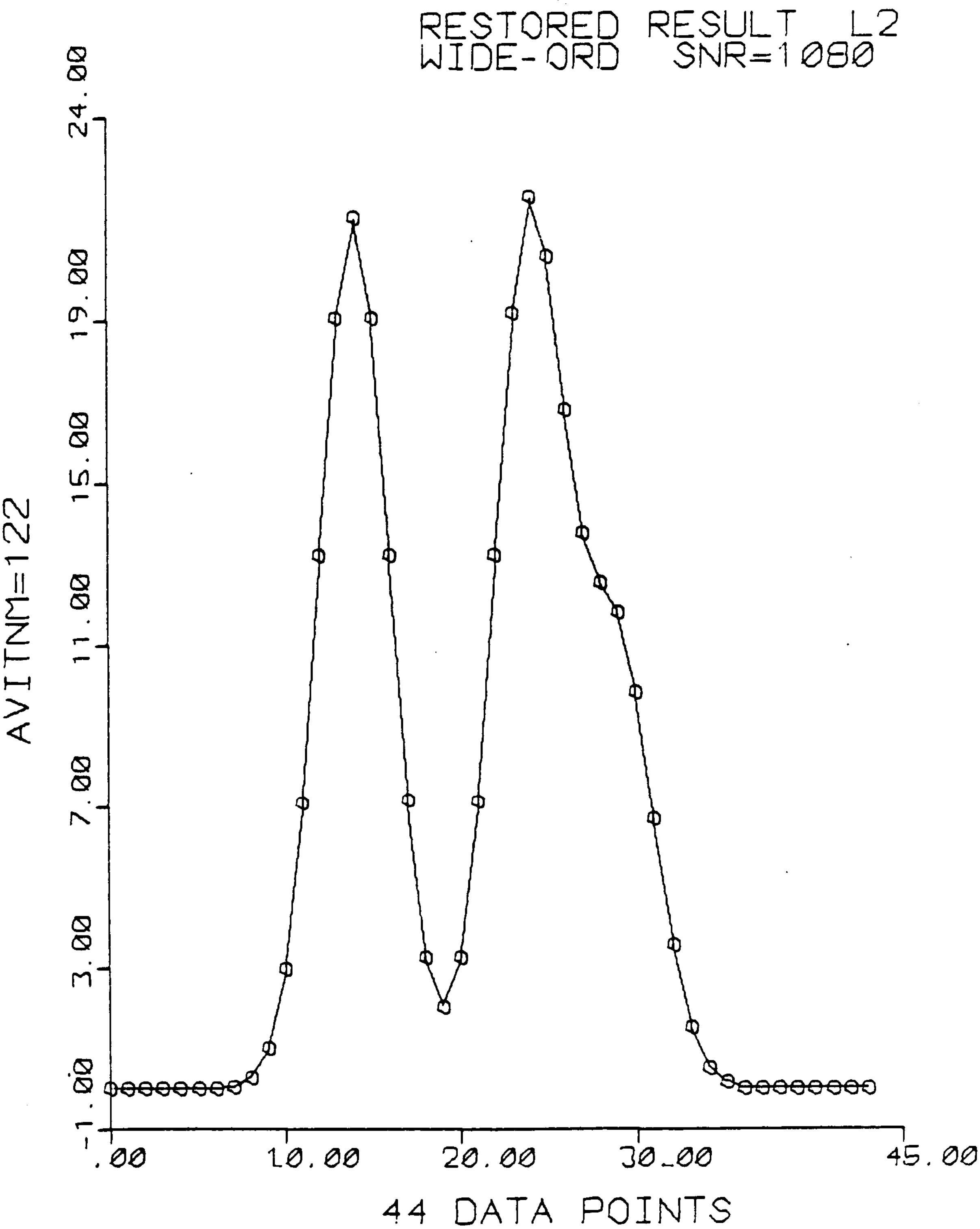

RESTORED RESULT L2
WIDE-ORD SNR=1080
AVITNM=122
24.00
19.00
15.00
11.00
7.00
3.00
1.00
-1.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.61)

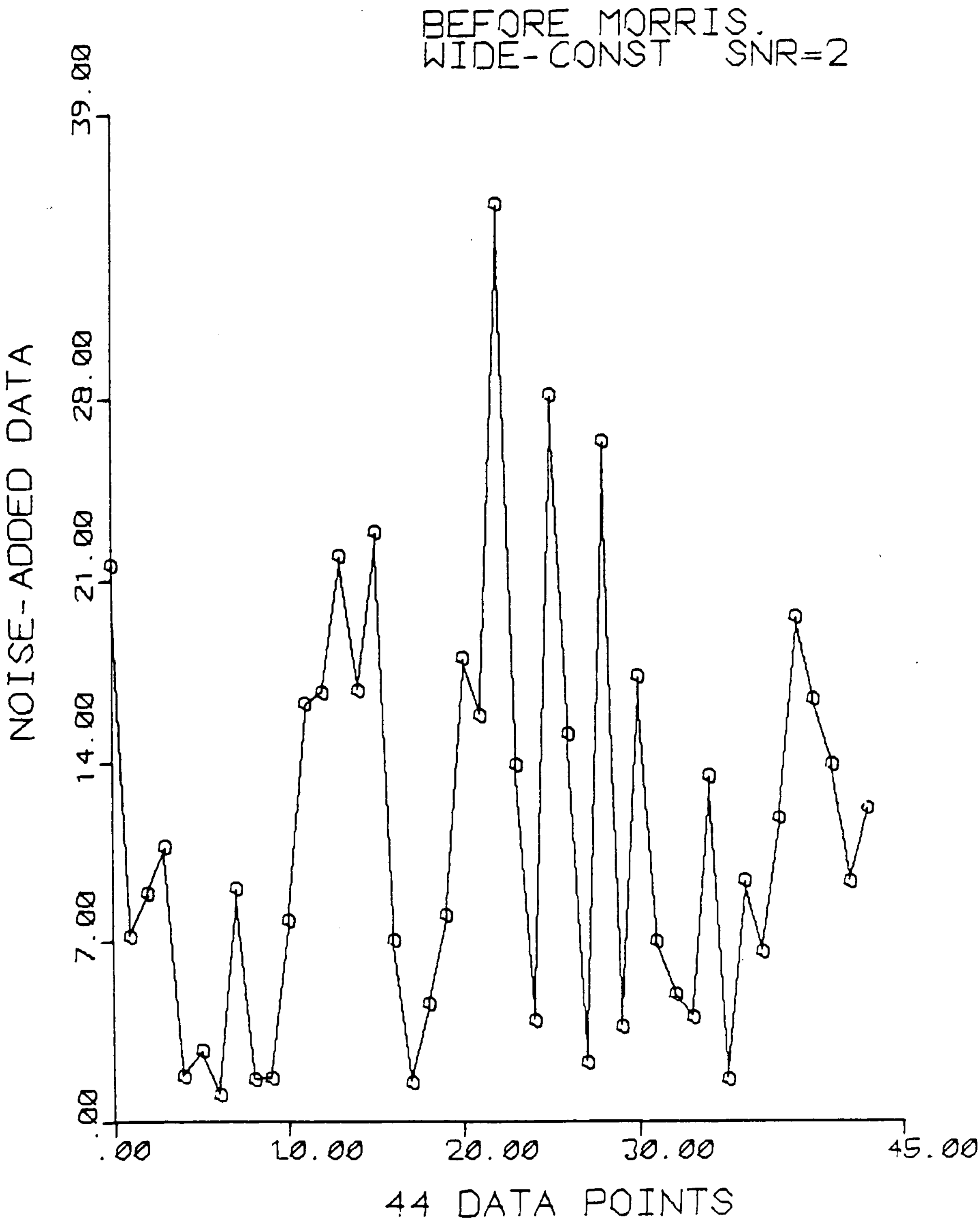

BEFORE MORRIS.
WIDE-CONST SNR=2
NOISE-ADDED DATA
39.00
28.00
21.00
14.00
7.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.62)

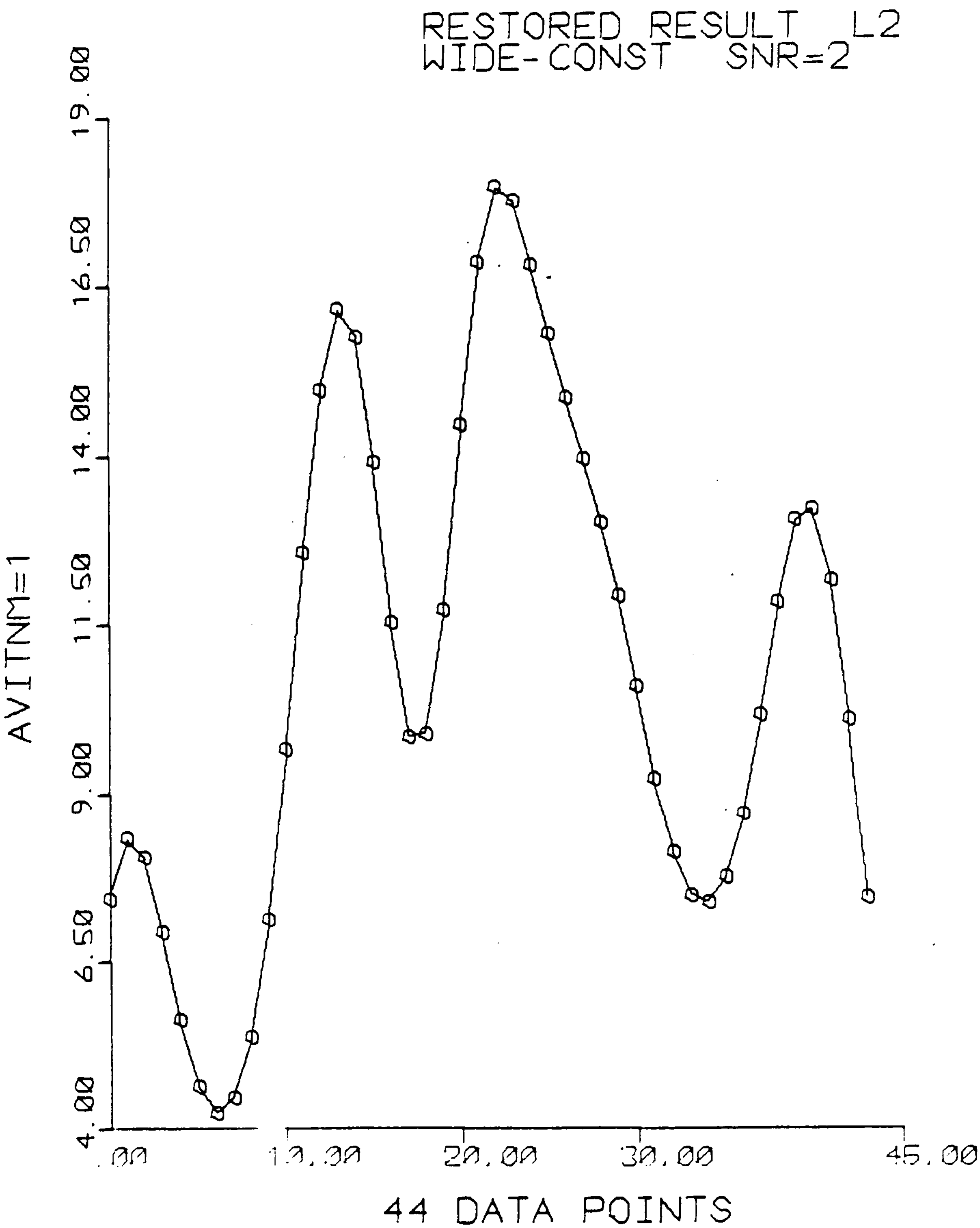

RESTORED RESULT L2
WIDE-CONST SNR=2
AVITNM=1
19.00
16.50
14.00
11.50
9.00
6.50
4.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.63)

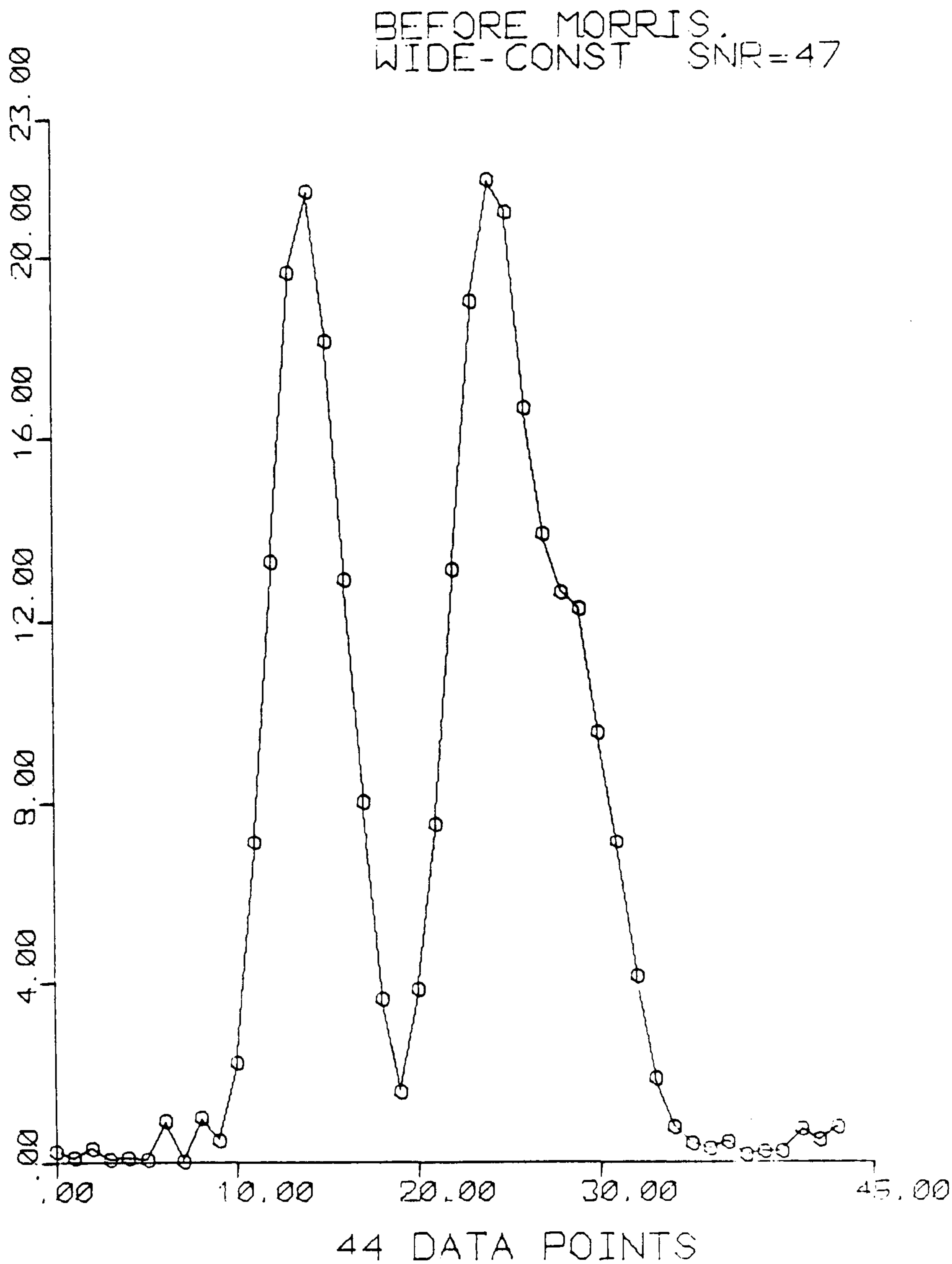

BEFORE MORRIS.
WIDE-CONST SNR=47
23.00
20.00
16.00
12.00
8.00
4.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.64)

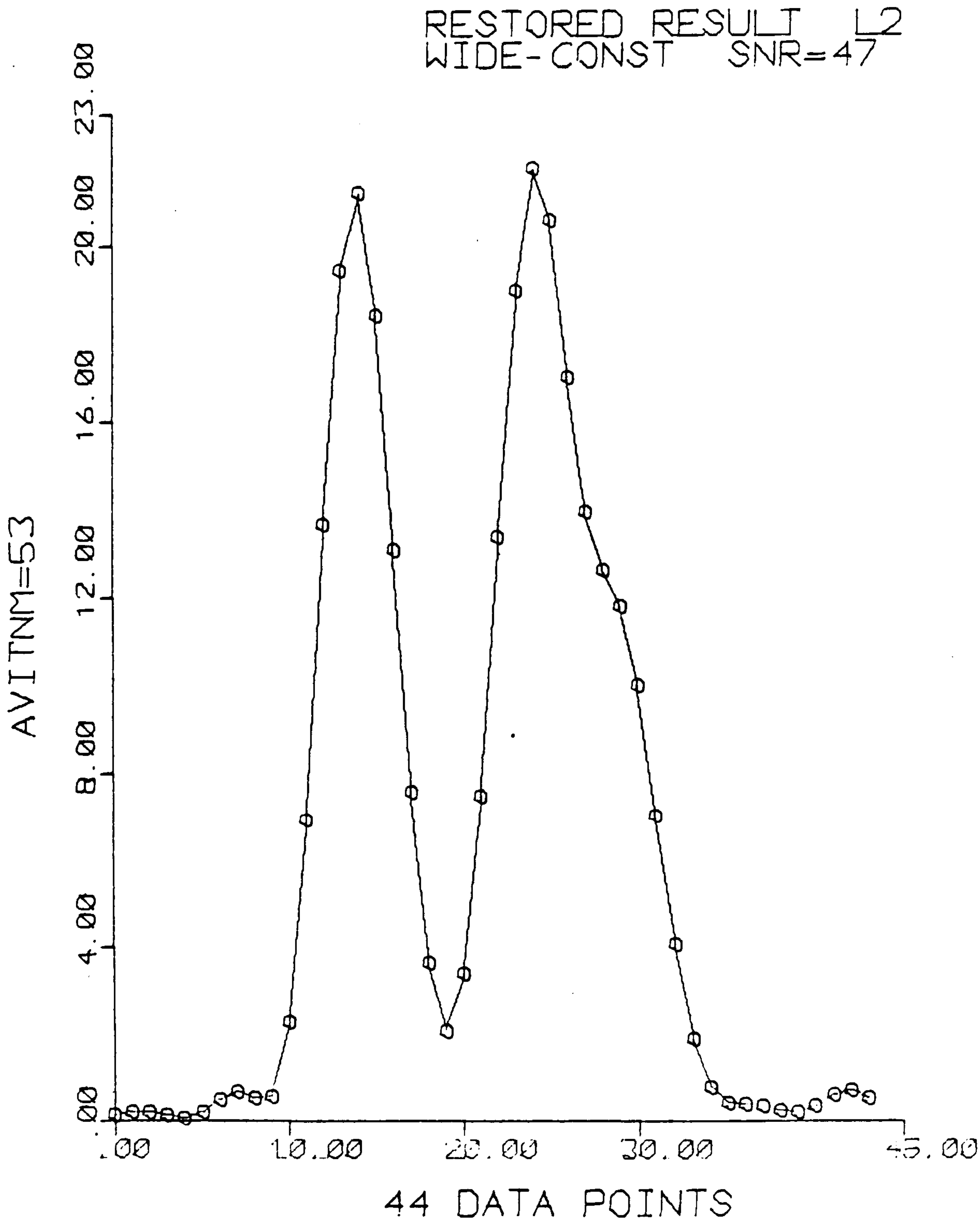

RESTORED RESULT L2
WIDE-CONST SNR=47
AVITNM=53
.00
4.00
8.00
12.00
16.00
20.00
23.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.65)

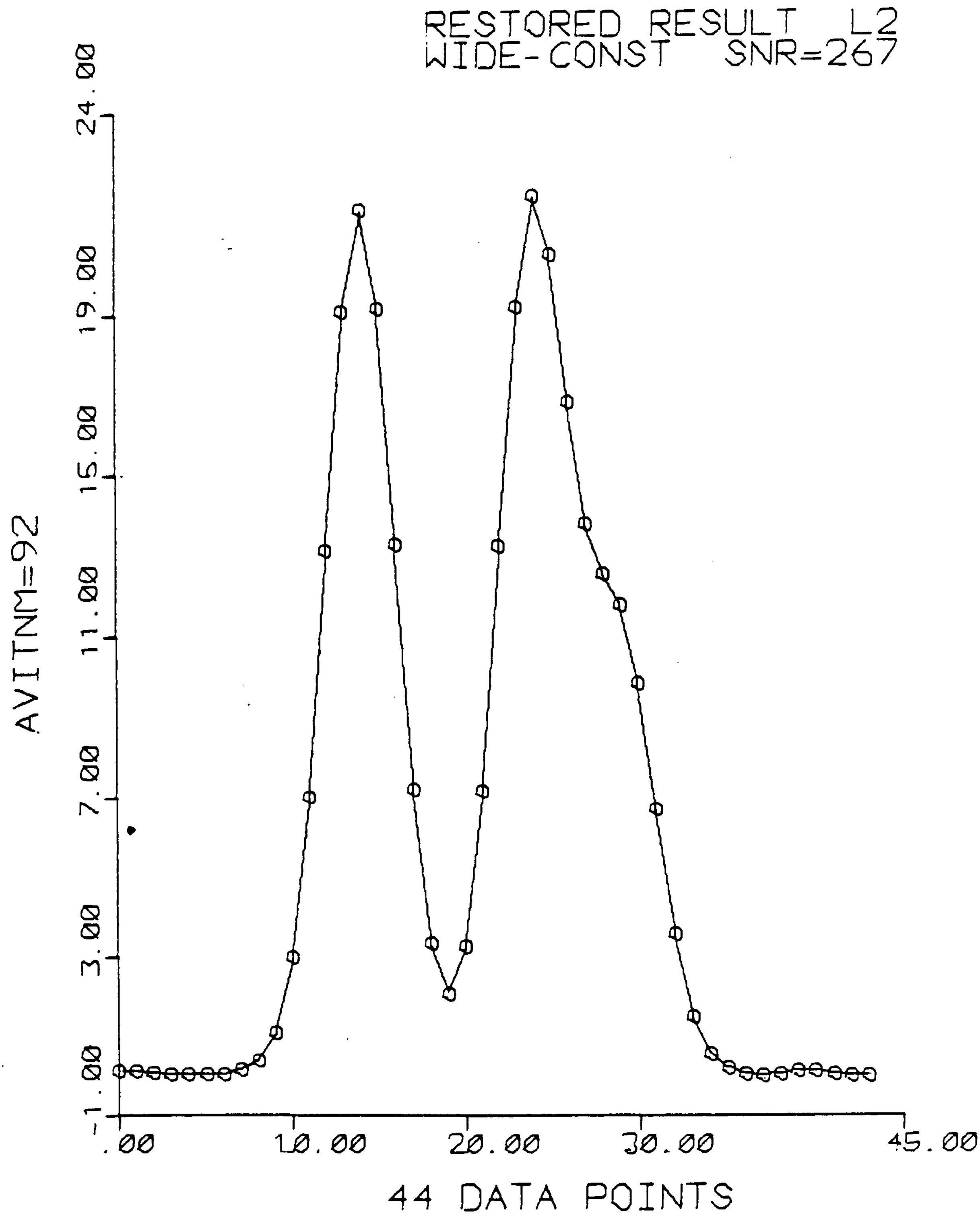
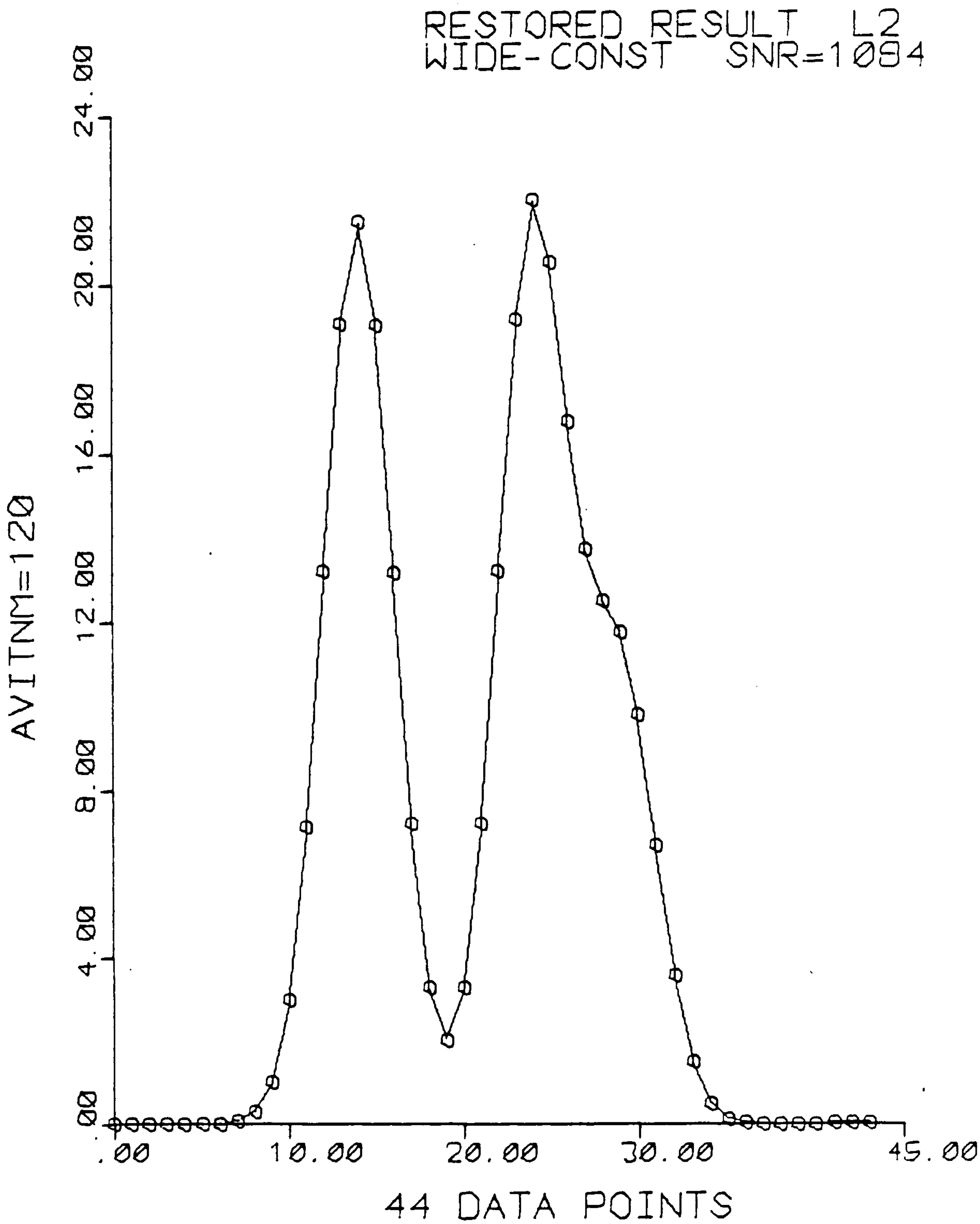

RESTORED RESULT L2
WIDE-CONST SNR=267
AVITNM=92
24.00
19.00
15.00
11.00
7.00
3.00
-1.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (3.66)


RESTORED RESULT L2
WIDE-CONST SNR=1084
AVITNM=120
24.00
20.00
16.00
12.00
8.00
4.00
.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

CHAPTER IV

MORRISON'S METHOD PRIOR TO DECONVOLUTION

This chapter Is a study of the optimum use of Morrison's noise removal, or smoothing, prior to deconvolution. After each smoothing iteration is applied to the two noise-added data sets analyzed in Chapter III, the data sets are deconvolved by convolution with the two most accurate inverse filters calculated in Chapter II. The deconvolved results are compared to the known input f after each iteration and an optimum iteration number chosen when either an error minimum or suitable convergence of error is realized.

Noise removal and deconvolution are applied to data sets having roughly the same average SNR values, AVSNR2, as those examined previously, where enough cases for each SNR are included to give the result statistical significance. As in the noise removal study, plots of average optimum iteration number and average error improvement versus AVSNR2 are produced, along with tables listing accurate average values and confidence limits of all quantities considered.

The results will provide an experimentalist having similar data with guidelines which will allow a more automatic selection of the optimum number of Morrison's iterations prior to deconvolution. As will be seen, optimum use of Morrison's noise removal for noise removal alone does not necessarily, though it may, correspond to optimum use prior to deconvolution.

There are two reasons for this. The first is that deconvolution amplifies noise selectively. Specifically, in the region of the transform domain where the response function, G(s), is smallest, noise is amplified the most. The transform domain representation for deconvolution of noise added data is as follows:

$$F(s) = H(s)/G(s) + N(s)/G(s)$$

where N(s) is the spectrum of the noise, n(x). As can be seen, dividing by small magnitude G(s) greatly increases the magnitude of the noise term. Applying Morrison's noise removal, which is an overall noise removal technique, for noise removal alone will not necessarily minimize noise resulting after division by G(s). Thus the results of the two applications of Morrison's method may differ.

The second problem has to do with the fact that Morrison's noise removal consists of a single smoothing iteration followed by restoring iterations that will ultimately restore all the signal and noise except in the regions of the frequency domain where G(s) is zero.

Deconvolution, on the other hand, consists purely of restoring the data by removing the effect of the response. Since the compromise in optimizing Morrison's method is between resolution of signal and restoration of noise, and the deconvolution consists of a correction of the signal for the effect of the response of the system, the interplay in the presence of noise between the noise removal and the deconvolution is a complex one.

Results obtained in the present chapter for optimum use of Morrison's prior to deconvolution are compared to similar results for noise removal alone. Hopefully, some insight is gained as to why similarities or differences exist in the results of the two uses of Morrison's method.

Optimization Procedure

The experimental procedure of optimization for deconvolution is similar to that used for noise removal alone. The same noise types, ordinate and constant, are added to the data in the same manner. As in the noise removal study, data sets having SNR's of approximately 2 to 1000 are created by varying the noise scale factor, NSF. The method of calculating an average SNR, AVESNR, and standard deviation, SDSNR, from the 100 data sets for each NSF is the same as in Chapter III. Again only data sets having a SNR that is within plus and minus one-half a SDSNR of the average, AVESNR, are used in optimization. The difference here is that 50 data sets are optimized for each AVESNR instead of 100.

In determining a statistically reliable number of data sets to optimize for each SNR, test results were calculated at SNR values of 2,47,260, and 1000 using one-hundred data sets, and results were not significantly different from those calculated from 50 sets. Using the lesser number has the benefit of cutting the computer time almost in half.

After each of Morrison's iterations is applied to the data, the data sets are deconvolved by convolution with the 257 and 129 point inverse filter for the narrow and wide gaussian cases, respectively. The deconvolved result is then compared to the known input, f, with both the L1 and L2 norms used previously. The error in the deconvolution is stored, then compared to the error of the result from the succeeding iteration. As already mentioned, the iterations are terminated at error minimum or by a convergence criterion to be described.

A complete study to determine if only one error minimum exists over the complete range of iterations and SNR's used was not attempted. Tests were carried out for selected low, middle, and high SNR values. After the error minimum was reached, the iterations were continued past the minimum with the result that error increased monotonically as iteration number increased. This result allows termination of iterations as the minimum is located.

The convergence formulas are the same fractional and absolute differences applied in Chapter III. The convergence values are different, however. For the narrow case, fractional and absolute differences of .001 and .0005, respectively, are used. For the wide case, .0005 and .005 are used. A process of comparing results calculated at selectd SNR´s using a range of convergence values was performed. The convergence criteria were chosen to allow the result to correspond to the expected behavior of increasing optimum iteration number as the SNR´s of the data are increased, without having iteration confidence limits so large as to prevent reliability of the results. Also, minimization of error is especially considered.

Note that the convergence criteria are stronger for the deconvolution optimization than for noise removal alone. The stronger criteria are used because one can expect greater error in the deconvolved result than the error in the restored data result for noise removal alone.

Next, averages of the optimum iteration number, AVITNM, are calculated from the 50 results for each SNR, along with their standard deviation, SDITNM, and the maximum and minimum of iteration number, MXIT and MNIT. Also, the average SNR´s, AVSNR2, of the 50 data sets within plus and minus one-half SDSNR of AVESNR are calculated, and the maximum and minimum within the range chosen.

The improvement in error is calculated as described in Chapter III, only now the error before the application of Morrison's smoothing is determined by comparing the deconvolved result to f. The error after Morrison's smoothing is calculated by comparing the known input f to the deconvolution performed at the optimum iteration number.

Plots of average optimum iteration number, AVITNM, versus AVSNR2 are produced,as are graphs of the ratio of error after to error before application of Morrison's method versus AVSNR2. Confidence limits are included on all plots.

Before an analysis of the results obtained, one thing should be noted. If the noise level is high enough to cause termination of iterations after only one smoothing iteration, this means that the original data, without incompatable noise, is closer to the original data f than the result of deconvolving any restoration of Morrison's method. The first smoothing iteration broadens the data by convolving with the response, removing incompatable noise. Deconvolving this result gives back the original noise-added h, except for incompatable noise. Thus Morrison's method is not useful for this case.

Narrow Gaussian Iteration Results

Examination of the narrow gaussian ordinate noise iteration results for both L1 and L2 error measures, figures (4.1)-(4.4) and tables (4.1) and (4.2), shows that the average iteration number increases rapidly with respect to AVSNR2 from AVSNR2 5 through 138. The increase is 1.3 to 39 and 1.3 to 37 average iterations for the L1 and L2 norms, respectively. For AVSRN2 below 5 the noise level is so high that in general only the smoothing iteration is performed before noise causes an increase of error in the deconvolution. For both cases there is a slight dip in average iteration number, AVITNM, for AVSNR2 175 to about 38 and 35 iterations. AVITNM then increases rapidly to 49 and 46 at AVSNR2 270. From AVSNR2 270 to 1017 the increase is much slower but monotonic, an increase of about 10 iterations for both cases. The dip in AVITNM at AVSNR2 175 is likely at the AVSNR2 value where the absolute difference convergence criterion becomes effective. Using a slightly weaker criterion would result in a smoother curve.

For the L1 and L2 norm results of the narrow constant noise data, figures (4.5)-(4.8) and tables (4.3) and (4.4), there is a rapid increase in AVITNM from AVSNR2 3 through 260. The increase is about 1 to 47 iterations for both norm cases. For AVSNR2 260 through 1050, the number of iterations levels off with only a 5 and 6 AVITNM change over this AVSNR2 range, with a slight dip in iteration number at

AVSNR2 532. Further experimentation with the convergence criteria is needed to know if this dip in iteration number was caused by a switch to a different criterion.

Where there is a rapid increase in iteration number with respect to AVSNR2, the noise levels chosen for the data are decreasing rapidly and thus there is a rapid increase in the number of iterations which may be carried out before noise obscures the deconvolution. For higher AVSNR2 values the leveling off of iteration number is due to the noise level being lower throughout the SNR region, which allows the relatively high iteration numbers. Thus there is less change in actual noise which could cause a wide variance in average iteration number.

Narrow Gaussian Error Results

In discussing the error improvements, one can refer to Chapter III for the method of calculating the percent error improvements. As shown in figures (4.9)-(4.12) and tables (4.5) and (4.6), error improvement for the narrow gaussian ordinate noise L1 and L2 cases decreases from 75% to 7.5% and 72% to 7.5%, respectively, for AVSNR2 2 through 95. For AVSNR2 95 through 1017 the decrease in error improvement is only 6% and 3% over this SNR range for the L1 and L2 norms, respectively.

For the narrow constant L1 and L2 cases, figures (4.13)-(4.16) and tables (4.7) and (4.8), there is a rapid decrease in error improvement from AVSNR2 2 through 46, a decrease of 64% to 8% and 64% to 7% for the L1 and L2 norms, respectively. For AVSNR2 higher than 64 the error improvement oscillates somewhat with a minumum and maximum error improvement of 5% and 9%, respectively, for the L1 case, and a minimum and maximum of 4% and 9%, respectively, for the L2 norm result.

The SNR region where there is a rapid decrease in error improvement corresponds roughly to the region where the noise level is decreasing most rapidly. For very low SNR the error in the deconvolved result before Morrison's technique is applied is large, and just a few iterations before deconvolution will greatly reduce the error. As the noise levels chosen become less, the deconvolutions applied without Morrison's smoothing have less and less error, thus less and less error improvement after Morrison's smoothing is applied is obtainable. A greater error improvement at a low AVSNR2 does not mean that the deconvolved result is better than the deconvolved result of a higher AVSNR2 case. Figures (4.17)-(4.34) show deconvolved results for the narrow gaussian, before and after Morrison's at selected AVSNR2 values.

Standard deviations of iteration number and error improvement are listed in the tables. The semilog plots have standard deviations for the iteration and error results included. The largest standard deviations are for SNR values where the variance in magnitude of the noise added per data point for each data set is greatest, and the noise levels not so high as to cause rapid termination of iterations.

Before discussion of the behavior of the wide gaussian results, it should be noted that the L1 norm data for both the ordinate and constant noise results is not considered reliable. Comparison of the L1 and L2 results -- figures (4.35)-(4.38) show AVITNM versus AVSNR2 for the L1 and L2 cases, and figures (4.39) and (4.40) are deconvolved results performed at the L1 and L2 optimum for the same SNR -- reveals that iterations are terminated too quickly for the L1 norm. Much more resolution of data is obtained in the L2 case. The reason is thought to be a consequence of the L1 norm weighting all points equally. As the deconvolved result figures show, good resolution of peaks is not obtainable for the wide gaussian deconvolution. A maximum of about 60 is all that can be achieved for the best case data, and the restoration of peaks is slow. In using the L1 norm the slow improvement at the peaks is not enough to compensate for the increase in noise about the baseline as iterations proceed. This noise is a consequence of the many small magnitude high frecuency components in the frequency domain representations of the wide gaussian, G(s), and the data, H(s). In deconvolution great amplification of noise occurrs where G(s) is small, and any small changes where H(s) and G(s) are small will be large percentage changes in the deconvolved result. The resulting function-domain high-frequency oscillations about the baseline have a greater effect on the L1 norm than the L2 norm. Generally the data analyst will accept an increase in baseline noise for increased resolution for peak-type data. For the L2 norm, which emphasizes the large error at the peaks, the restoration of the peaks is fast enough to compensate for the increase in error about the baseline. This result of the unreliability of the L1 norm results would not be as significant for smooth or non-peak-type data, or data with less baseline, as there would be less effect from baseline noise. It would be interesting to add more baseline data points to the narrow gaussian deconvolution optimization and observe if the faster restoration of peaks would compensate for the increase in baseline noise.

Wide Gaussian Iteration Results

The wide gaussian ordinate noise L2 norm AVITNM result, figures (4.36) and (4.41) and tables (4.9) and (4.10), shows a rapid increase in AVITNM for AVSNR2 4.4 through 183, an increase of 1.2 to 41 average iterations. Again the higher noise level for lower AVSNR2's causes quick termination of iterations. The iterations increase less rapidly to AVSNR2 376 where the AVITMN is 48, and then decrease slowly to an AVITNM of 42 at AVSNR2 1035. It is noted that the high AVITNM at AVSNR2 376 also has an inordinately large standard deviation.

For the wide constant L2 result, figures (4.38) and (4.42) and tables (4.11) and (4.12), the rapid increase in iteration numbers is over the 16 through 185 AVSNR2 range. The increase in AVITNM is from 2 to 24. There is a slight dip in AVITNM to 23 at AVSNR2 263, probably due to a switch to another convergence criterion, succeeded by average iterations which increase to 40 at AVSNR2 743. The AVITNM dips slightly to 39.5 at AVSNR2 1041. As the L1 norm results are unreliable they will not be discussed.

Wide Gaussian Error Results

Examination of the wide case ordinate noise L2 norm error curves, figures (4.43) and (4.44) and tables (4.13) and (4.14), shows that the percent error improvement decreases monotonically as the AVSNR2's increase. There is a maximum error improvement of about 21,000,000% at AVSNR2 1.9, and a minimum error improvement of 67,000% at AVSNR2 1035.

The wide case constant L2 error results, figures (4.45) and (4.46) and tables (4.15) and (4.16), also show monotonically decreasing error improvement as AVSNR2 increases. Here the maximum error improvement is 17,000,000% at AVSNR2 2.2, and the minimum improvement is 61,000% at AVSNR2 1041. The error improvements for the L1 norm for both noise types are of the same order of magnitude as those for the L2 norm. A brief discusssion of the result is given immediately after the following paragraph.

Analysis of Results

Studying the error improvement results, one observes that the improvement in error is significantly greater for the wide gaussian case than for the narrow, even though the deconvolved result is much more accurate for the narrow case. Figures (4.17)-(4.34) and (4.47)-(4.64) show deconvolved results for the narrow and wide cases, respectively, before and after Morrison's method is applied at selected SNR values. This is due to the wide case deconvolution before Morrison's smoothing being so inaccurate. The inaccuracy is a consequence of the wide gaussian transform, G(s), being narrower and thus containing many more small-magnitude high-frequency components. As discussed previously, these components cause great amplification of noise in deconvolution.

In observing the deconvolution plots, one should note that the graphs do not represent an average of results for each SNR. The plots are of selected data sets that make up the averages for each SNR. The AVSNR2 and AVITNM are listed on the graphs, the actual SNR and iteration number of the data shown may be different from the averages. For AVSNR2's where the AVITNM is approximately equal for the L1 and L2 norm results only the L2 norm deconvolution is given, though for a specific data set the L1 and L2 results could be significantly different. For the wide gaussian only a few of the L1 norm results are given as they are considered unreliable.

Even the error improvement obtained for the wide case L1 norms is considerable. Just the smoothing iteration, or the smoothing followed by one or a few restoring iterations, and deconvolution is enough to achieve a great amount of error improvement over the deconvolution result of the unsmoothed data. Though as alluded to, the deconvolution result after two or three iterations is not much different from the original noise-added data.

For the amount of error improvement at specific AVSNR2 values the reader may refer to tables (4.5)-(4.8) and (4.13)-(4.16). Standard deviations for the AVITNM and AVERNM results are shown in the semilog figures and listed in the tables.

The average iteration numbers for the wide ordinate L2 result are consistently higher than the corresponding iterations of the constant L2 case. As decribed in Chapter III, it is believed that the ordinate and constant noise types have different frequency distributions. The ordinate noise has a somewhat bimodal frequency distribution and the constant noise a more even distribution of frequencies, with larger magnitude frequencies for the low middle to middle range of frequencies, though it must be remembered that this description of the frequency distributions is speculation, as a frequency domain study of the noise was not done. It is possible that the restoration of the relatively large low middle to middle range noise frequencies, which are magnified in deconvolution as G(s) is narrow, caused the faster termination of iterations for the wide gaussian constant noise case.

This effect of higher wide ordinate case iteration numbers is not as prevelant for the noise removal study (where the effect of differences in the noise frequency restoration is not enough to cause great differences in iteration results) because deconvolution magnifies the effect.

For the narrow gaussian deconvolution study the ordinate and constant noise iteration results are more closely related than for the wide case. Perhaps this closer correlation of iteration numbers is due to the relative flatness, or wideness, of the magnitude of G(s) for the narrow gaussian, as there is less magnification of noise at higher frequencies in deconvolution. In speaking of the relative widths of the frequency domain representations for the narrow and wide gaussian cases, it is important to remember that both fill the same transform domain window determined by the sampling interval in the function domain.

Comparing the iteration results of the narrow ordinate and constant cases, one may find a greater difference in iterations over specific AVSNR2 regions than in the wide case. This is also true for the noise removal study. But over the complete SNR range, higher ordinate-noise iteration results are most significant for the wide gaussian deconvolution study.

As the explanation of the frequency domain behavior of the ordinate and constant noise studies is not known with certainty, a useful study in this matter would be to analyze the frequency domain representations of the Morrison restored data at each iteration. This would allow one to observe how the frequency components of the data are being restored and possibly make a better determination of why differences or similarities occur in the two results.

An examination of the error improvement results for the wide L2 cases reveals that in general the ordinate case error improvements are slightly better than the corresponding constant case improvements. However, this does not necessarily imply that the deconvolved optimum results for the ordinate case are slightly better than those for the constant noise case. The deconvolution prior to application of Morrison's noise removal likely contains more error for the ordinate case because of the larger magnitude high frequencies. In this determination a listing of the error after Morrison's noise removal would be benefical though it is not given here. One may analyze the deconvolutions for the ordinate and constant noise cases at the same SNR for selected SNR's, figures (4.47)-(4.64), to make a judgement in this regard. For the narrow case one may examine figures (4.17)-(4.34) to decide whether the ordinate or constant noise deconvolution results are better. One may find that the SNR of the data has an effect on the relative goodness of the two results.

Weighted Error Measure

It should be noted that in the course of experimentation a modification to the L1 and L2 error measures was applied in the determination of optimum iteration number for the deconvolution study. This modification was to weight the L1 and L2 error at each data point by the known input f. This was accomplished by multiplying the error at each point by the value of f if f was greater than one there. Where f is less than or equal to one, or zero, the error was multiplied by one. The results, determined by examining plots of the optimum deconvolution achieved for the weighted and unweighted error measures, were that for most SNR values the iterations seemed to be continued past the number that would produce what most observers would regard as optimum. Resolution of peaks was not significantly better than the unweighted optimum result, and noise about the baseline began to obscure the data. However for some SNR values, specifically low middle range values, an argument could be made for using the weighted error measure for the wide case, as there was a significant increase in the resolution of peaks. The determination of which error measure achieves the best result is very user and data dependent as the data analyst may or may not be willing to accept increased noise for increased resolution of signal. Figure (4.65) shows this result at SNR 68, where the deconvolved wide case result, denoted by "o", is the wide case unweighted L2 optimum, and the result with more resolution of peaks is the weighted L2 optimum. The least resolved result is the L1 unweighted case. The weighted measure was applied to the wide case L1 optimization, but with little success. There was a slight improvement in the iteration results over the lower middle SNR range, but not enough of an improvement to consider the result correct.

The results given in this work are all calculated using the unweighted error measures. An experimenter applying these results to low middle range SNR data may want to continue Morrison's smoothing for considerably more iterations and then choose the optimal number of iterations which best suits his or her needs. Using the maximum iteration, MXIT, listed in the tables of iteration results would perhaps be a good starting point in the selection of a higher number of iterations for this SNR range.

The appendix lists all computer programs used for this work, along with documentation. The program for the deconvolution study contains the necessary algorithm for applying the weighted error measure.

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Table (4.1)

Narrow Ordinate

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
1.92914700E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
2.90717990E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.67953220E+00	1.06000000E+00	2.37486840E-01	1.02000000E+00	1.40000000E-01
4.99172510E+00	1.28000000E+00	4.48998890E-01	1.26000000E+00	5.21919540E-01
6.45776750E+00	1.68000000E+00	7.05407680E-01	1.78000000E+00	9.00888420E-01
8.59153030E+00	2.08000000E+00	6.88186030E-01	2.36000000E+00	1.12712020E+00
1.16718530E+01	3.24000000E+00	2.19599640E+00	3.78000000E+00	2.23866030E+00
1.68961660E+01	5.36000000E+00	2.49607690E+00	6.64000000E+00	4.09272520E+00
2.40237000E+01	8.30000000E+00	5.58300990E+00	9.94000010E+00	5.83921230E+00
3.37279790E+01	1.59600000E+01	9.87311490E+00	1.84200000E+01	9.74903080E+00
4.96078260E+01	2.37000000E+01	1.40032140E+01	2.30400000E+01	1.19849240E+01
6.38476130E+01	2.85200000E+01	1.48408090E+01	2.80000000E+01	1.26174480E+01
9.17223700E+01	3.31000000E+01	1.53639190E+01	3.23200000E+01	1.31430440E+01
1.37843650E+02	3.93200000E+01	1.48302930E+01	3.74600000E+01	1.34435260E+01
1.75481070E+02	3.77600000E+01	1.48223620E+01	3.47200000E+01	1.32000610E+01
2.70181120E+02	4.91200000E+01	1.49701570E+01	4.57000000E+01	1.43055930E+01
3.67229980E+02	5.04000000E+01	1.31544670E+01	4.65800000E+01	1.45163220E+01
5.22138850E+02	5.39800000E+01	1.29714920E+01	5.09000000E+01	1.43767170E+01
7.44416970E+02	5.88200000E+01	1.06821160E+01	5.45400000E+01	1.20767710E+01
1.01733810E+03	5.90600000E+01	9.95471750E+00	5.59400000E+01	1.21431630E+01

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Table (4.2)

Narrow Ordinate

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.0600000E+00	1.0000000E+00	2.0000000E+00	1.0200000E+00	1.0000000E+00	2.0000000E+00
1.2800000E+00	1.0000000E+00	2.0000000E+00	1.2600000E+00	1.0000000E+00	3.0000000E+00
1.6800000E+00	1.0000000E+00	4.0000000E+00	1.7800000E+00	1.0000000E+00	4.0000000E+00
2.0800000E+00	1.0000000E+00	4.0000000E+00	2.3600000E+00	1.0000000E+00	5.0000000E+00
3.2400000E+00	1.0000000E+00	1.5000000E+01	3.7800000E+00	1.0000000E+00	1.6000000E+01
5.3600000E+00	2.0000000E+00	1.5000000E+01	6.6400000E+00	3.0000000E+00	2.2000000E+01
8.3000000E+00	2.0000000E+00	3.2000000E+01	9.9400001E+00	5.0000000E+00	3.3000000E+01
1.5960000E+01	6.0000000E+00	4.2000000E+01	1.8420000E+01	7.0000000E+00	4.0000000E+01
2.3700000E+01	9.0000000E+00	5.5000000E+01	2.3040000E+01	8.0000000E+00	5.3000000E+01
2.8520000E+01	8.0000000E+00	5.4000000E+01	2.8000000E+01	1.0000000E+01	4.8000000E+01
3.3100000E+01	1.2000000E+01	6.0000000E+01	3.2020000E+01	1.3000000E+01	5.7000000E+01
3.9320000E+01	1.5000000E+01	6.6000000E+01	3.7460000E+01	1.6000000E+01	6.1000000E+01
3.7760000E+01	1.8000000E+01	6.7000000E+01	3.4720000E+01	1.7000000E+01	6.1000000E+01
4.9120000E+01	2.2000000E+01	7.0000000E+01	4.5700000E+01	2.0000000E+01	6.7000000E+01
5.0400000E+01	2.7000000E+01	7.3000000E+01	4.6580000E+01	2.6000000E+01	7.2000000E+01
5.3980000E+01	2.8000000E+01	7.5000000E+01	5.0900000E+01	2.8000000E+01	7.3000000E+01
5.8820000E+01	3.8000000E+01	7.6000000E+01	5.4540000E+01	3.5000000E+01	7.5000000E+01
5.9060000E+01	4.0000000E+01	7.5000000E+01	5.5940000E+01	3.7000000E+01	7.4000000E+01

Table (4.3)

Narrow Constant

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.23130400E+00	1.08000000E+00	2.71293190E-01	1.00000000E+00	0.00000000E+00
2.92201880E+00	1.16000000E+00	3.66606060E-01	1.00000000E+00	0.00000000E+00
4.17410710E+00	1.40000000E+00	4.89897950E-01	1.34000000E+00	4.73708770E-01
5.90043210E+00	2.08000000E+00	5.23067870E-01	2.26000000E+00	4.82078840E-01
8.35934270E+00	2.36000000E+00	6.24819990E-01	3.20000000E+00	8.94427180E-01
1.18831690E+01	2.92000000E+00	1.36879510E+00	4.64000000E+00	1.50678460E+00
1.67317960E+01	6.24000000E+00	3.30792980E+00	7.88000000E+00	3.35642670E+00
2.34061670E+01	1.06800000E+01	5.45688560E+00	1.25800000E+01	6.00030000E+00
3.25068630E+01	1.49200000E+01	7.69893490E+00	1.62800000E+01	7.07966090E+00
4.58305290E+01	2.43400000E+01	1.17976440E+01	2.56600000E+01	1.08896470E+01
6.60498170E+01	2.96000000E+01	1.17575510E+01	3.09600000E+01	1.10289800E+01
9.35149550E+01	3.29600000E+01	1.30199230E+01	3.39400000E+01	1.27081230E+01
1.30980920E+02	3.60600000E+01	1.20969580E+01	3.82600000E+01	1.16169020E+01
1.84049330E+02	3.89600000E+01	1.23401140E+01	4.01200000E+01	1.17824280E+01
2.60376880E+02	4.65400000E+01	1.20966280E+01	4.65600000E+01	1.25413870E+01
3.84301830E+02	4.84800000E+01	1.40360110E+01	5.06400000E+01	1.34175410E+01
5.31587270E+02	4.59000000E+01	1.14354710E+01	4.70800000E+01	1.18335790E+01
7.28244380E+02	5.16800000E+01	1.10859190E+01	5.26400000E+01	1.16374570E+01
1.05017380E+03	5.15000000E+01	9.20923450E+00	5.22800000E+01	9.76942170E+00

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Table (4.4)

Narrow Constant

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
3.5578314E-01	2.0189220E-01	5.5298388E-01	3.5859312E-01	2.2495888E-01	5.1876681E-01
3.6190961E-01	2.2476267E-01	6.2047513E-01	3.7294671E-01	2.3607821E-01	6.7216469E-01
3.7184663E-01	2.0968195E-01	5.7681315E-01	4.0405243E-01	2.3716631E-01	6.7279655E-01
4.6302014E-01	1.8714314E-01	7.5486019E-01	5.0108812E-01	2.1699299E-01	7.9312971E-01
5.3666092E-01	3.2968461E-01	8.0992913E-01	5.9701961E-01	3.6497937E-01	9.5425840E-01
6.3689163E-01	3.3094563E-01	9.2348299E-01	7.0320460E-01	3.2979891E-01	9.6566367E-01
7.2894153E-01	4.1883507E-01	1.0060230E+00	7.5889728E-01	4.5208046E-01	1.0104098E+00
8.3543080E-01	5.6262252E-01	1.0242942E+00	8.6365946E-01	5.7185442E-01	1.0086414E+00
8.4207907E-01	4.6868569E-01	1.0150517E+00	8.5821457E-01	4.9436350E-01	1.0107447E+00
9.1665539E-01	6.1874742E-01	1.0208486E+00	9.3493956E-01	6.1552911E-01	1.0108989E+00
9.2661125E-01	6.1702368E-01	1.0109071E+00	9.4059995E-01	6.1790300E-01	1.0121094E+00
9.1957293E-01	5.9288352E-01	1.0126426E+00	9.3168985E-01	6.2657936E-01	1.0098243E+00
9.4643381E-01	4.8503159E-01	1.0208912E+00	9.5080869E-01	4.8599855E-01	1.0104906E+00
9.3669663E-01	6.3653211E-01	1.0110017E+00	9.4190481E-01	6.3766611E-01	1.0103990E+00
9.4861883E-01	6.2318571E-01	1.0110611E+00	9.5308254E-01	6.5856908E-01	1.0101517E+00
9.5105965E-01	7.3198964E-01	1.0132101E+00	9.6237698E-01	7.9000892E-01	1.0108973E+00
9.0521237E-01	6.2469935E-01	1.0218602E+00	9.1868658E-01	6.5938052E-01	1.0163089E+00
9.4840074E-01	6.0891113E-01	1.0284835E+00	9.4515286E-01	6.9201713E-01	1.0217354E+00
9.1933999E-01	5.0306732E-01	1.0395385E+00	9.2004003E-01	4.9542446E-01	1.0265380E+00

Table (4.5)

Narrow Ordinate

AVSQR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
1.92914700E+00	2.48673180E-01	6.49800580E-02	2.84347860E-01	6.58923810E-02
2.90717990E+00	2.74007610E-01	9.74307030E-02	3.21932130E-01	1.06502710E-01
3.67953220E+00	3.00147090E-01	9.73291800E-02	3.70864560E-01	1.31286040E-01
4.99172510E+00	3.22251590E-01	1.03370200E-01	4.15701330E-01	1.26735500E-01
6.45776750E+00	3.68932640E-01	1.22695430E-01	4.70662070E-01	1.59193770E-01
8.59153030E+00	4.36043120E-01	1.22802490E-01	5.43872950E-01	1.36157770E-01
1.16718530E+01	4.98300530E-01	1.68339730E-01	5.96686150E-01	1.78890340E-01
1.68961660E+01	5.84243410E-01	2.06449790E-01	6.59771550E-01	2.17633660E-01
2.40237000E+01	6.68926280E-01	2.09360940E-01	7.43458680E-01	2.01482980E-01
3.37279790E+01	8.29837570E-01	1.85535980E-01	8.54526530E-01	1.84490800E-01
4.96078260E+01	8.59360430E-01	1.88218570E-01	8.67561590E-01	1.73179460E-01
6.38476130E+01	8.84545130E-01	1.57238240E-01	8.96643560E-01	1.53175470E-01
9.47223700E+01	9.25308880E-01	1.11777910E-01	9.25193480E-01	1.15181830E-01
1.37843650E+02	9.35399150E-01	1.04762780E-01	9.29140710E-01	1.20689110E-01
1.75481070E+02	9.04776260E-01	1.42374660E-01	8.81510970E-01	1.50501910E-01
2.70181120E+02	9.37349230E-01	1.18534310E-01	9.29523910E-01	1.34785140E-01
3.67229980E+02	9.44453840E-01	1.01852840E-01	9.23260850E-01	1.21590130E-01
5.22138850E+02	9.59333430E-01	8.93899210E-02	9.31859110E-01	1.09239850E-01
7.44416970E+02	9.79193150E-01	7.20149740E-02	9.54719740E-01	9.60974520E-02
1.01733810E+03	9.84897320E-01	6.43140720E-02	9.52390490E-01	9.61670780E-02

Table (4.6)

Narrow Ordinate

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.4867318E-01	1.0573342E-01	4.2072693E-01	2.8434786E-01	1.4377032E-01	4.5311865E-01
2.7400761E-01	1.1053019E-01	5.2011878E-01	3.2193213E-01	1.3826874E-01	6.6433105E-01
3.0014709E-01	1.8248187E-01	5.6213869E-01	3.7086456E-01	2.2406609E-01	7.3736765E-01
3.2225159E-01	1.4374234E-01	5.5012421E-01	4.1570133E-01	1.9438731E-01	7.1730331E-01
3.6893264E-01	1.8379248E-01	6.8547694E-01	4.7066207E-01	1.8683655E-01	9.0196224E-01
4.3604312E-01	1.5461071E-01	8.1120564E-01	5.4387295E-01	2.1421753E-01	9.6082181E-01
4.9830053E-01	1.5138826E-01	9.1448864E-01	5.9668615E-01	1.7970791E-01	9.5285461E-01
5.8424341E-01	2.0404615E-01	9.9373580E-01	6.5977155E-01	2.2982235E-01	1.0062946E+00
6.6892628E-01	1.3885804E-01	1.0091929E+00	7.4345868E-01	1.4411891E-01	1.0079833E+00
8.2983757E-01	3.1236282E-01	1.0114549E+00	8.5452653E-01	3.5548855E-01	1.0089768E+00
8.5936043E-01	3.3375061E-01	1.1673208E+00	8.6756159E-01	3.5466877E-01	1.0105923E+00
8.8454513E-01	4.3472724E-01	1.0195293E+00	8.9664356E-01	4.5445820E-01	1.0101163E+00
9.2530888E-01	5.7367157E-01	1.0238406E+00	9.2519348E-01	5.5210386E-01	1.0107308E+00
9.3539915E-01	5.7270215E-01	1.0153099E+00	9.2914071E-01	5.6041165E-01	1.0109656E+00
9.0477626E-01	4.4524075E-01	1.0124938E+00	8.8151097E-01	4.3171027E-01	1.0106240E+00
9.3734923E-01	4.5065594E-01	1.0119894E+00	9.2952391E-01	4.2312225E-01	1.0110565E+00
9.4445384E-01	5.4064571E-01	1.0187551E+00	9.2326085E-01	4.7647823E-01	1.0116963E+00
9.5933343E-01	6.5316182E-01	1.0290268E+00	9.3185911E-01	5.4222809E-01	1.0172859E+00
9.7919315E-01	7.1882326E-01	1.0321681E+00	9.5471974E-01	5.9438752E-01	1.0218754E+00
9.8489782E-01	7.5438644E-01	1.0474647E+00	9.5239049E-01	6.5324094E-01	1.0270658E+00

Table (4.7)

Narrow Constant

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.20130460E+00	3.55783140E-01	7.21226120E-02	3.58593120E-01	6.55510280E-02
2.92201880E+00	3.61909610E-01	8.16121570E-02	3.72946710E-01	7.87961190E-02
4.17410710E+00	3.71846630E-01	9.15802000E-02	4.04052430E-01	9.52420390E-02
5.90043210E+00	4.63020140E-01	1.28653670E-01	5.01088120E-01	1.30748460E-01
8.35934270E+00	5.36660920E-01	1.27939880E-01	5.97019610E-01	1.37295150E-01
1.18831690E+01	6.36891630E-01	1.33384730E-01	7.03204600E-01	1.35549860E-01
1.67317960E+01	7.28941530E-01	1.47966570E-01	7.58897280E-01	1.47839500E-01
2.34061670E+01	8.35430800E-01	1.22879690E-01	8.63659460E-01	1.20391820E-01
3.25068630E+01	8.42079070E-01	1.57706120E-01	8.58214570E-01	1.52072710E-01
4.58305290E+01	9.16655390E-01	9.99503040E-02	9.34939560E-01	9.27609190E-02
6.60498170E+01	9.26611250E-01	1.17070290E-01	9.40599950E-01	1.04419400E-01
9.35149550E+01	9.19572930E-01	1.10775220E-01	9.31689850E-01	1.03283140E-01
1.30980920E+02	9.46433810E-01	9.75025710E-02	9.50808690E-01	9.78451060E-02
1.84049330E+02	9.36696630E-01	1.02006250E-01	9.41904810E-01	9.73687940E-02
2.60376880E+02	9.48618830E-01	1.05239880E-01	9.53082540E-01	9.27659380E-02
3.84301830E+02	9.51059650E-01	7.72703700E-02	9.62376980E-01	6.59862200E-02
5.31587270E+02	9.05212370E-01	1.12673260E-01	9.18686580E-01	1.02690160E-01
7.28244380E+02	9.48400740E-01	9.43530300E-02	9.45152860E-01	8.57033970E-02
1.05017380E+03	9.19339990E-01	1.09529050E-01	9.20040030E-01	1.10602110E-01

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Table (4.8)

Narrow Constant

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.0800000E+00	1.0000000E+00	2.0000000E+00	1.0000000E+00	1.0000000E+00	1.2000000E+00
1.1600000E+00	1.0000000E+00	2.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.4000000E+00	1.0000000E+00	2.0000000E+00	1.3400000E+00	1.0000000E+00	2.0000000E+00
2.0800000E+00	1.0000000E+00	4.0000000E+00	2.2600000E+00	2.0000000E+00	4.0000000E+00
2.3600000E+00	1.0000000E+00	4.0000000E+00	3.2000000E+00	2.0000000E+00	6.0000000E+00
2.9200000E+00	1.0000000E+00	8.0000000E+00	4.6400000E+00	3.0000000E+00	1.0000000E+01
6.2400000E+00	2.0000000E+00	1.6000000E+01	7.8800000E+00	4.0000000E+00	2.2000000E+01
1.0680000E+01	2.0000000E+00	2.7000000E+01	1.2580000E+01	6.0000000E+00	2.9000000E+01
1.4920000E+01	7.0000000E+00	4.0000000E+01	1.6280000E+01	8.0000000E+00	3.5000000E+01
2.4340000E+01	1.1000000E+01	4.7000000E+01	2.5660000E+01	1.1000000E+01	4.6000000E+01
2.9600000E+01	1.3000000E+01	5.2000000E+01	3.0960000E+01	1.4000000E+01	5.2000000E+01
3.2960000E+01	1.5000000E+01	5.7000000E+01	3.3940000E+01	1.6000000E+01	5.8000000E+01
3.6060000E+01	1.8000000E+01	6.1000000E+01	3.8260000E+01	1.8000000E+01	5.9000000E+01
3.8960000E+01	2.2000000E+01	6.2000000E+01	4.0120000E+01	2.2000000E+01	6.3000000E+01
4.6540000E+01	2.5000000E+01	7.0000000E+01	4.6560000E+01	2.6000000E+01	7.0000000E+01
4.8480000E+01	2.7000000E+01	7.3000000E+01	5.0640000E+01	3.0000000E+01	7.4000000E+01
4.5900000E+01	3.0000000E+01	7.2000000E+01	4.7080000E+01	3.0000000E+01	7.1000000E+01
5.1680000E+01	3.5000000E+01	7.4000000E+01	5.2640000E+01	3.5000000E+01	7.5000000E+01
5.1500000E+01	3.7000000E+01	7.2000000E+01	5.2280000E+01	3.8000000E+01	7.3000000E+01

Table (4.9)

Wide Ordinate

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
1.87245340E+00	1.04000000E+00	1.95959180E-01	1.02000000E+00	1.40000000E-01
2.65888590E+00	1.02000000E+00	1.40000000E-01	1.02000000E+00	1.40000000E-01
3.43019570E+00	1.08000000E+00	2.71293190E-01	1.14000000E+00	3.46987020E-01
4.37693920E+00	1.08000000E+00	2.71293190E-01	1.22000000E+00	5.01597450E-01
5.86346320E+00	1.20000000E+00	4.00000010E-01	1.72000000E+00	8.00999370E-01
8.25777240E+00	1.42000000E+00	8.02246830E-01	2.26000000E+00	1.27765410E+00
1.15796970E+01	2.16000000E+00	1.71300910E+00	3.94000000E+00	2.16711790E+00
1.68266870E+01	2.52000000E+00	1.97220690E+00	4.54000000E+00	2.41834660E+00
2.34442350E+01	2.88000000E+00	2.20581050E+00	7.52000000E+00	4.10969590E+00
3.33080610E+01	3.62000000E+00	3.45189800E+00	1.04200000E+01	5.64301340E+00
4.70279470E+01	3.62000000E+00	3.77830650E+00	1.50600000E+01	8.33405070E+00
6.51263070E+01	3.12000000E+00	3.46202270E+00	1.92000000E+01	8.98220470E+00
9.06410430E+01	2.00000000E+00	0.00000000E+00	2.54400000E+01	1.12412810E+01
1.29958750E+02	2.02000000E+00	1.40000000E-01	3.54800000E+01	1.66544170E+01
1.82638690E+02	2.00000000E+00	0.00000000E+00	4.14600000E+01	2.31492640E+01
2.62151470E+02	2.00000000E+00	0.00000000E+00	4.43200000E+01	1.73498590E+01
3.75569480E+02	2.00000000E+00	0.00000000E+00	4.82800000E+01	3.33130850E+01
5.30806370E+02	2.00000000E+00	0.00000000E+00	4.55400000E+01	1.77315650E+01
7.26204910E+02	2.00000000E+00	0.00000000E+00	4.27200000E+01	1.05811910E+01
1.03535510E+03	2.00000000E+00	0.00000000E+00	4.22600000E+01	9.96756730E+00
1.49110890E+03	2.00000000E+00	0.00000000E+00	3.95600000E+01	4.32710110E+00

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Table (4.10)

Wide Ordinate

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.0400000E+00	1.0000000E+00	2.0000000E+00	1.0200000E+00	1.0000000E+00	2.0000000E+00
1.0200000E+00	1.0000000E+00	2.0000000E+00	1.0200000E+00	1.0000000E+00	2.0000000E+00
1.0800000E+00	1.0000000E+00	2.0000000E+00	1.1400000E+00	1.0000000E+00	2.0000000E+00
1.0800000E+00	1.0000000E+00	2.0000000E+00	1.2200000E+00	1.0000000E+00	3.0000000E+00
1.2000000E+00	1.0000000E+00	2.0000000E+00	1.7200000E+00	1.0000000E+00	3.0000000E+00
1.4200000E+00	1.0000000E+00	5.0000000E+00	2.2600000E+00	1.0000000E+00	6.0000000E+00
2.1600000E+00	1.0000000E+00	8.0000000E+00	3.9400000E+00	1.0000000E+00	9.0000000E+00
2.5200000E+00	1.0000000E+00	9.0000000E+00	4.5400000E+00	2.0000000E+00	1.0000000E+01
2.8800000E+00	1.0000000E+00	8.0000000E+00	7.5200000E+00	2.0000000E+00	1.8000000E+01
3.6200000E+00	1.0000000E+00	1.3000000E+01	1.0420000E+01	3.0000000E+00	2.8000000E+01
3.6200000E+00	1.0000000E+00	2.0000000E+01	1.5060000E+01	5.0000000E+00	3.5000000E+01
3.1200000E+00	2.0000000E+00	2.0000000E+01	1.9200000E+01	6.0000000E+00	3.9000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	2.5440000E+01	9.0000000E+00	5.7000000E+01
2.0200000E+00	2.0000000E+00	3.0000000E+00	3.5480000E+01	1.2000000E+01	7.9000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.1460000E+01	1.7000000E+01	1.1600000E+02
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.4320000E+01	2.2000000E+01	7.4000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.8280000E+01	2.1000000E+01	2.3800000E+02
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.5540000E+01	3.4000000E+01	1.3700000E+02
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.2720000E+01	3.3000000E+01	7.3000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	4.2260000E+01	3.3000000E+01	7.6000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	3.9560000E+01	3.5000000E+01	6.6000000E+01

Table (4.11)

Wide Constant

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.23959120E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.07585700E+00	1.00000000E+00	0.00000000E+00	1.12000000E+00	3.24961540E-01
4.31340940E+00	1.04000000E+00	1.95959170E-01	1.34000000E+00	4.73708770E-01
5.94708800E+00	1.02000000E+00	1.40000000E-01	1.64000000E+00	4.80000010E-01
8.26534350E+00	1.10000000E+00	2.99999990E-01	1.88000000E+00	3.24961540E-01
1.17580850E+01	1.14000000E+00	3.46987030E-01	2.02000000E+00	3.15594680E-01
1.64479550E+01	1.22000000E+00	4.14246310E-01	2.28000000E+00	7.22218790E-01
2.33008700E+01	1.54000000E+00	4.98397420E-01	2.90000000E+00	1.13578170E+00
3.29718540E+01	1.60000000E+00	4.89897950E-01	3.92000000E+00	1.21391930E+00
4.66893980E+01	1.90000000E+00	2.99999990E-01	5.50000000E+00	2.26495030E+00
6.57973680E+01	1.98000000E+00	1.40000000E-01	7.90000000E+00	4.31856480E+00
9.51947080E+01	2.00000000E+00	0.00000000E+00	1.38800000E+01	6.87790670E+00
1.31077820E+02	2.00000000E+00	0.00000000E+00	1.70400000E+01	6.67221090E+00
1.84987330E+02	2.00000000E+00	0.00000000E+00	2.43400000E+01	9.67803690E+00
2.62603050E+02	2.00000000E+00	0.00000000E+00	2.32600000E+01	6.59336040E+00
3.76989660E+02	2.00000000E+00	0.00000000E+00	3.03800000E+01	1.21899790E+01
5.30123390E+02	2.00000000E+00	0.00000000E+00	3.49800000E+01	1.15870450E+01
7.42560760E+02	2.00000000E+00	0.00000000E+00	3.97000000E+01	7.95047170E+00
1.04156250E+03	2.00000000E+00	0.00000000E+00	3.95000000E+01	3.64005490E+00

Table (4.12)

Wide Constant

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00	1.0000000E+00
1.0000000E+00	1.0000000E+00	1.9000000E+00	1.1200000E+00	1.0000000E+00	2.0000000E+00
1.0400000E+00	1.0000000E+00	2.0000000E+00	1.3400000E+00	1.0000000E+00	2.0000000E+00
1.0200000E+00	1.0000000E+00	2.0000000E+00	1.6400000E+00	1.0000000E+00	2.0000000E+00
1.1000000E+00	1.0000000E+00	2.0000000E+00	1.8800000E+00	1.0000000E+00	2.0000000E+00
1.1400000E+00	1.0000000E+00	2.0000000E+00	2.0200000E+00	1.0000000E+00	4.0000000E+00
1.2200000E+00	1.0000000E+00	2.0000000E+00	2.2800000E+00	2.0000000E+00	5.0000000E+00
1.5400000E+00	1.0000000E+00	2.0000000E+00	2.9000000E+00	2.0000000E+00	5.0000000E+00
1.6000000E+00	1.0000000E+00	2.0000000E+00	3.9200000E+00	2.0000000E+00	5.0000000E+00
1.9000000E+00	1.0000000E+00	2.0000000E+00	5.5000000E+00	2.0000000E+00	1.4000000E+01
1.9800000E+00	1.0000000E+00	2.0000000E+00	7.9000000E+00	5.0000000E+00	2.6000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	1.3880000E+01	5.0000000E+00	3.4000000E+01
2.0000000E+00	2.0000000E+00	2.0200000E+00	1.7040000E+01	5.0000000E+00	3.5000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	2.4340000E+01	1.4000000E+01	4.3000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	2.3260000E+01	1.6000000E+01	3.8000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	3.0380000E+01	1.8000000E+01	7.6000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	3.4980000E+01	2.0000000E+01	7.1000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	3.9700000E+01	2.2000000E+01	7.0000000E+01
2.0000000E+00	2.0000000E+00	2.0000000E+00	3.9500000E+01	2.4000000E+01	5.2000000E+01

Table (4.13)

Wide Ordinate

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
1.87245340E+00	3.50746500E-06	1.85947930E-06	4.66348560E-06	2.29723220E-06
2.65888590E+00	4.14115840E-06	1.89320510E-06	6.18059440E-06	3.02886100E-06
3.43019570E+00	4.04545370E-06	2.21160620E-06	6.24805660E-06	3.38020880E-06
4.37693920E+00	5.81433340E-06	2.94992930E-06	9.00449330E-06	4.34520770E-06
5.86346320E+00	8.02314430E-06	4.58763660E-06	1.24746900E-05	7.12543250E-06
8.25777240E+00	9.78264760E-06	4.87514810E-06	1.57211350E-05	7.91468210E-06
1.15796970E+01	1.35448840E-05	7.00211640E-06	2.04078590E-05	1.05623220E-05
1.68266870E+01	2.31711470E-05	1.42417550E-05	3.67698920E-05	2.48160770E-05
2.34442350E+01	2.92283120E-05	2.13197520E-05	4.44006960E-05	3.44164520E-05
3.33080610E+01	3.93763540E-05	1.95713240E-05	5.76083040E-05	2.84249010E-05
4.70279470E+01	5.02367480E-05	1.96063630E-05	7.05072820E-05	2.85824530E-05
6.51263070E+01	7.40863670E-05	3.66500090E-05	1.01355270E-04	5.26496370E-05
9.06410430E+01	1.08302800E-04	6.66338230E-05	1.39881890E-04	7.99783590E-05
1.29958750E+02	1.90725120E-04	1.09322220E-04	2.43346280E-04	1.38028360E-04
1.82638690E+02	2.10717820E-04	9.46559350E-05	2.70550890E-04	1.28807410E-04
2.62151470E+02	3.64116960E-04	2.27979820E-04	4.50704170E-04	2.78854610E-04
3.75569480E+02	4.30890180E-04	2.41854020E-04	5.20898330E-04	2.72172490E-04
5.30806370E+02	7.38800140E-04	4.56671600E-04	9.37251640E-04	5.73034550E-04
7.26204910E+02	8.98327170E-04	4.83636420E-04	1.12128410E-03	6.10077590E-04
1.03535510E+03	1.16042270E-03	6.50011090E-04	1.48513100E-03	8.30724330E-04
1.49110890E+03	1.98498240E-03	1.14487800E-03	2.49786570E-03	1.28867970E-03

Table (4.14)

Wide Ordinate

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
3.5074650E-06	1.2477028E-06	8.3950479E-06	4.6634856E-06	1.5698916E-06	1.0162340E-05
4.1411584E-06	1.1494189E-06	1.0085891E-05	6.1805944E-06	1.8345377E-06	1.7901411E-05
4.0454537E-06	1.5734618E-06	1.4398674E-05	6.2480566E-06	2.4787173E-06	2.3552486E-05
5.8143334E-06	2.3876085E-06	1.8166922E-05	9.0044933E-06	3.5868721E-06	2.6107682E-05
8.0231443E-06	2.1452928E-06	2.4607013E-05	1.2474690E-05	3.2802841E-06	3.6112868E-05
9.7826476E-06	3.7398101E-06	3.0571137E-05	1.5721135E-05	6.3134277E-06	5.0159456E-05
1.3544884E-05	5.2650146E-06	4.4345011E-05	2.0407859E-05	7.8597035E-06	6.8073060E-05
2.3171147E-05	8.1405676E-06	8.4302281E-05	3.6768982E-05	1.1180766E-05	1.4496758E-04
2.9228312E-05	1.1515856E-05	1.3280906E-04	4.4400696E-05	1.6048669E-05	2.1872301E-04
3.9376354E-05	1.9016660E-05	1.2480509E-04	5.7608304E-05	3.0061763E-05	1.7532597E-04
5.0236748E-05	1.9746735E-05	1.1876462E-04	7.0507282E-05	3.0547307E-05	1.5773590E-04
7.4086367E-05	2.5693679E-05	1.9020424E-04	1.0135527E-04	3.5796184E-05	2.5593988E-04
1.0830280E-04	3.4339395E-05	4.3773122E-04	1.3988189E-04	4.9777072E-05	5.0889083E-04
1.9072512E-04	4.5521831E-05	6.1936952E-04	2.4334628E-04	4.8199614E-05	6.6981563E-04
2.1071782E-04	8.1463795E-05	4.6466499E-04	2.7055089E-04	8.3070730E-05	7.0658097E-04
3.6411696E-04	1.1786476E-04	1.2894554E-03	4.5070417E-04	1.6497639E-04	1.3963879E-03
4.3089018E-04	1.7121902E-04	1.3123292E-03	5.2089833E-04	2.1215331E-04	1.6445014E-03
7.3880014E-04	2.4474148E-04	2.3451423E-03	9.3725164E-04	2.6657689E-04	2.6703359E-03
8.9832717E-04	3.8997061E-04	2.9627841E-03	1.1212841E-03	4.6853705E-04	3.9732449E-03
1.1604227E-03	3.9303409E-04	3.6395207E-03	1.4851310E-03	5.6642024E-04	4.4442183E-03
1.9849824E-03	6.4345194E-04	6.3862311E-03	2.4978657E-03	8.8427175E-04	6.5720759E-03

ORIGINAL PAGE IS
OF POOR QUALITY

Table (4.15)

Wide Constant

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.23959120E+00	4.49950800E-06	2.25362580E-06	5.79903010E-06	2.71369860E-06
3.07585700E+00	6.03488470E-06	2.34013580E-06	8.25212490E-06	3.12739680E-06
4.31340940E+00	6.11766340E-06	2.16499090E-06	9.03074830E-06	3.28028110E-06
5.94708800E+00	8.46976760E-06	3.13721830E-06	1.29045580E-05	4.28089630E-06
8.26534350E+00	1.03765320E-05	3.15013430E-06	1.63444380E-05	4.71487370E-06
1.17580850E+01	1.54087320E-05	6.88319890E-06	2.53112440E-05	1.08843780E-05
1.64479550E+01	2.09556300E-05	8.94006540E-06	3.45678930E-05	1.41882190E-05
2.33008700E+01	3.00433960E-05	1.25956820E-05	4.87337120E-05	2.17488980E-05
3.29718540E+01	4.05604260E-05	1.85356190E-05	6.62311340E-05	3.06870120E-05
4.66893980E+01	5.41731720E-05	2.36143390E-05	8.75293140E-05	3.86600490E-05
6.57973680E+01	7.57461110E-05	2.87613840E-05	1.20430750E-04	4.44252180E-05
9.51947080E+01	1.20206310E-04	5.27744990E-05	1.82949330E-04	7.68572910E-05
1.31077820E+02	1.56685750E-04	5.79614850E-05	2.37767160E-04	8.97647920E-05
1.84987330E+02	2.14335730E-04	8.55375240E-05	3.06233640E-04	1.23983520E-04
2.62603050E+02	3.09529820E-04	1.39964180E-04	4.55940980E-04	1.91439630E-04
3.76989660E+02	4.21546930E-04	1.56126580E-04	6.11760600E-04	2.30647390E-04
5.30123390E+02	5.43499030E-04	1.89932020E-04	7.77579300E-04	2.64481180E-04
7.42560760E+02	8.19692340E-04	3.77418270E-04	1.17569600E-03	5.38174140E-04
1.04156250E+03	1.18067800E-03	4.76472650E-04	1.62987310E-03	6.31116650E-04

ORIGINAL PAGE IS
OF POOR QUALITY

Table (4.16)

Wide Constant

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
4.4995080E-06	1.9209998E-06	1.3198815E-05	5.7990301E-06	2.5276169E-06	1.6425134E-05
6.0348847E-06	1.9716609E-06	1.4009756E-05	8.2521249E-06	2.9397611E-06	1.8991333E-05
6.1176634E-06	3.4280808E-06	1.3734898E-05	9.0307483E-06	4.8589997E-06	2.0717784E-05
8.4697676E-06	3.7179966E-06	1.6235499E-05	1.2904558E-05	6.2589414E-06	2.4062155E-05
1.0376532E-05	4.1635993E-06	2.0239276E-05	1.6344438E-05	7.4545485E-06	3.0911920E-05
1.5408732E-05	7.1016105E-06	4.2644694E-05	2.5311244E-05	1.2288485E-05	7.0187503E-05
2.0955630E-05	9.8075360E-06	4.6495064E-05	3.4567893E-05	1.4991630E-05	7.7851406E-05
3.0043396E-05	1.2050644E-05	7.7485451E-05	4.8733712E-05	2.0099044E-05	1.3791052E-04
4.0560426E-05	1.4567395E-05	1.2237128E-04	6.6231134E-05	2.4533852E-05	2.0351557E-04
5.1173172E-05	2.5987473E-05	1.4407311E-04	8.7529314E-05	4.2455667E-05	2.3662188E-04
7.5746111E-05	3.4020272E-05	1.6601599E-04	1.2043075E-04	4.7863761E-05	2.5575412E-04
1.2320631E-04	4.5203039E-05	3.3191848E-04	1.8294933E-04	6.7816708E-05	4.3392169E-04
1.5669575E-04	8.3450947E-05	3.1523273E-04	2.3776716E-04	1.0904665E-04	5.4026907E-04
2.1433573E-04	9.0949966E-05	4.6889465E-04	3.0623364E-04	1.4675799E-04	7.0207429E-04
3.0952982E-04	1.3013568E-04	9.5291338E-04	4.5594098E-04	1.8389843E-04	1.1539485E-03
4.2154693E-04	1.6110834E-04	7.8751599E-04	6.1176060E-04	2.5922253E-04	1.1924994E-03
5.4349903E-04	2.4137306E-04	1.1736196E-03	7.7775793E-04	3.5997482E-04	1.6065648E-03
8.1969234E-04	3.4925577E-04	2.1724975E-03	1.1756960E-03	4.7535721E-04	3.1393511E-03
1.1806780E-03	4.9842309E-04	2.6022405E-03	1.6298731E-03	7.6529263E-04	3.6543391E-03

Figure (4.1)

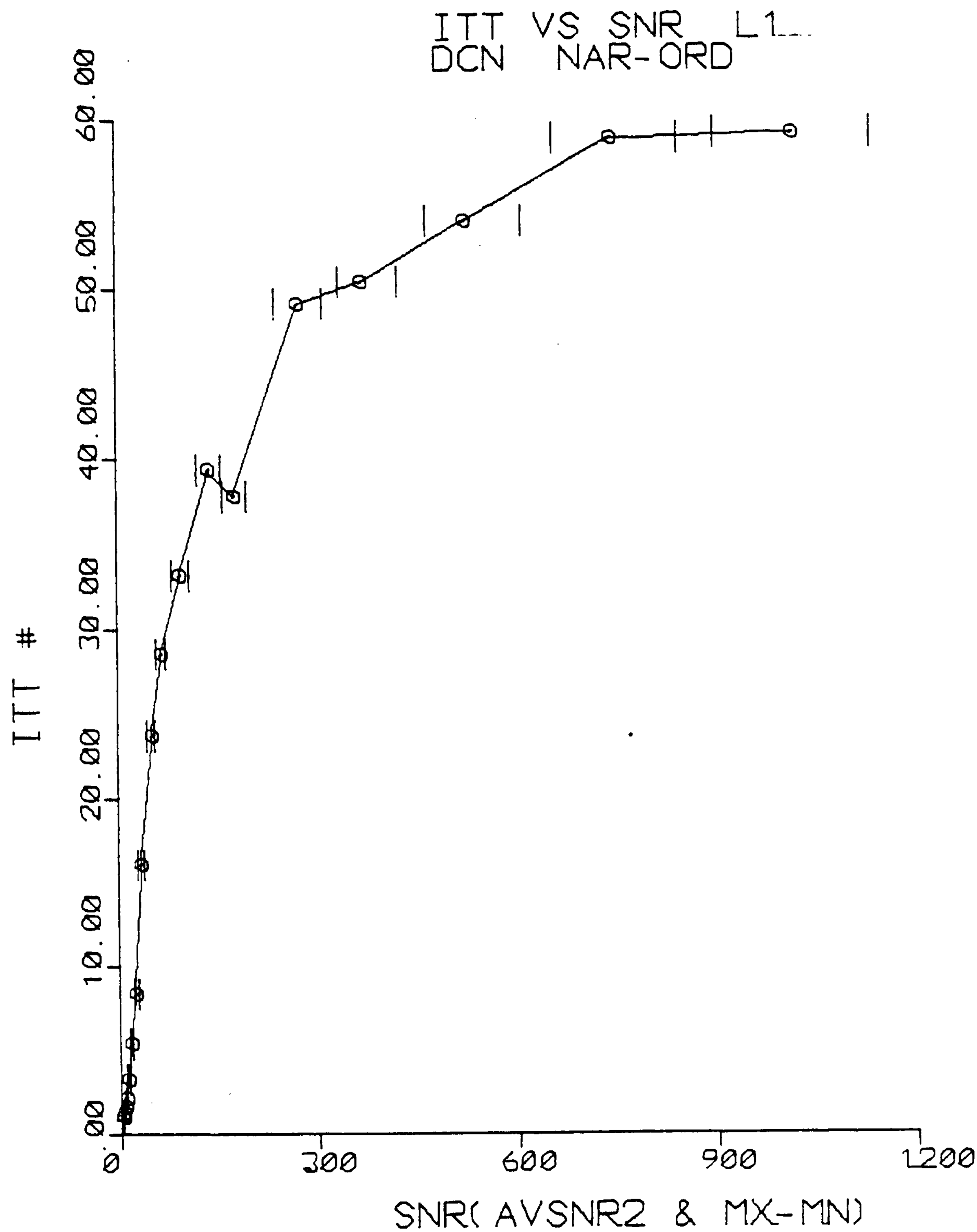

ITT VS SNR L1
DCN NAR-ORD
ITT #
60.00
50.00
40.00
30.00
20.00
10.00
00
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.2)

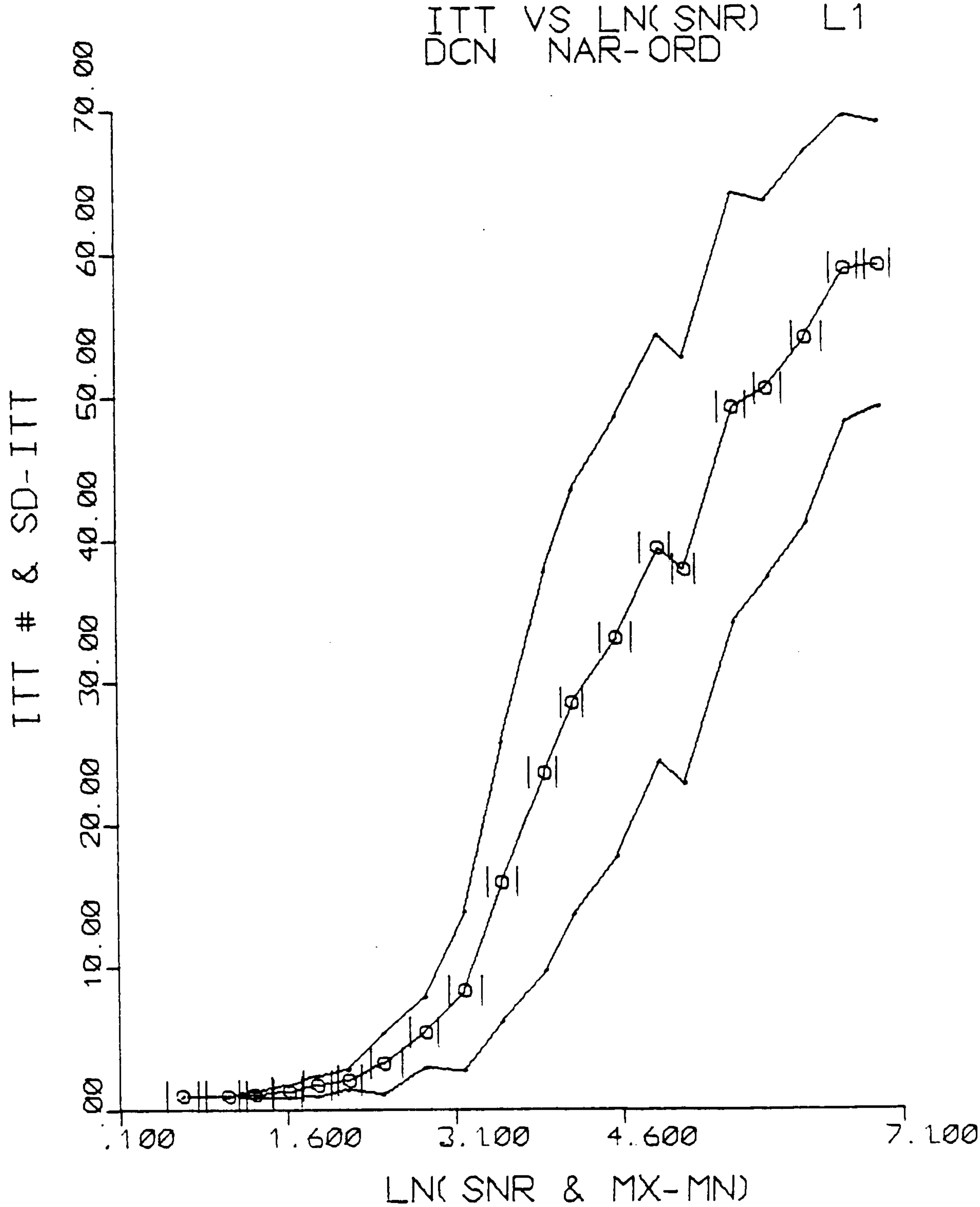

ITT VS LN(SNR) L1
DCN NAR-ORD
ITT # & SD-ITT
70.00
60.00
50.00
40.00
30.00
20.00
10.00
00
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (4.3)

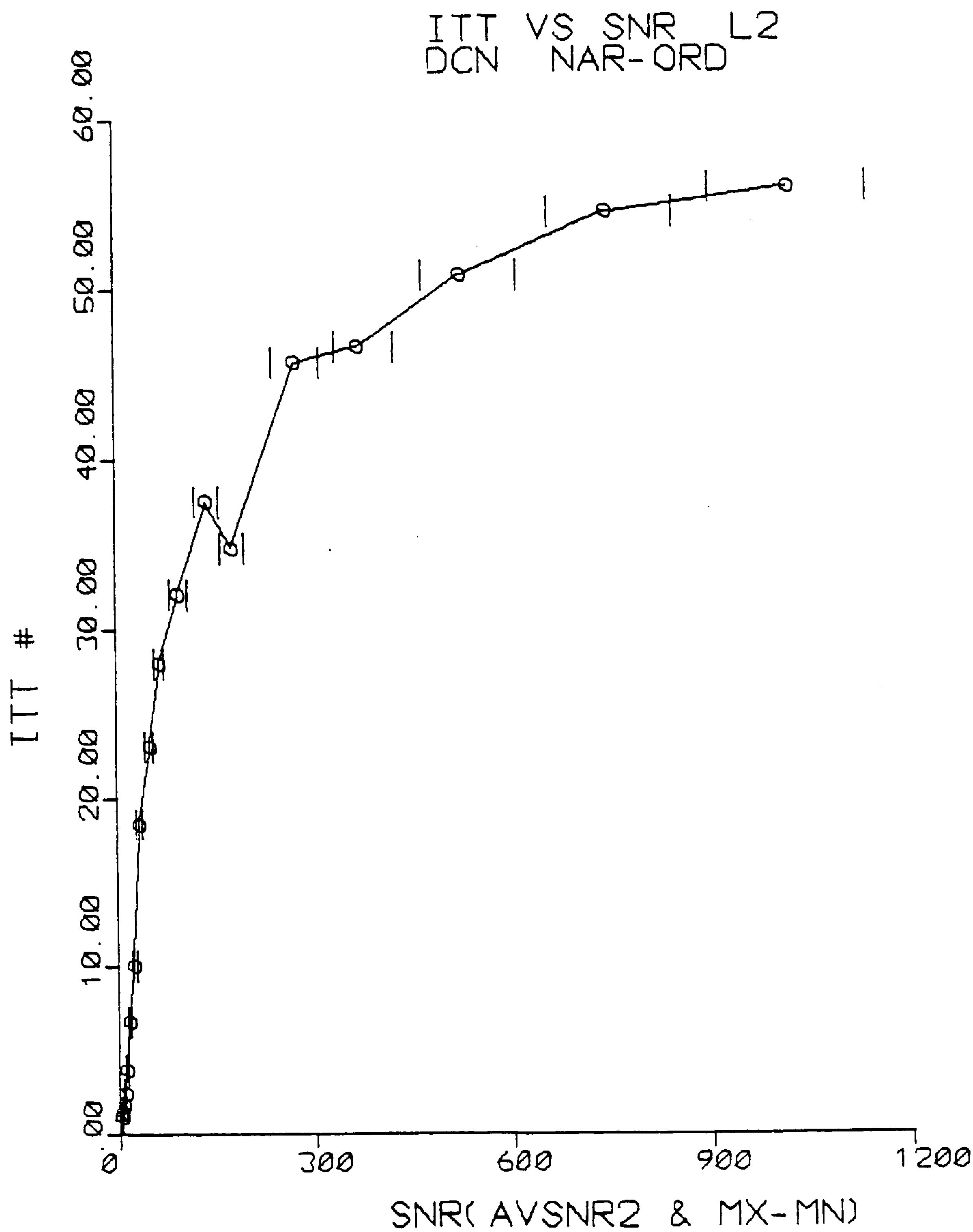
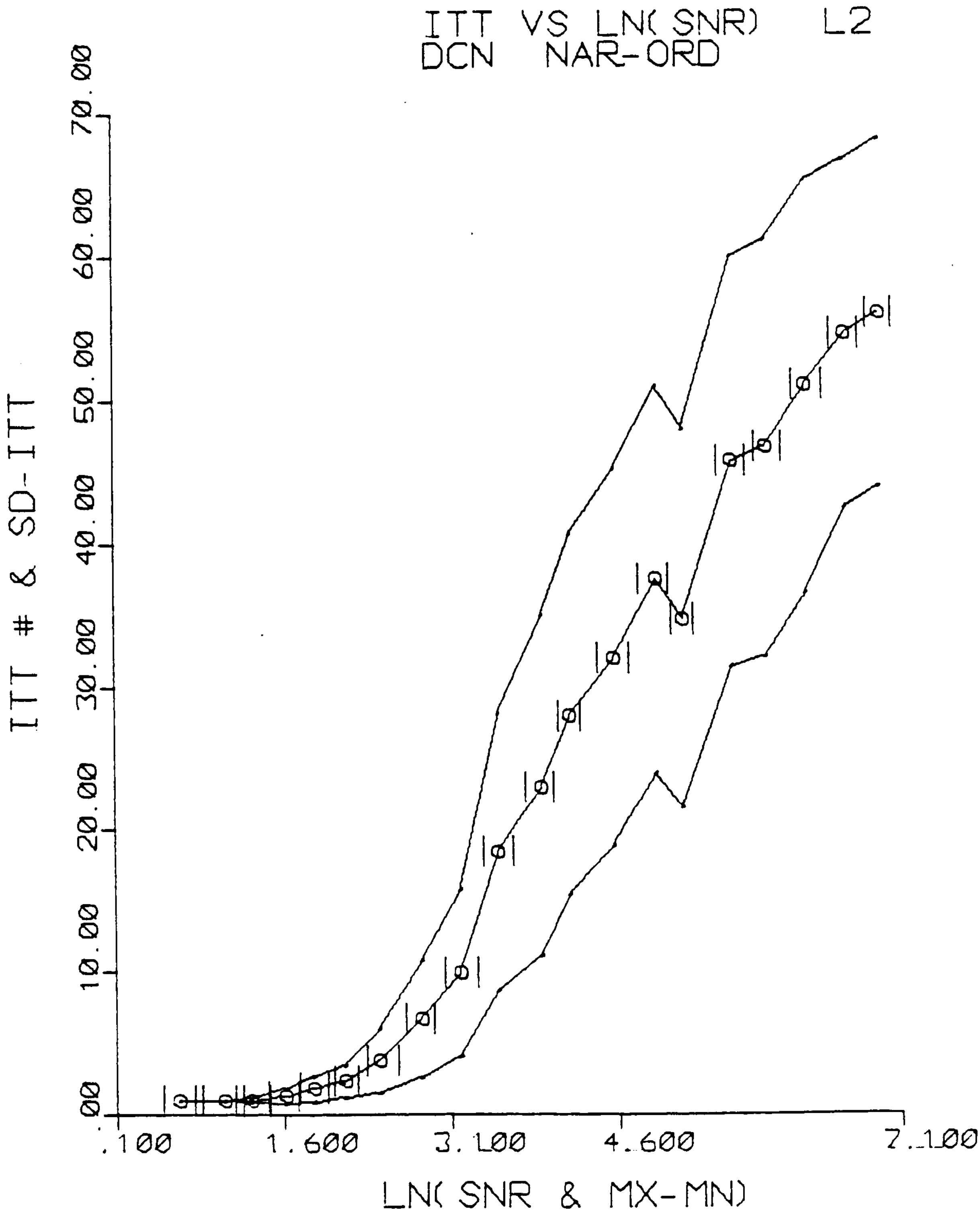

ITT VS SNR L2
DCN NAR-ORD
ITT #
60.00
50.00
40.00
30.00
20.00
10.00
00
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.4)



ITT VS LN(SNR) L2
DCN NAR-ORD
ITT # & SD-ITT
70.00
60.00
50.00
40.00
30.00
20.00
10.00
.00
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (4.5)

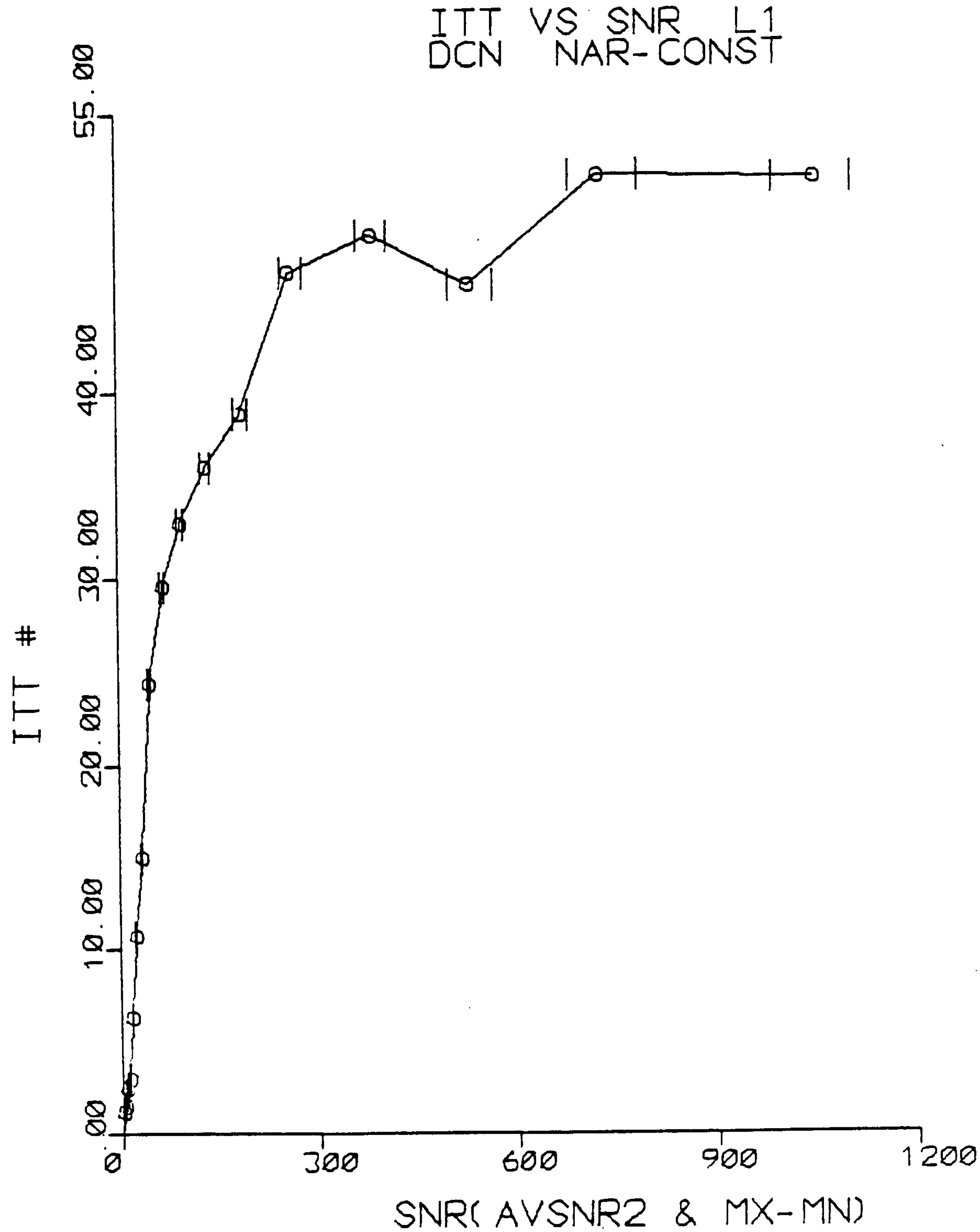

ITT VS SNR L1
DCN NAR-CONST
55.00
40.00
30.00
20.00
10.00
00
ITT #
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.6)

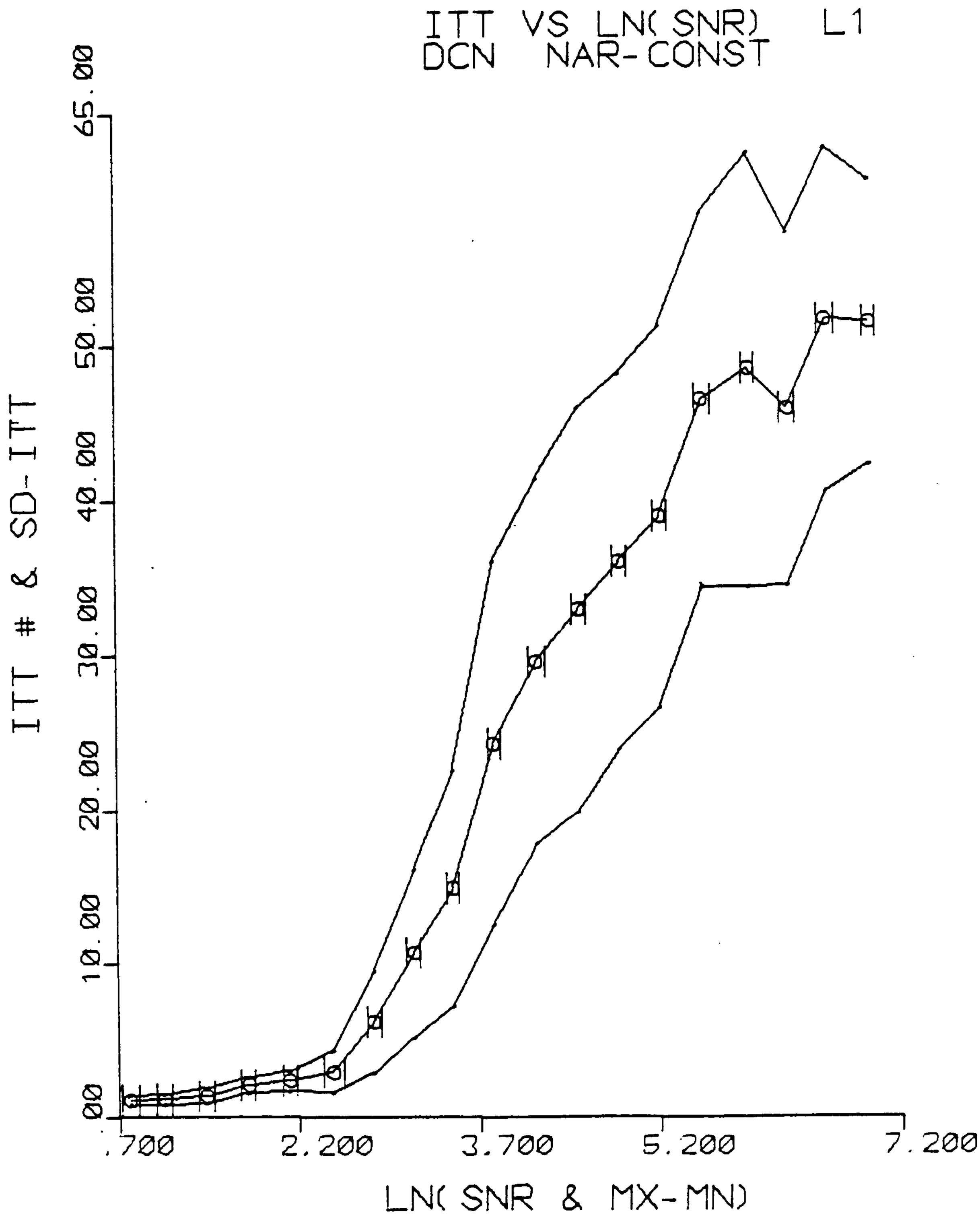

ITT VS LN(SNR) L1
DCN NAR-CONST
ITT # & SD-ITT
65.00
50.00
40.00
30.00
20.00
10.00
00
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (4.7)

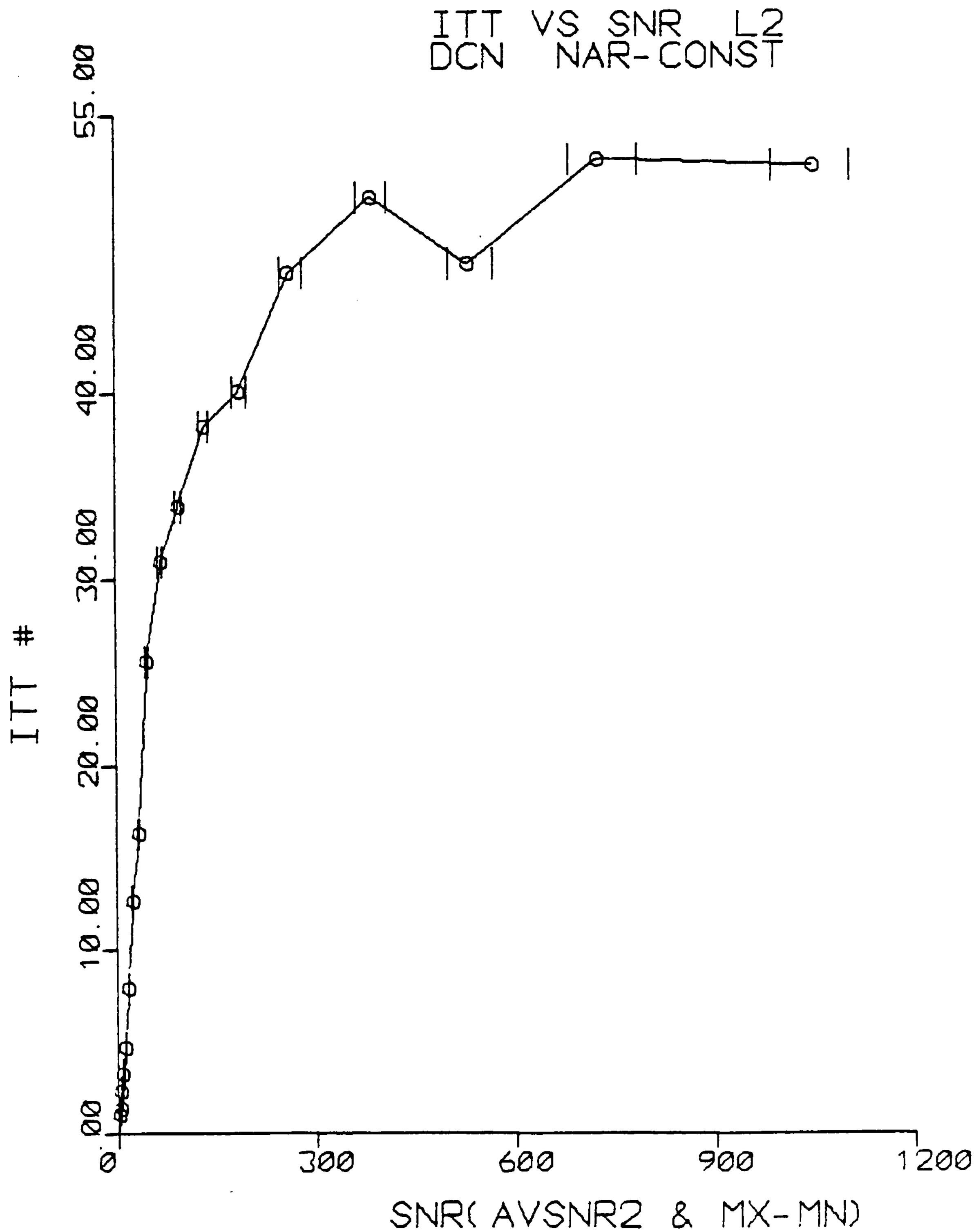

ITT VS SNR L2
DCN NAR-CONST
ITT #
55.00
40.00
30.00
20.00
10.00
00
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.8)

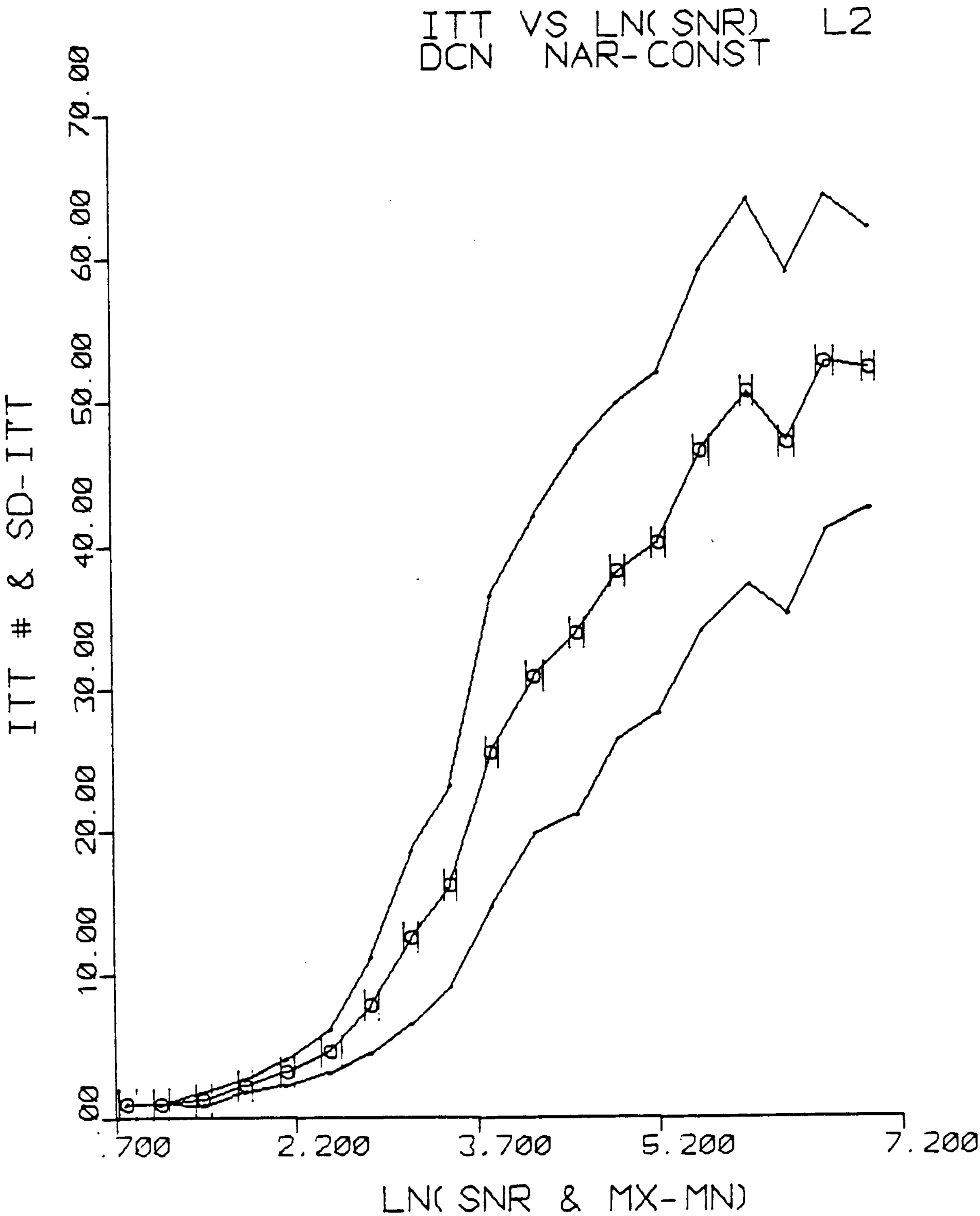

ITT VS LN(SNR) L2
DCN NAR-CONST
ITT # & SD-ITT
LN(SNR & MX-MN)
.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
.700
2.200
3.700
5.200
7.200

Figure (4.9)

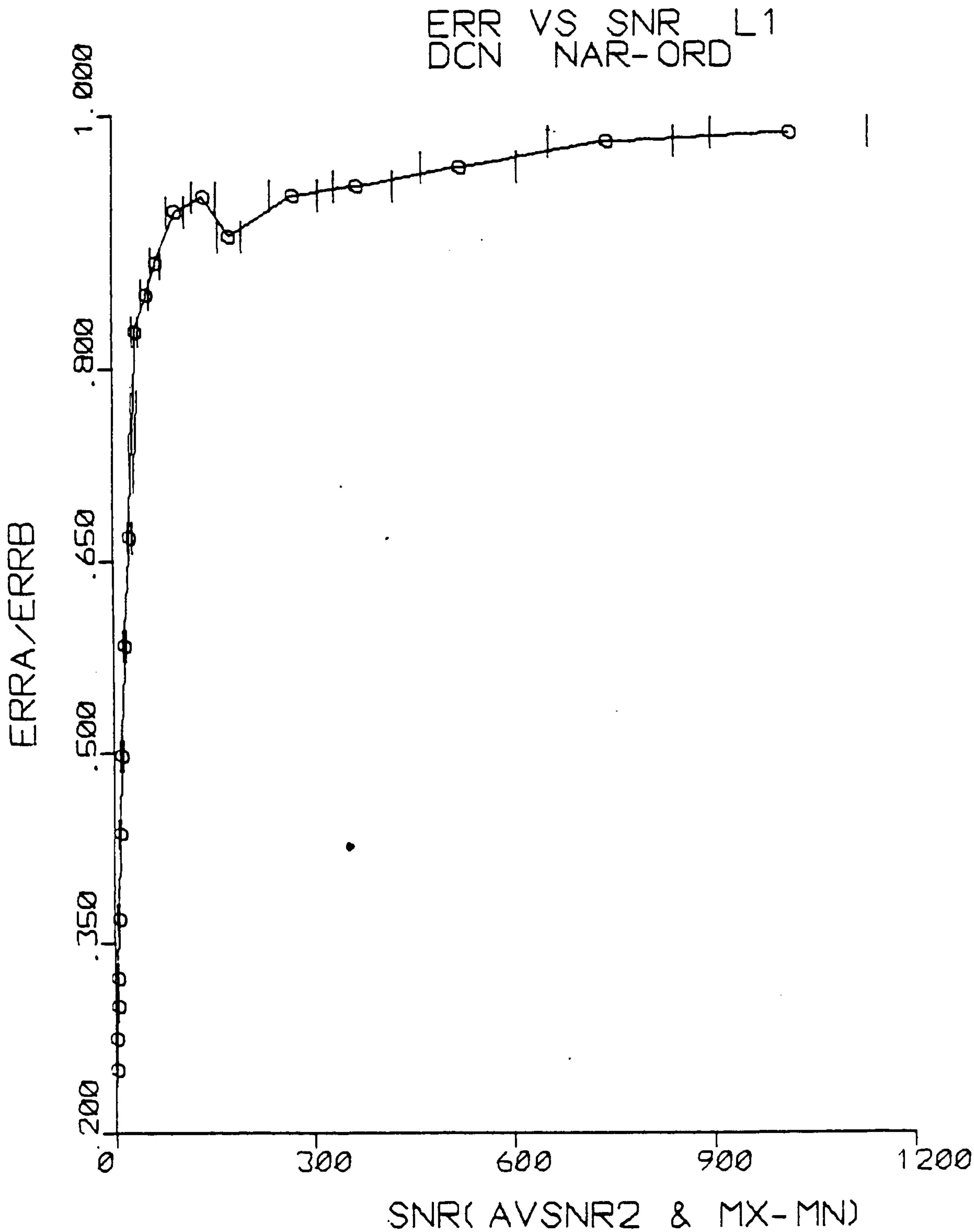

ERR VS SNR L1
DCN NAR-ORD
ERRA/ERRB
1.000
.800
.650
.500
.350
.200
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.10)

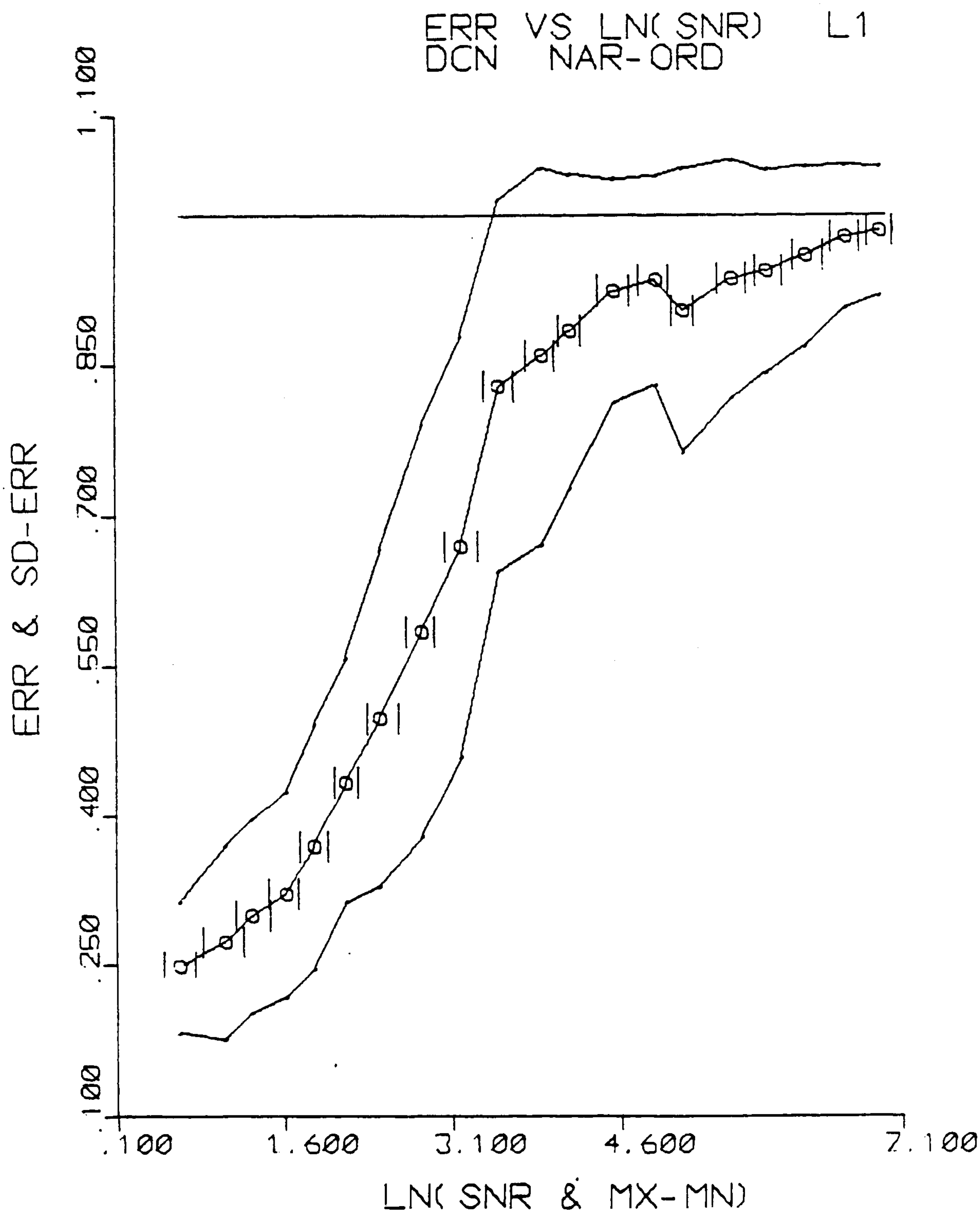

ERR VS LN(SNR) L1
DCN NAR-ORD
ERR & SD-ERR
1.100
.850
.700
.550
.400
.250
.100
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (4.11)

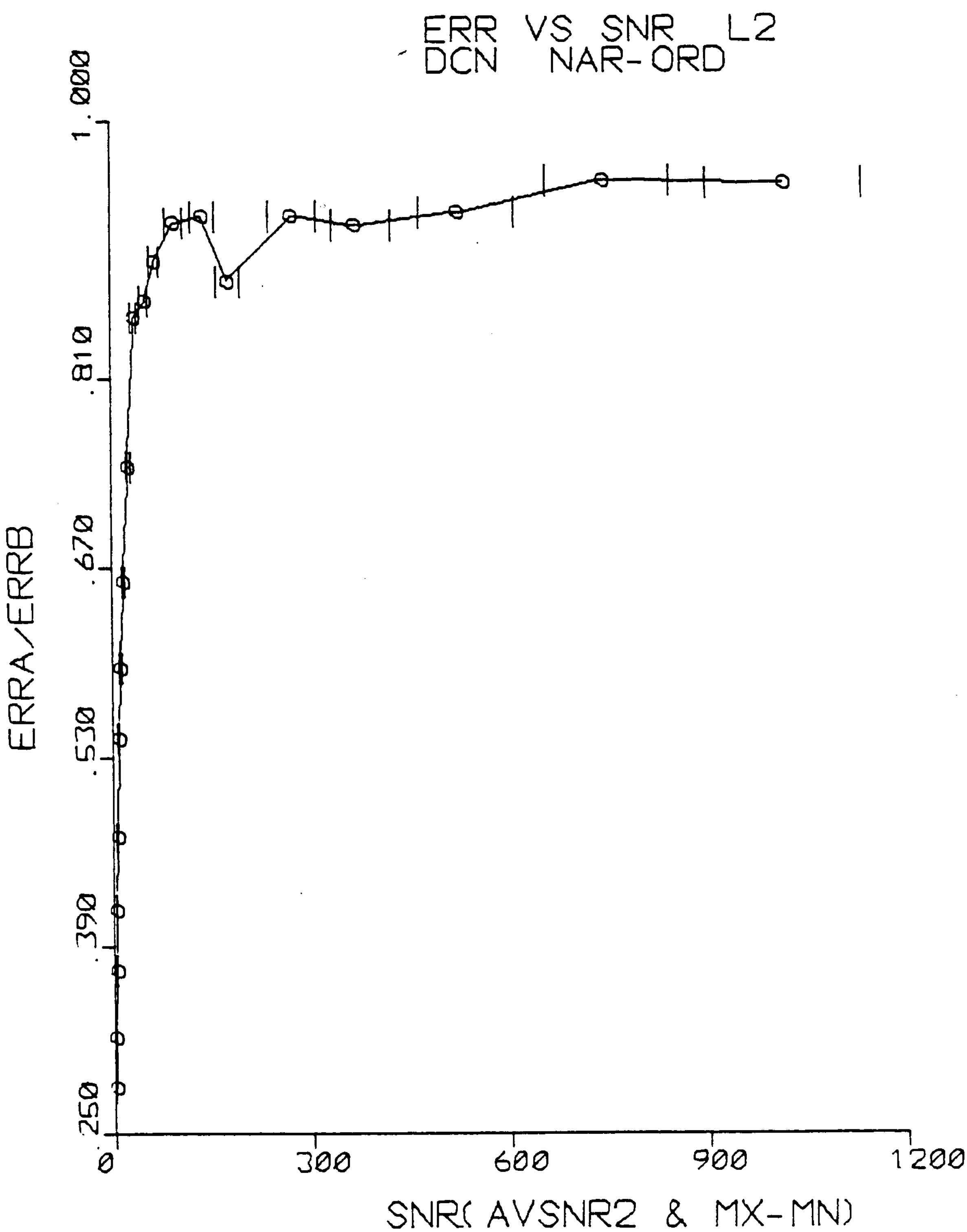

ERR VS SNR L2
DCN NAR-ORD
1.000
.810
.670
.530
.390
.250
ERRA/ERRB
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.12)

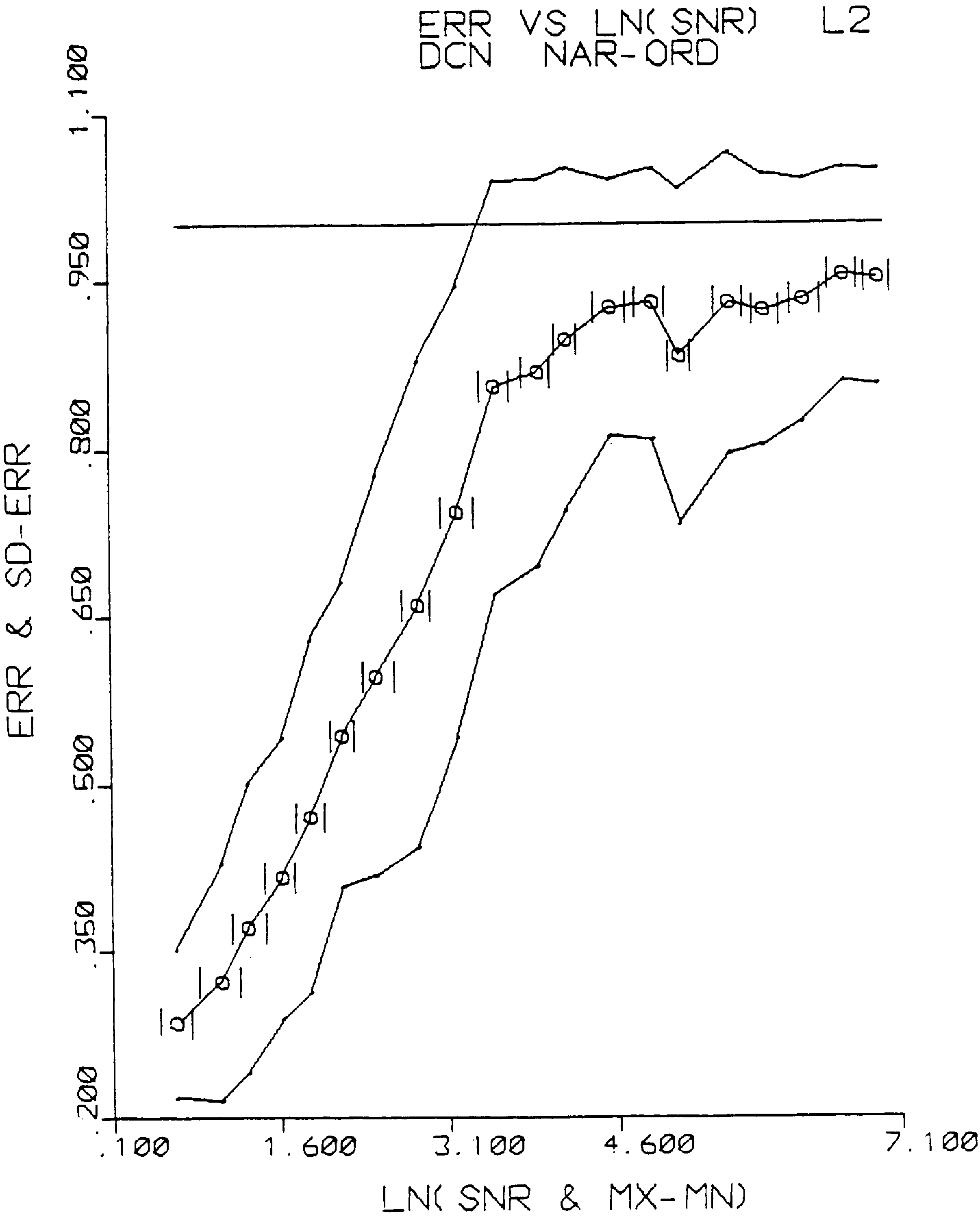

ERR VS LN(SNR) L2
DCN NAR-ORD
ERR & SD-ERR
1.100
.950
.800
.650
.500
.350
.200
.100
1.600
3.100
4.600
7.100
LN(SNR & MX-MN)

Figure (4.13)

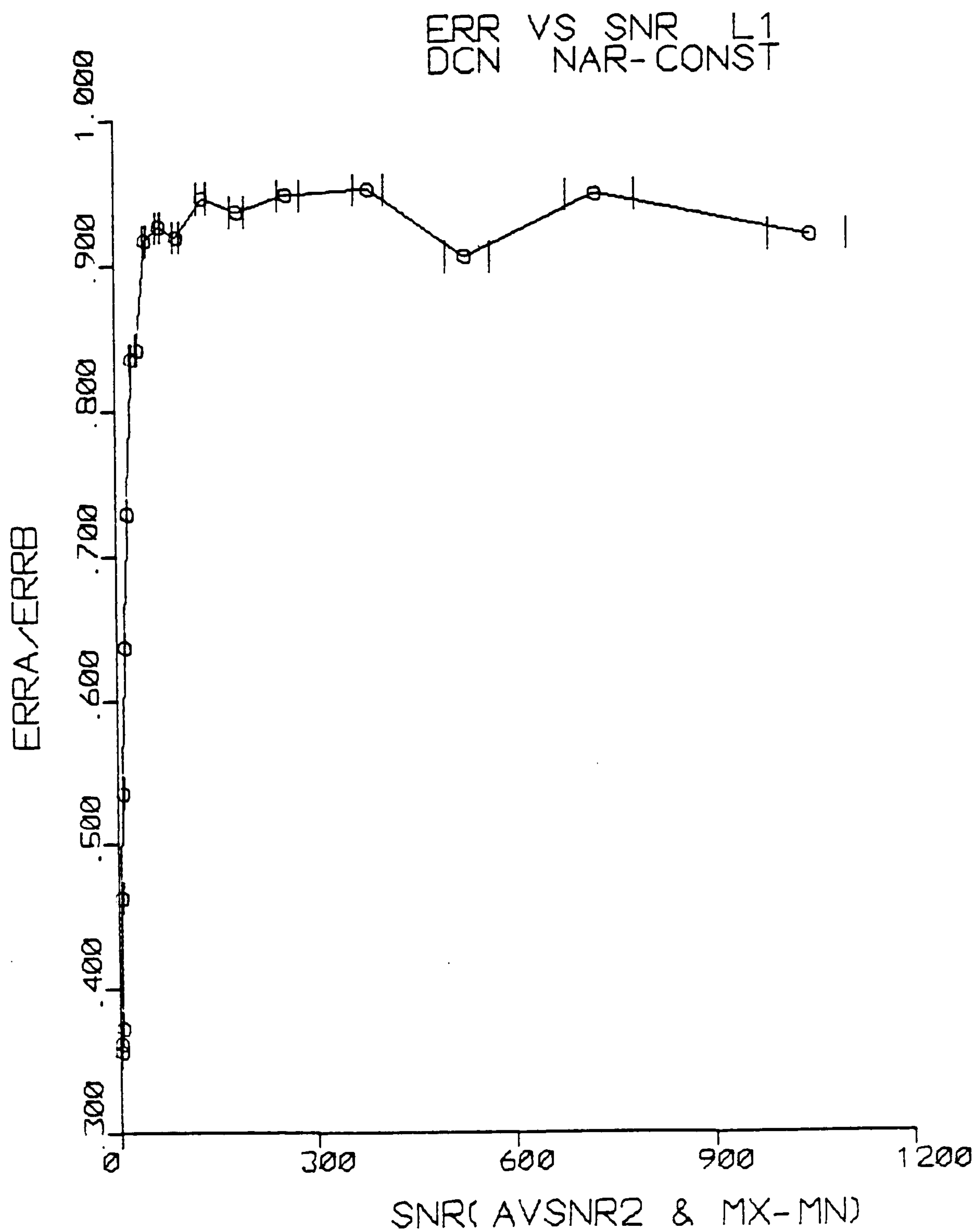

ERR VS SNR L1
DCN NAR-CONST
ERRA/ERRB
1.000
.900
.800
.700
.600
.500
.400
.300
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.14)

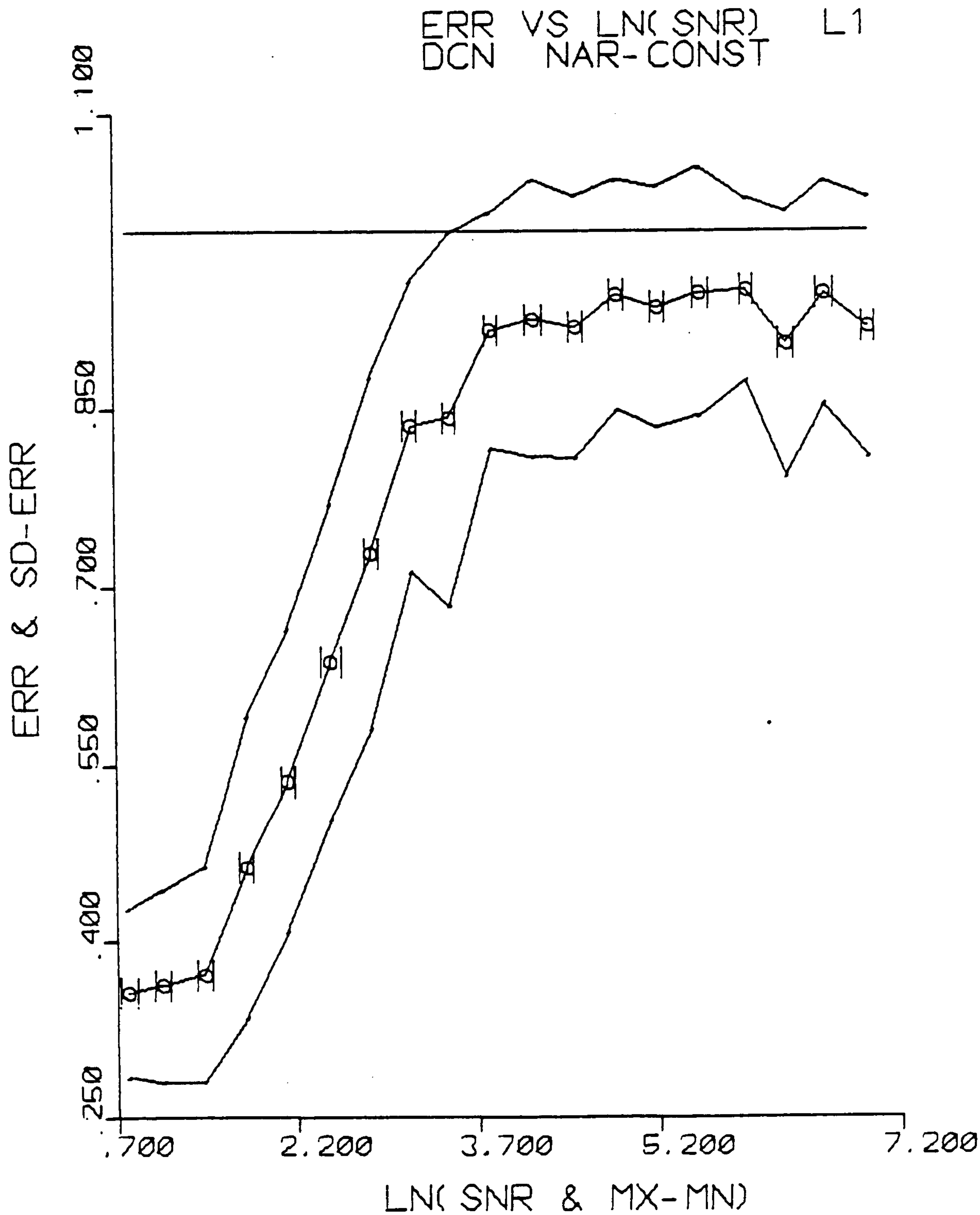

ERR VS LN(SNR) L1
DCN NAR-CONST
1.100
.850
.700
.550
.400
.250
ERR & SD-ERR
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (4.15)

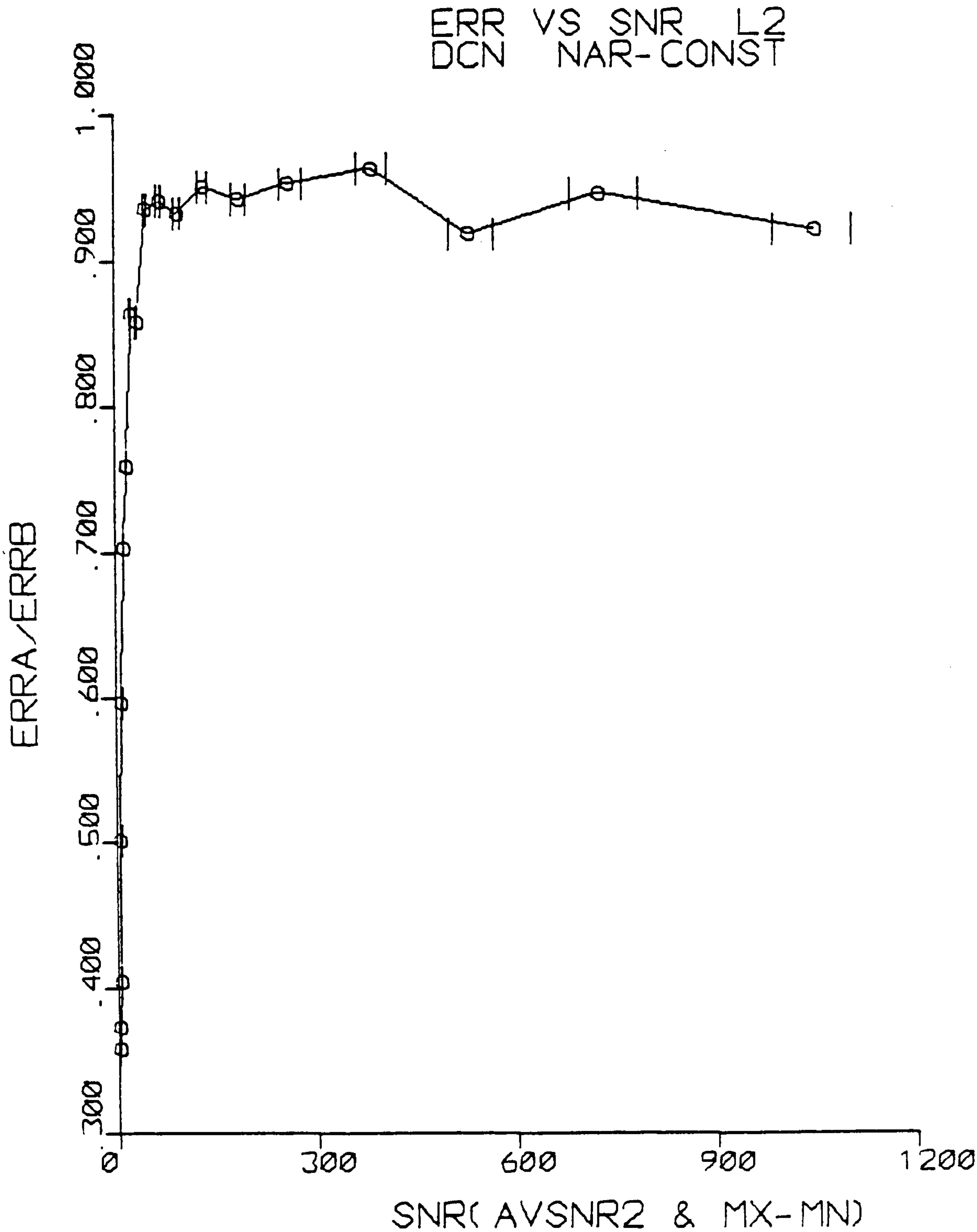

ERR VS SNR L2
DCN NAR-CONST
ERRA/ERRB
SNR(AVSNR2 & MX-MN)
.300
.400
.500
.600
.700
.800
.900
1.000
0
300
600
900
1200

Figure (4.16)

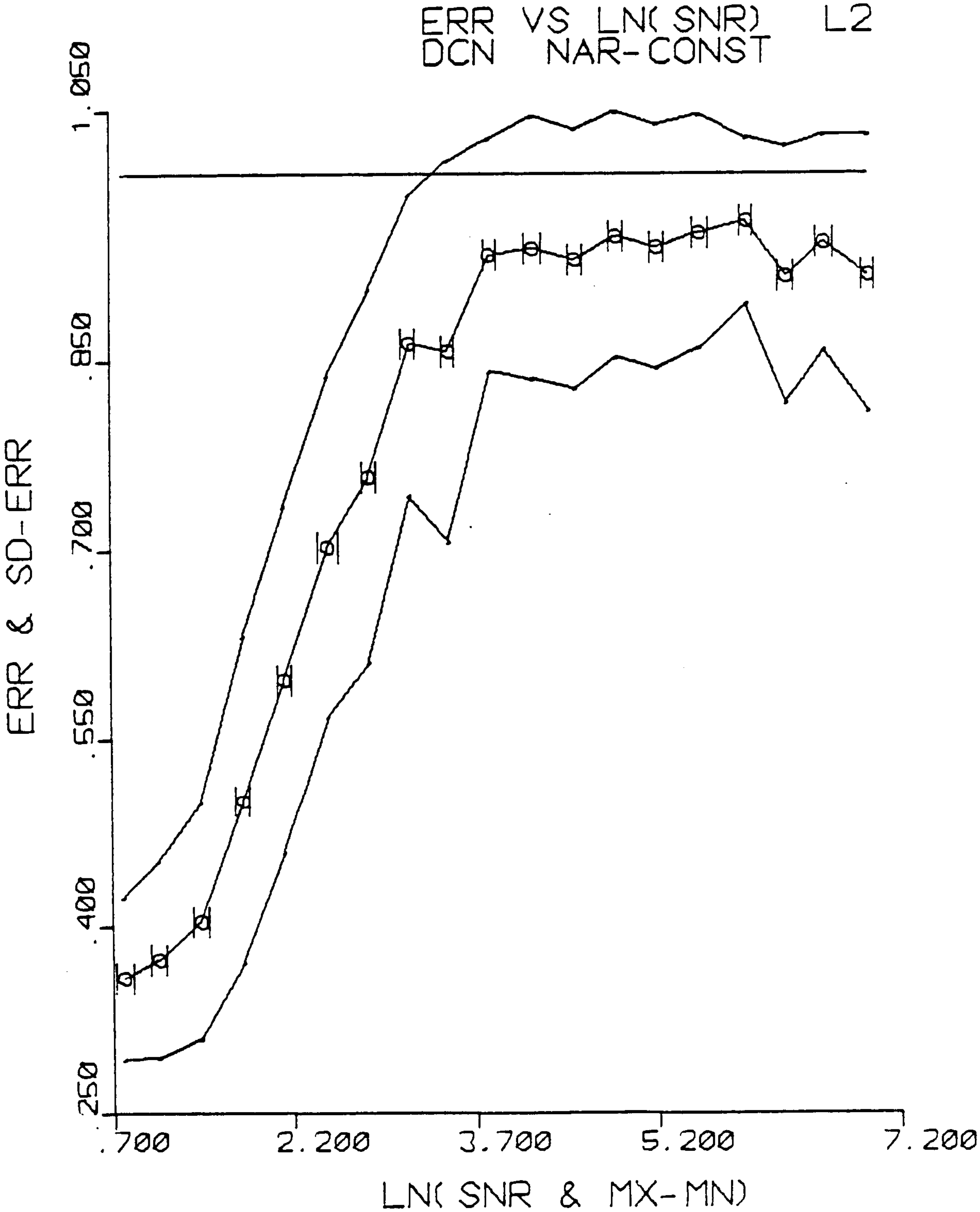

ERR VS LN(SNR) L2
DCN NAR-CONST
ERR & SD-ERR
1.050
.850
.700
.550
.400
.250
.700
2.200
3.700
5.200
7.200
LN(SNR & MX-MN)

Figure (4.17)

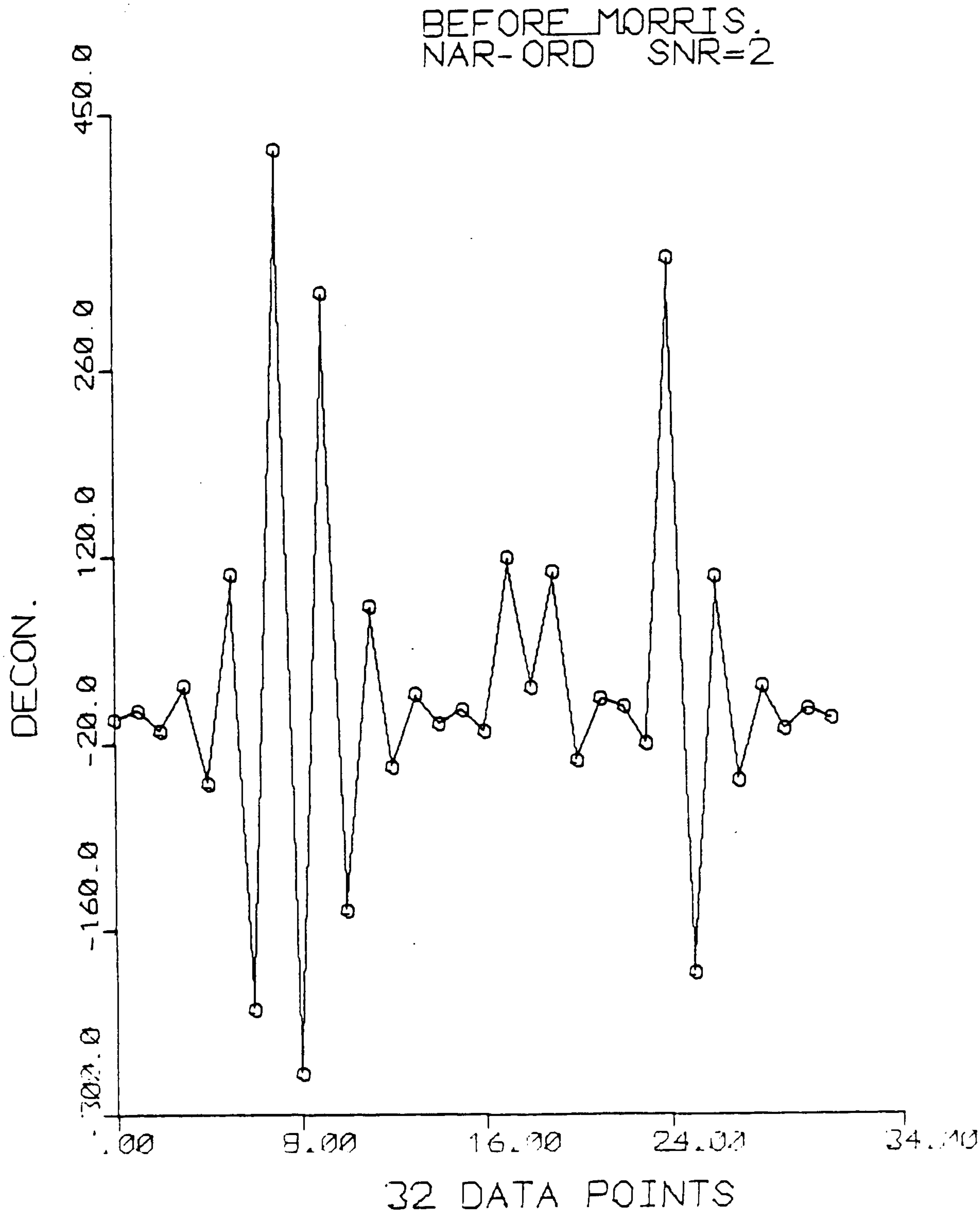

BEFORE MORRIS.
NAR-ORD SNR=2
DECON.
450.0
260.0
120.0
-20.0
-160.0
.00
8.00
16.00
24.00
32 DATA POINTS

Figure (4.18)

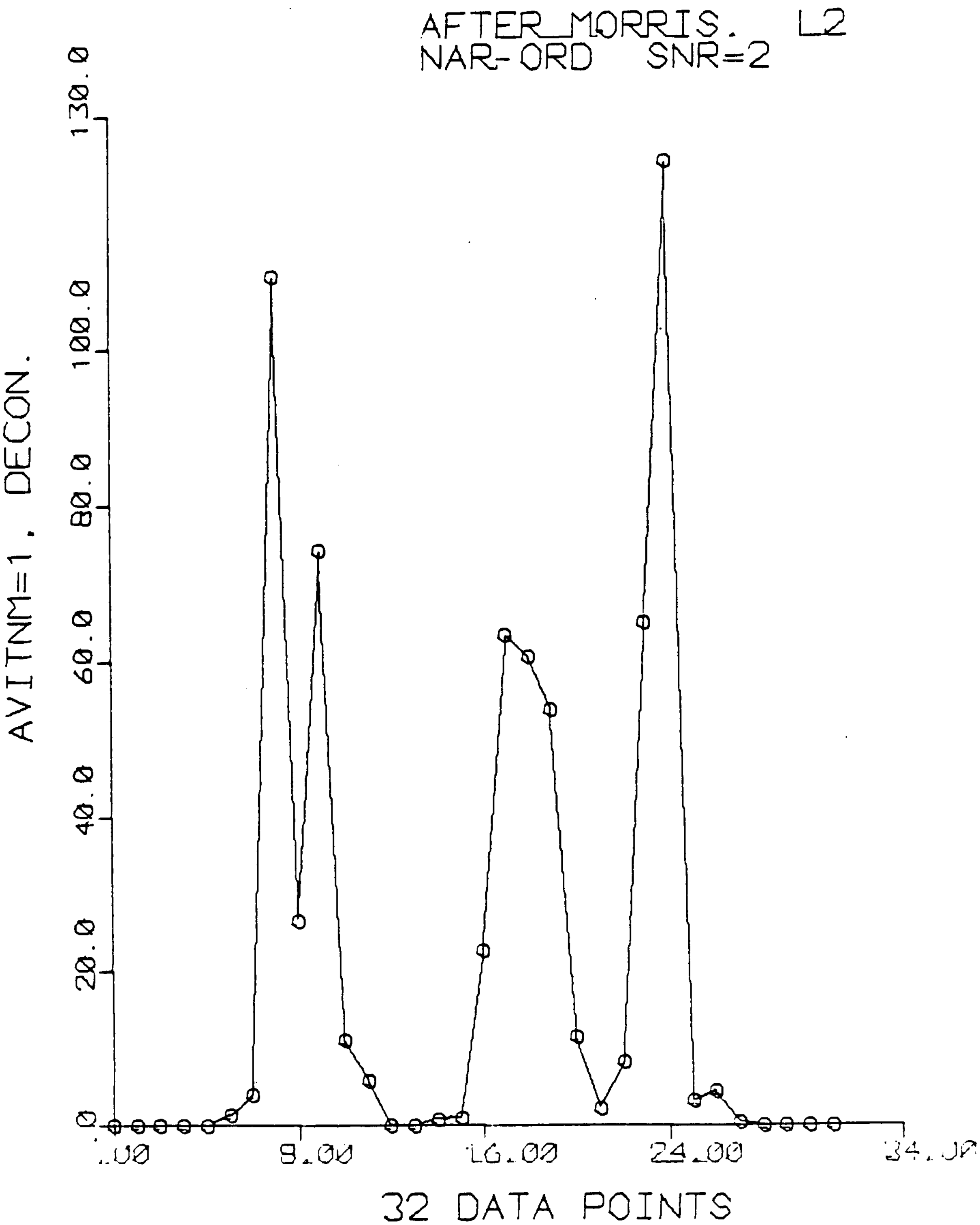

AFTER_MORRIS. L2
NAR-ORD SNR=2
AVITNM=1. DECON.
130.0
100.0
80.0
60.0
40.0
20.0
0
.00
8.00
16.00
24.00
32 DATA POINTS

Figure (4.19)

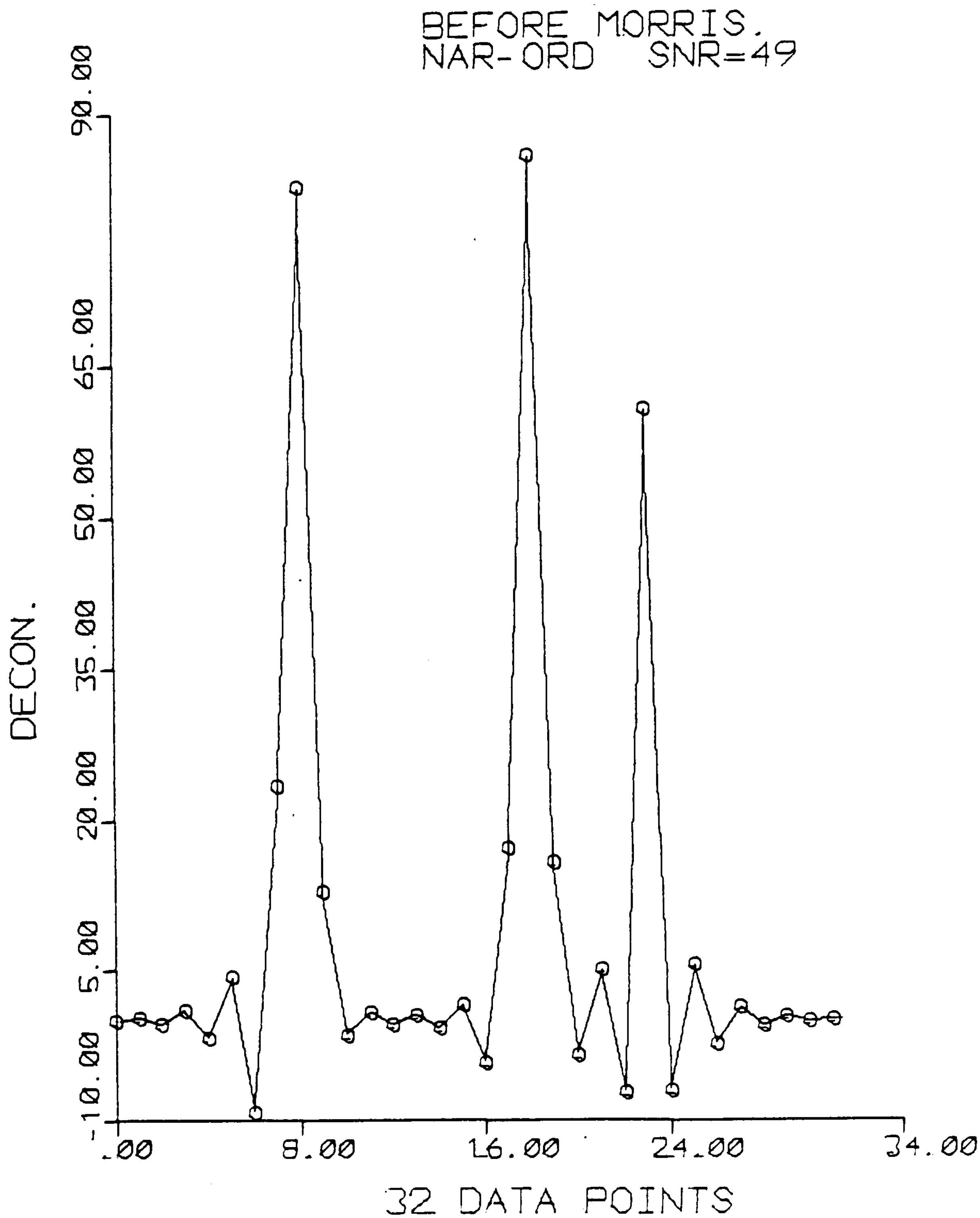

BEFORE MORRIS.
NAR-ORD SNR=49
DECON.
90.00
65.00
50.00
35.00
20.00
5.00
-10.00
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.20)

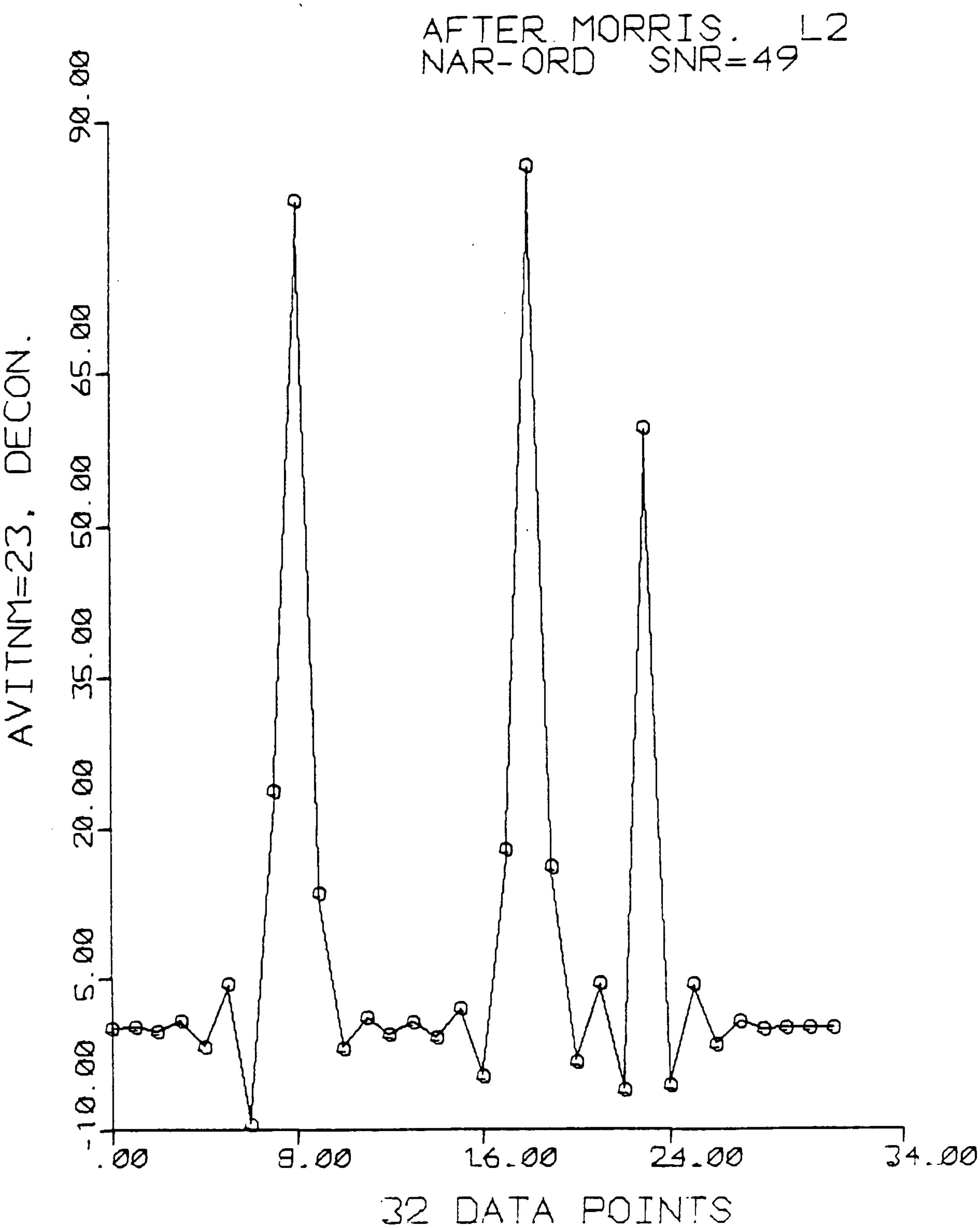

AFTER MORRIS. L2
NAR-ORD SNR=49
AVITNM=23. DECON.
90.00
65.00
50.00
35.00
20.00
5.00
-10.00
.00
9.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.21)

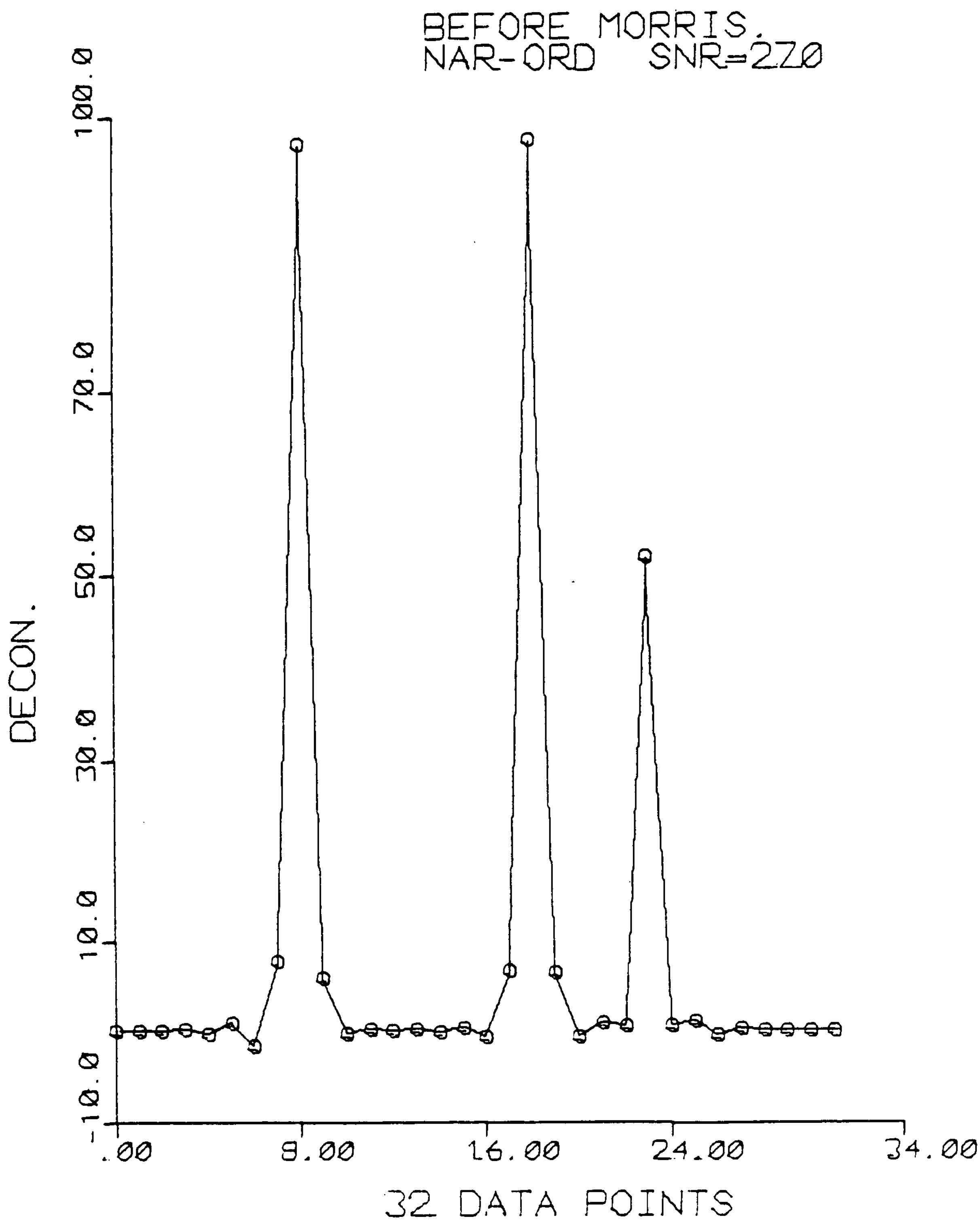

BEFORE MORRIS.
NAR-ORD SNR=270
DECON.
100.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.22)

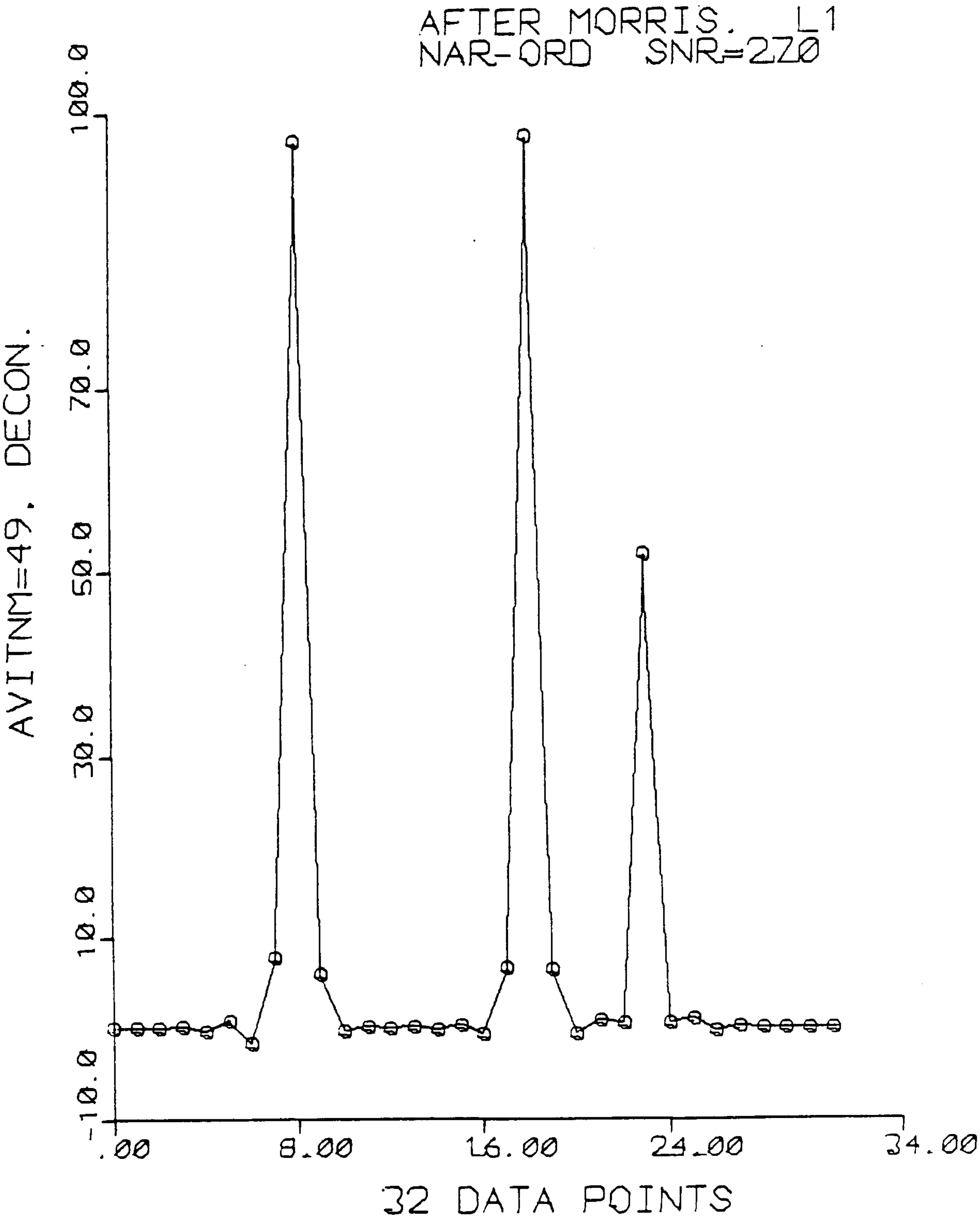

AFTER MORRIS. L1
NAR-ORD SNR=220
AVITNM=49. DECON.
-10.0
10.0
30.0
50.0
70.0
100.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.23)

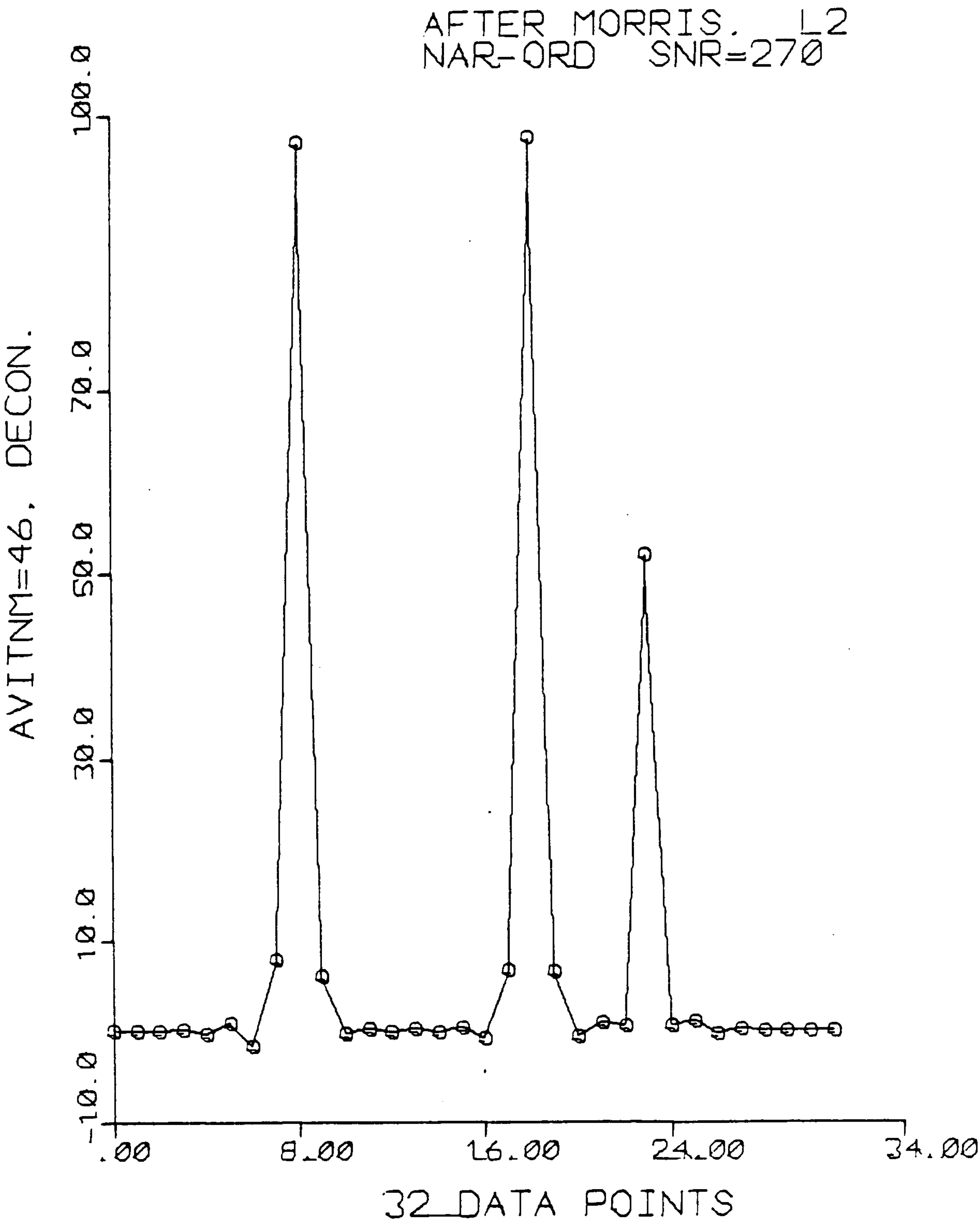

AFTER MORRIS. L2
NAR-ORD SNR=270
AVITNM=46. DECON.
100.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.24)

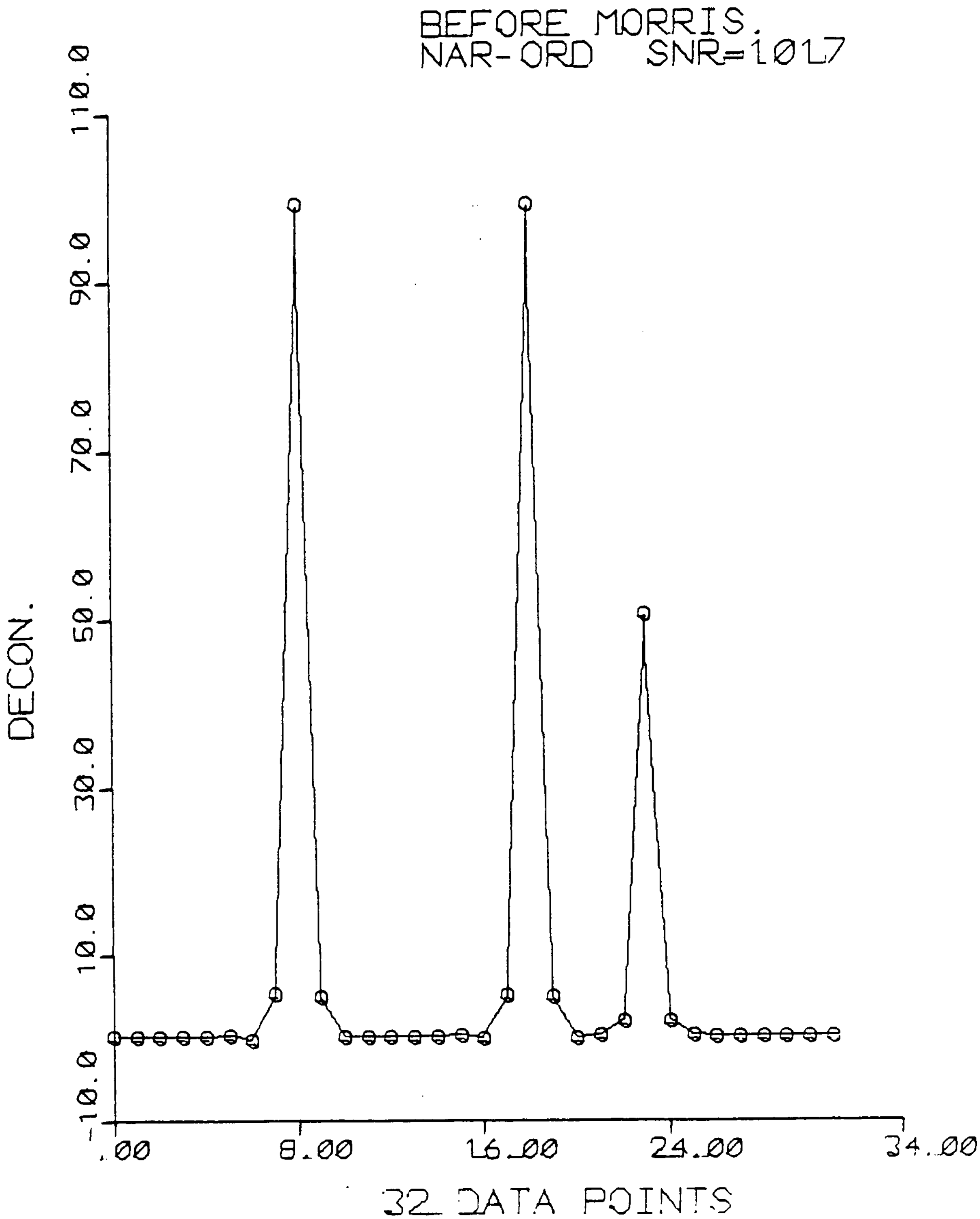
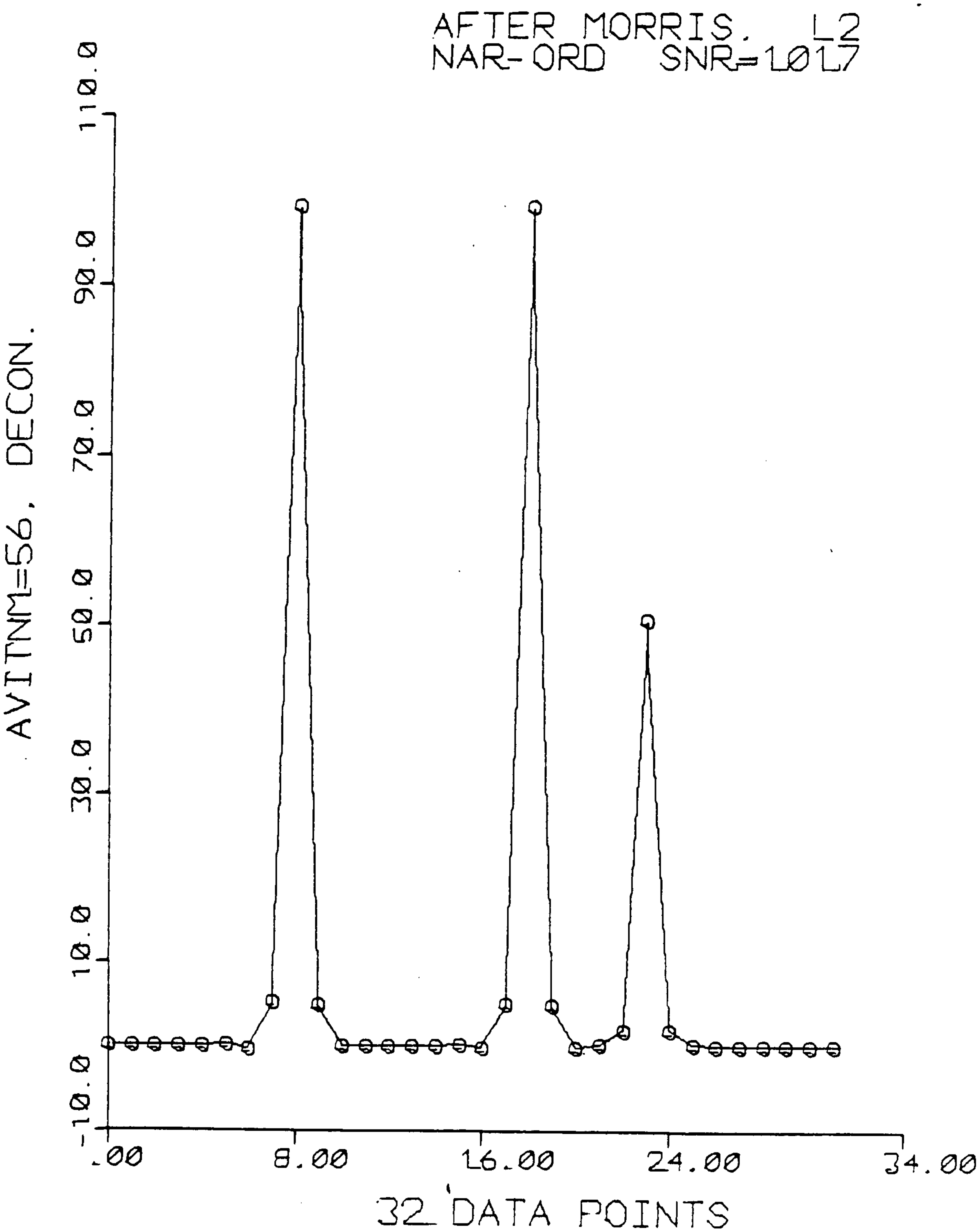

BEFORE MORRIS.
NAR-ORD SNR=1017
DECON.
-10.0
10.0
30.0
50.0
70.0
90.0
110.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.25)


AFTER MORRIS. L2
NAR-ORD SNR=10L7
AVITNM=56, DECON.
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

ORIGINAL PAGE IS
OF POOR QUALITY

Figure (4.26)

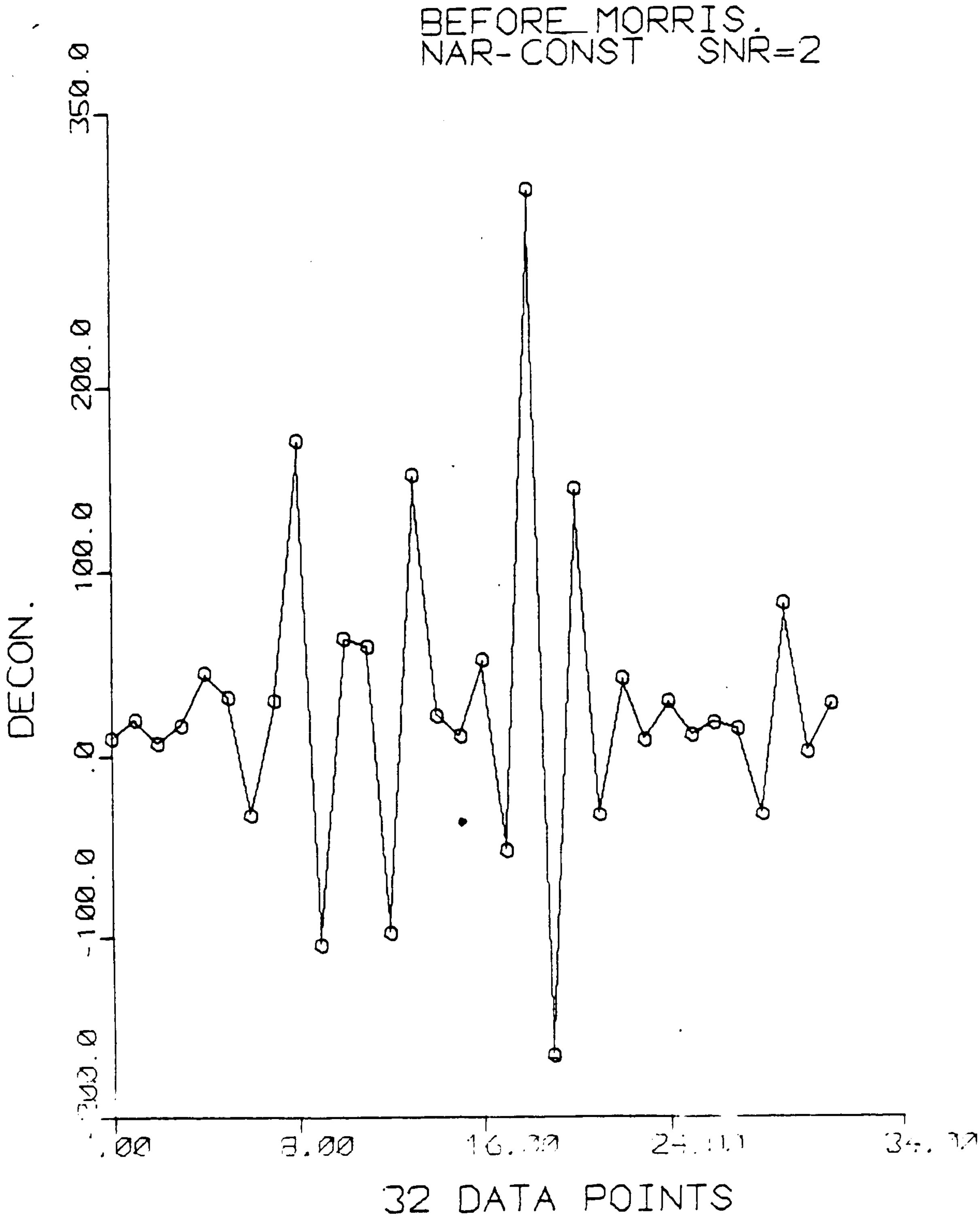


Figure (4.27)

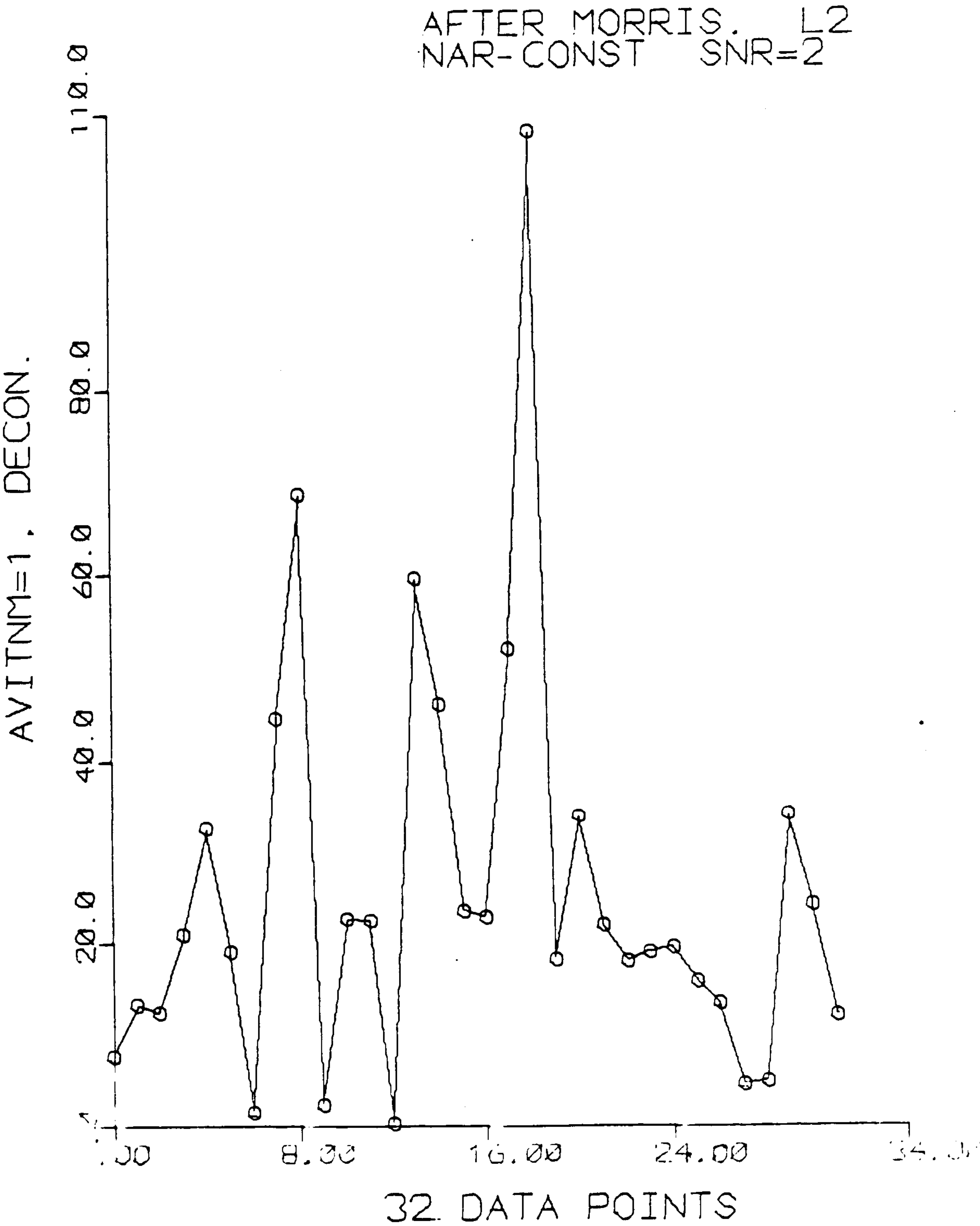

AFTER MORRIS. L2
NAR-CONST SNR=2
AVITNM=1. DECON.
110.0
80.0
60.0
40.0
20.0
8.00
16.00
24.00
32. DATA POINTS

Figure (4.28)

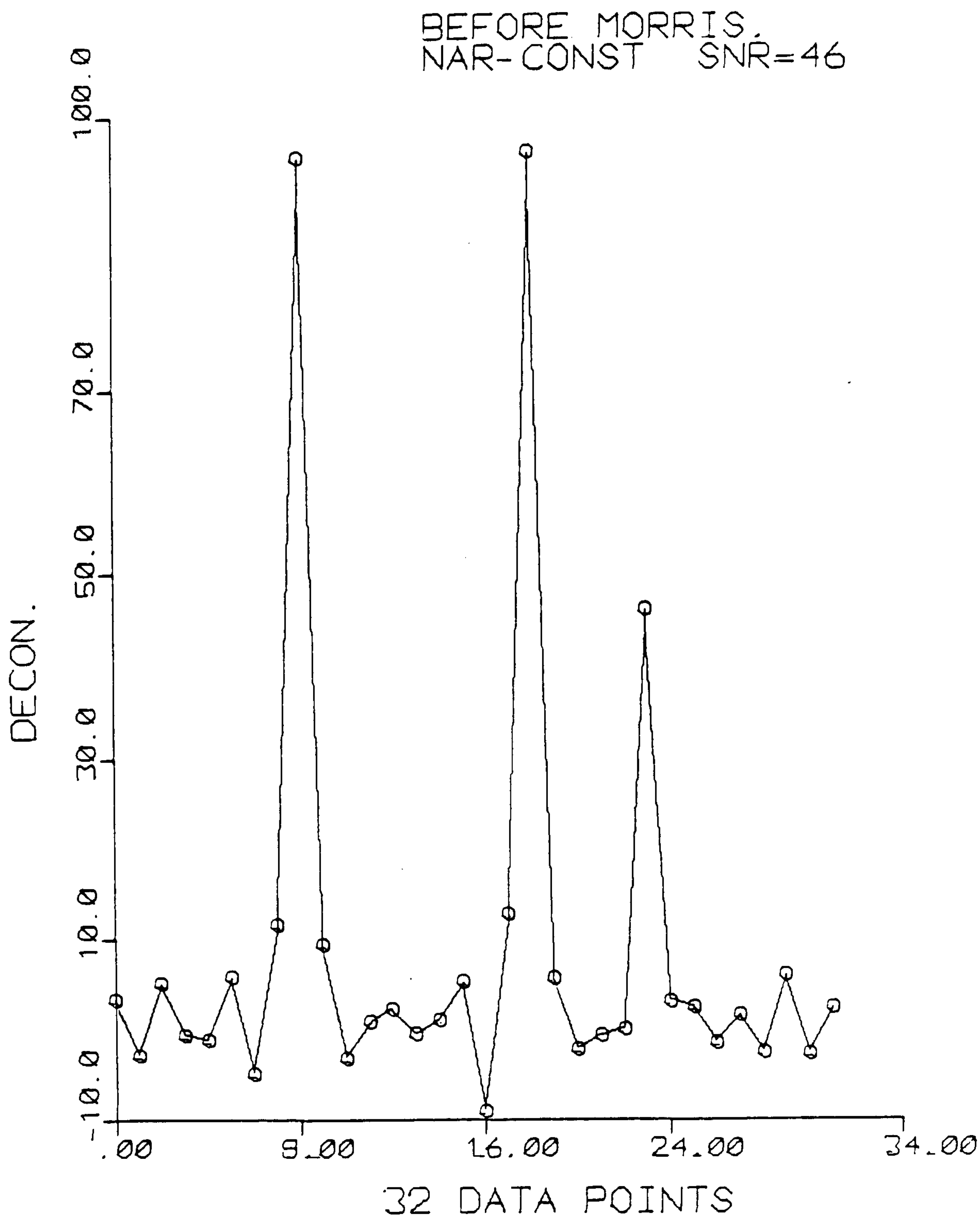

BEFORE MORRIS.
NAR-CONST SNR=46
DECON.
100.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.29)

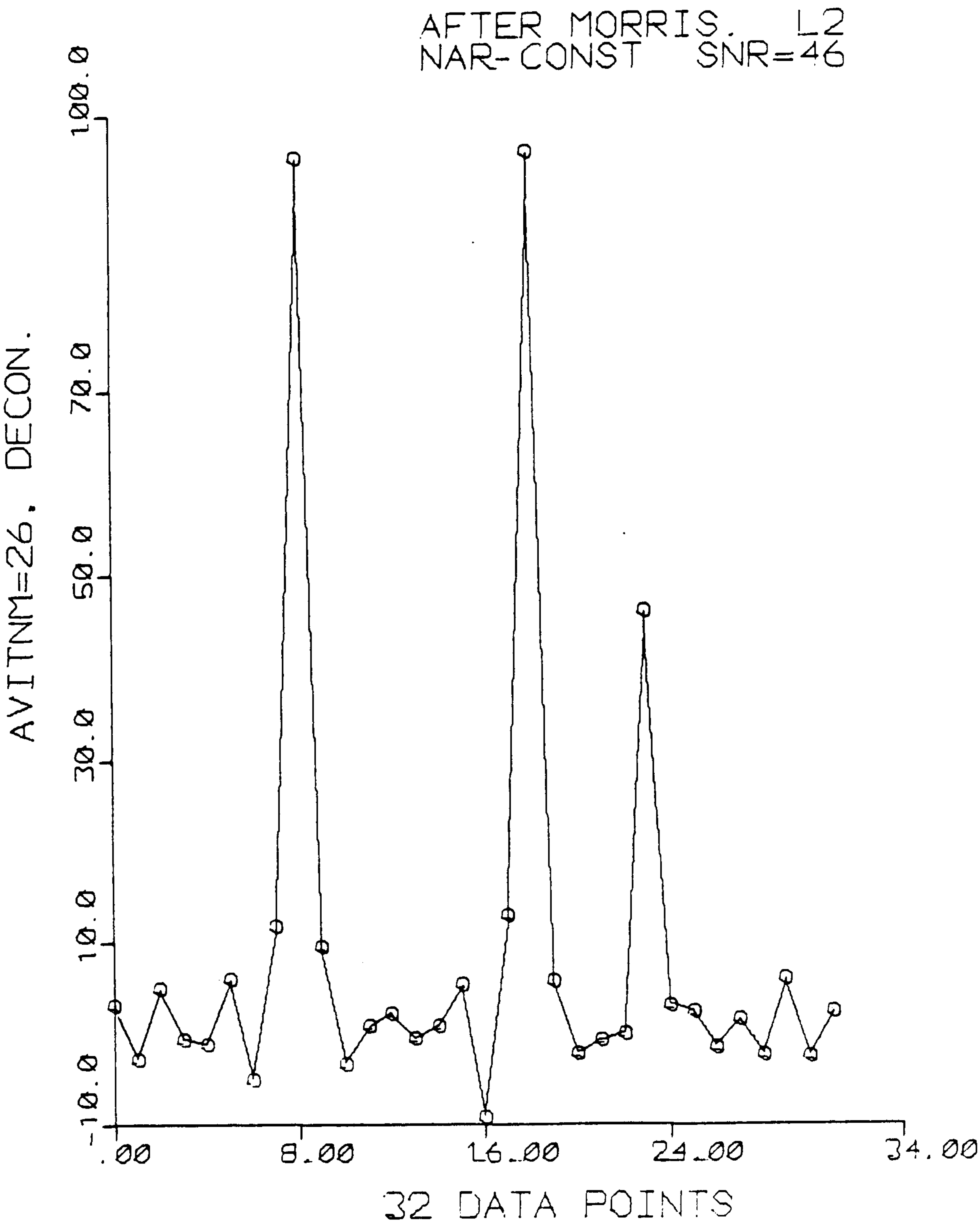
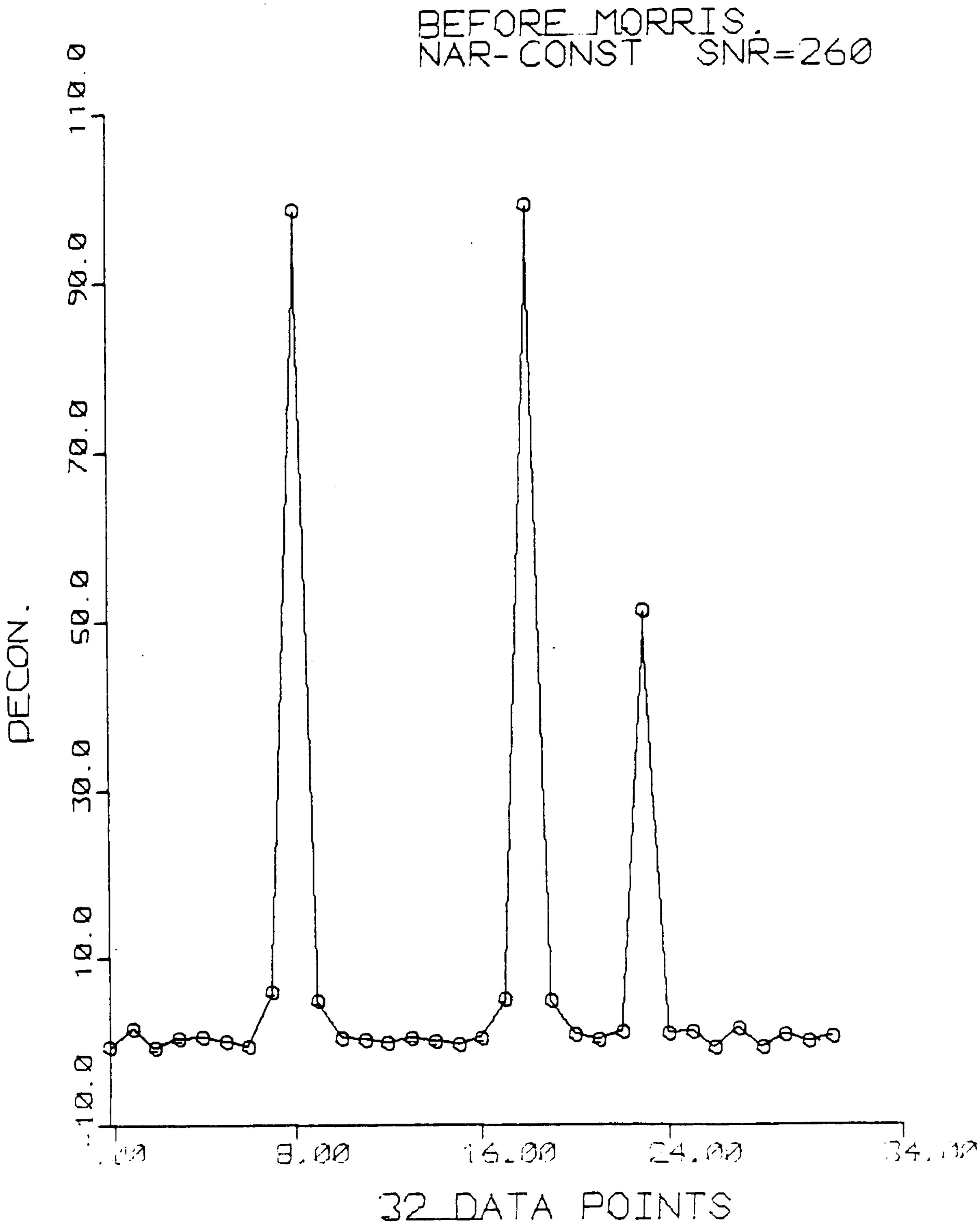
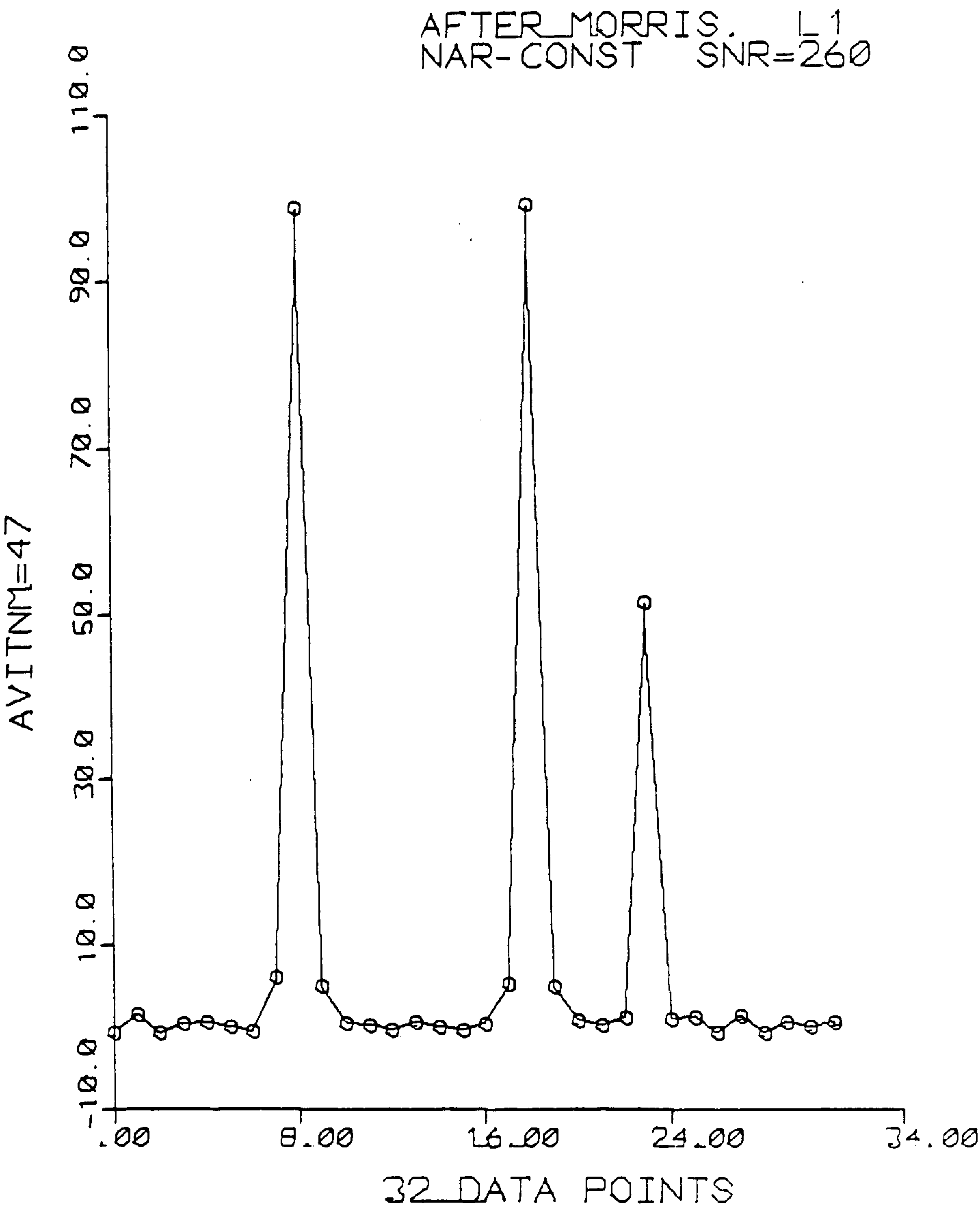

AFTER MORRIS. L2
NAR-CONST SNR=46
AVITNM=26. DECON.
100.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.30)



ORIGINAL PAGE IS
OF POOR QUALITY

Figure (4.31)



c. 4

Figure (4.32)

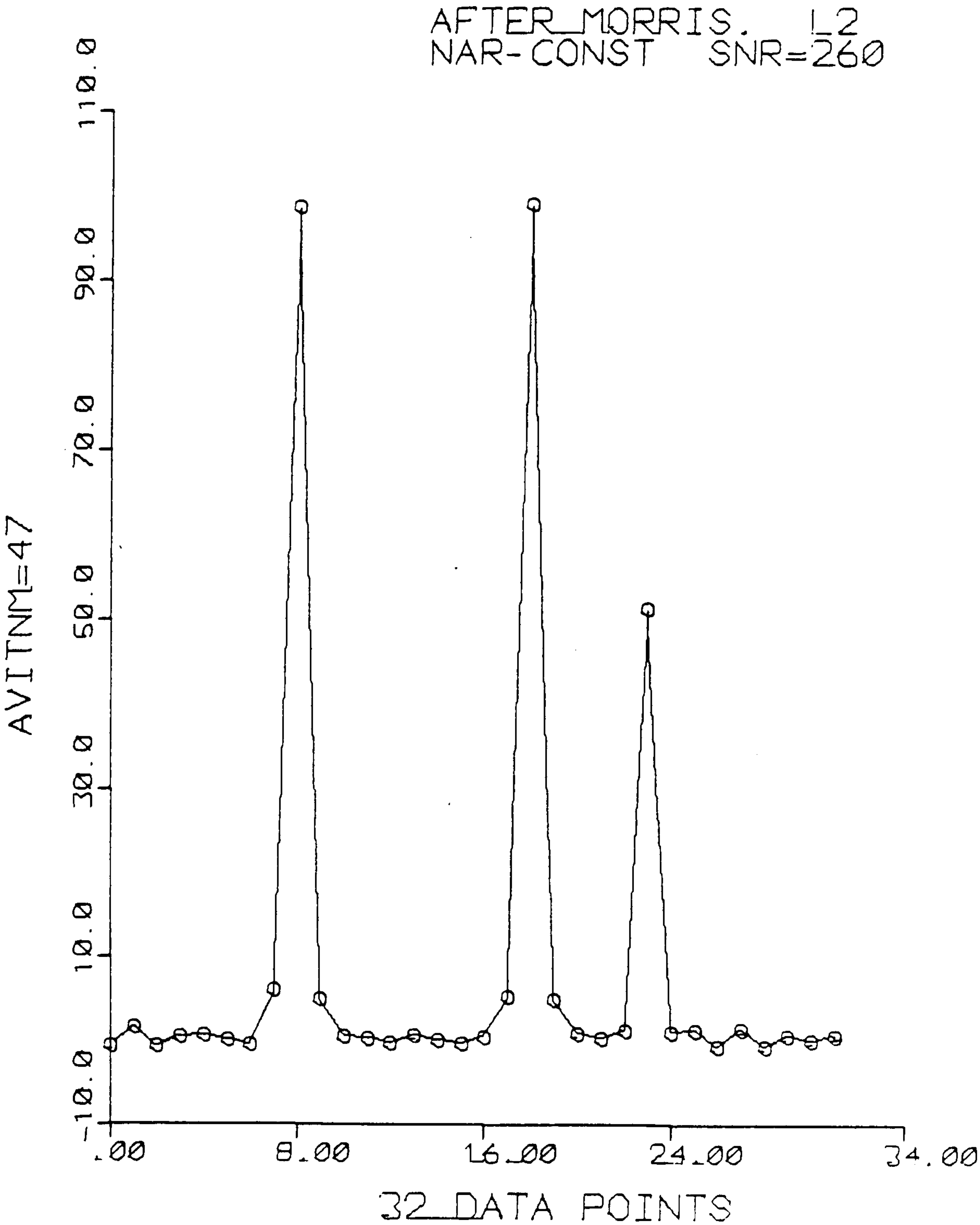

AFTER MORRIS. L2
NAR-CONST SNR=260
AVITNM=47
-10.0
10.0
30.0
50.0
70.0
90.0
110.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.33)

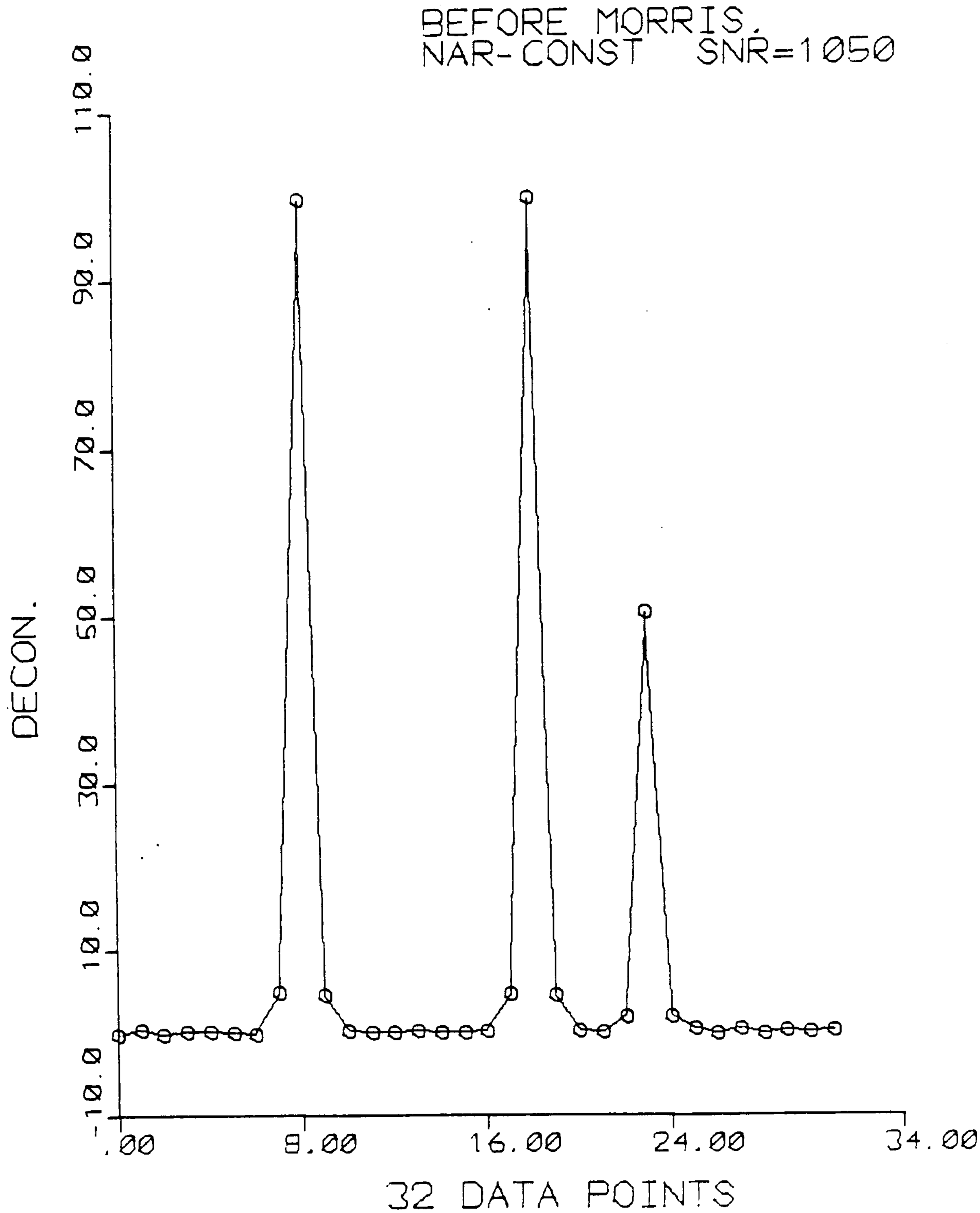

BEFORE MORRIS.
NAR-CONST SNR=1050
DECON.
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.34)

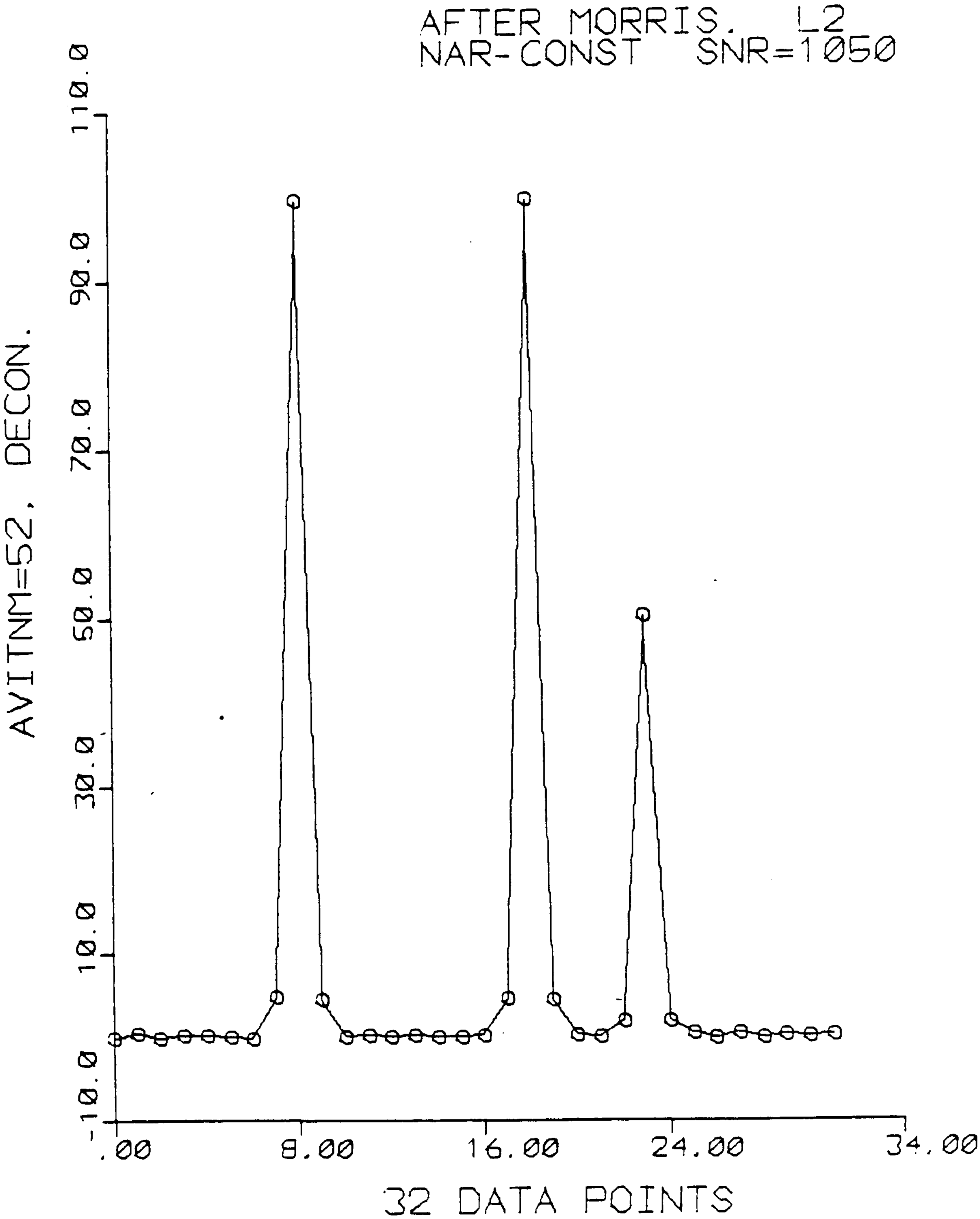

AFTER MORRIS. L2
NAR-CONST SNR=1050
AVITNM=52, DECON.
110.0
90.0
70.0
50.0
30.0
10.0
-10.0
.00
8.00
16.00
24.00
34.00
32 DATA POINTS

Figure (4.35)

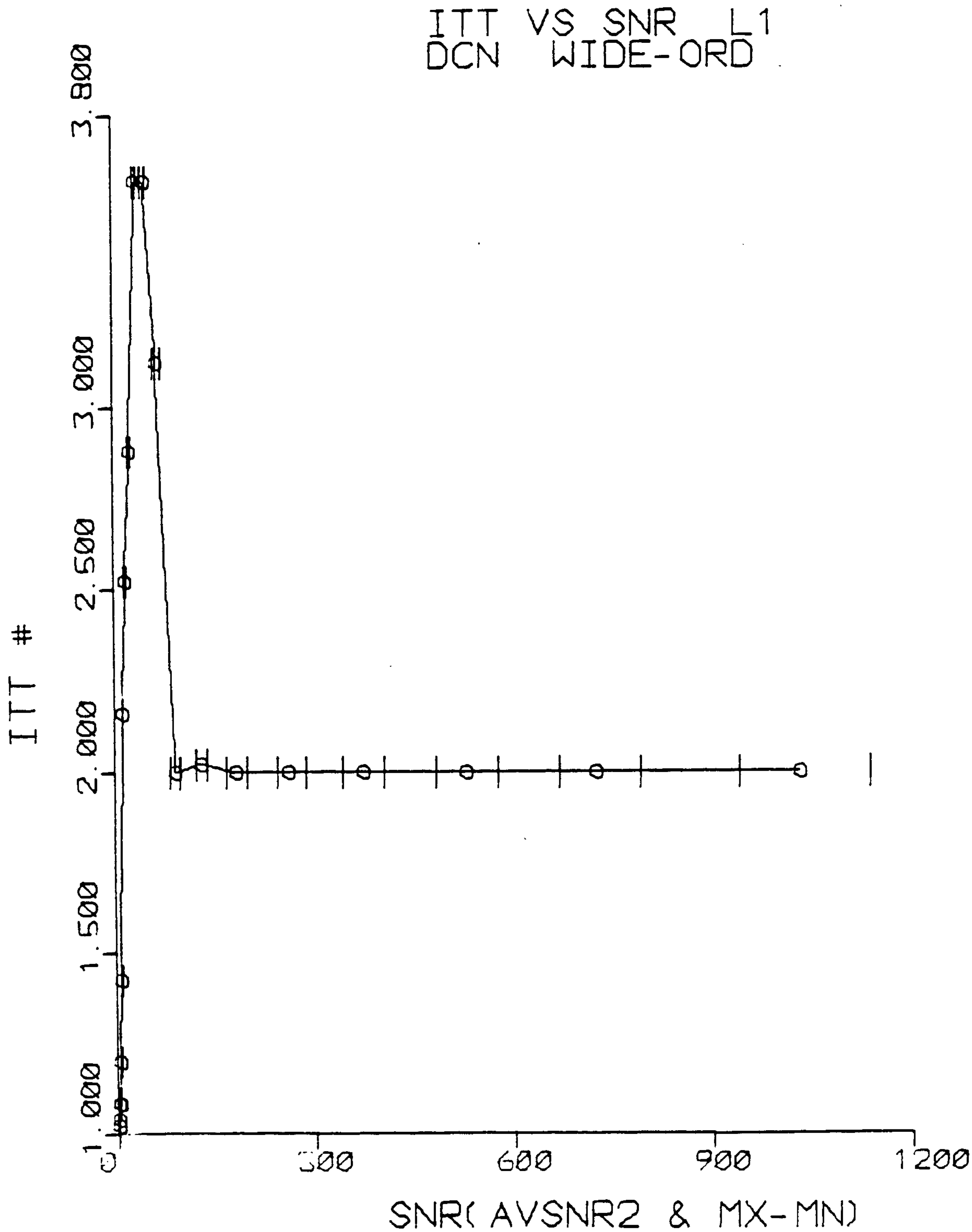

ITT VS SNR L1
DCN WIDE-ORD
ITT #
3.800
3.000
2.500
2.000
1.500
1.000
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.36)

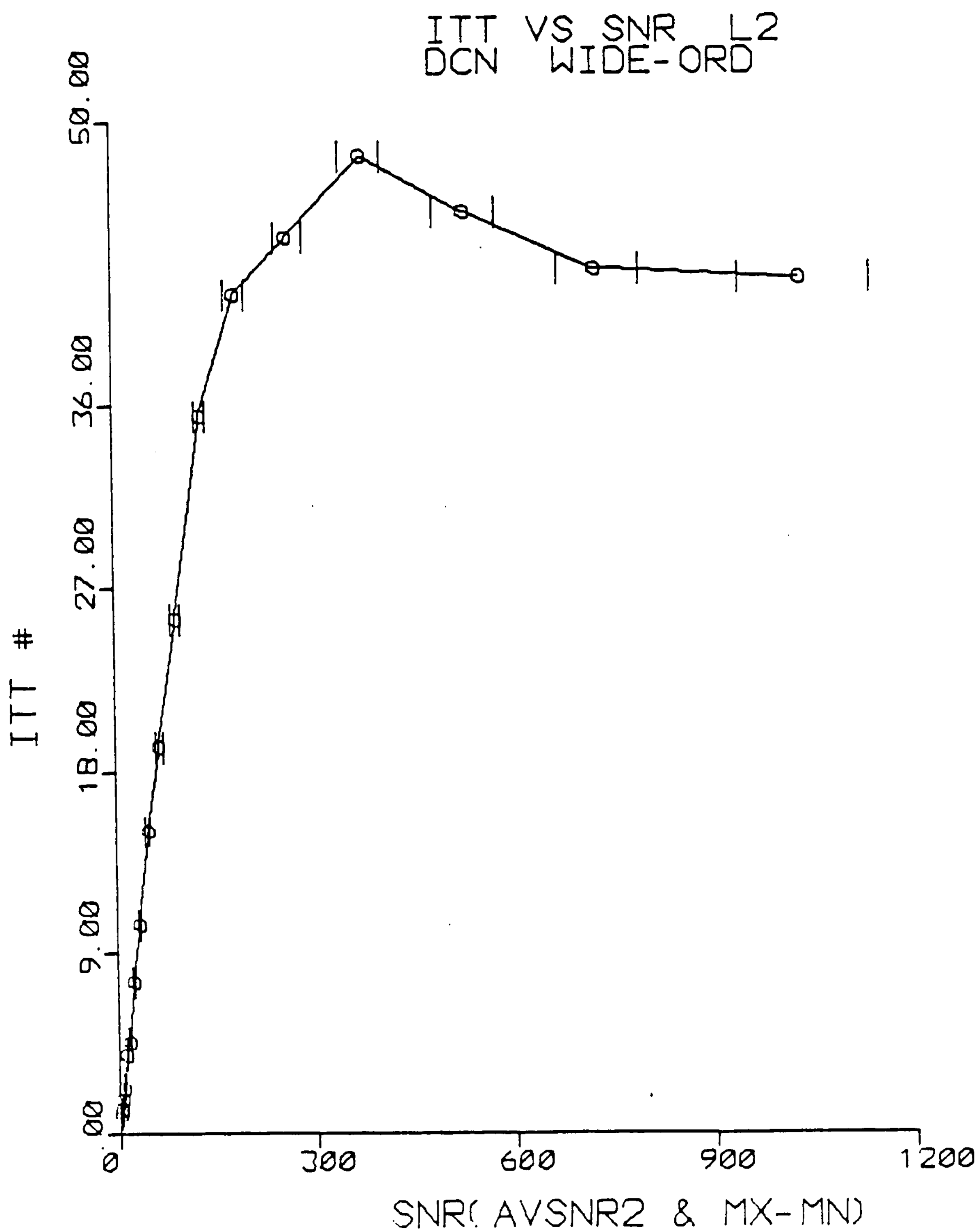

ITT VS SNR L2
DCN WIDE-ORD
ITT #
50.00
36.00
27.00
18.00
9.00
00
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.37)

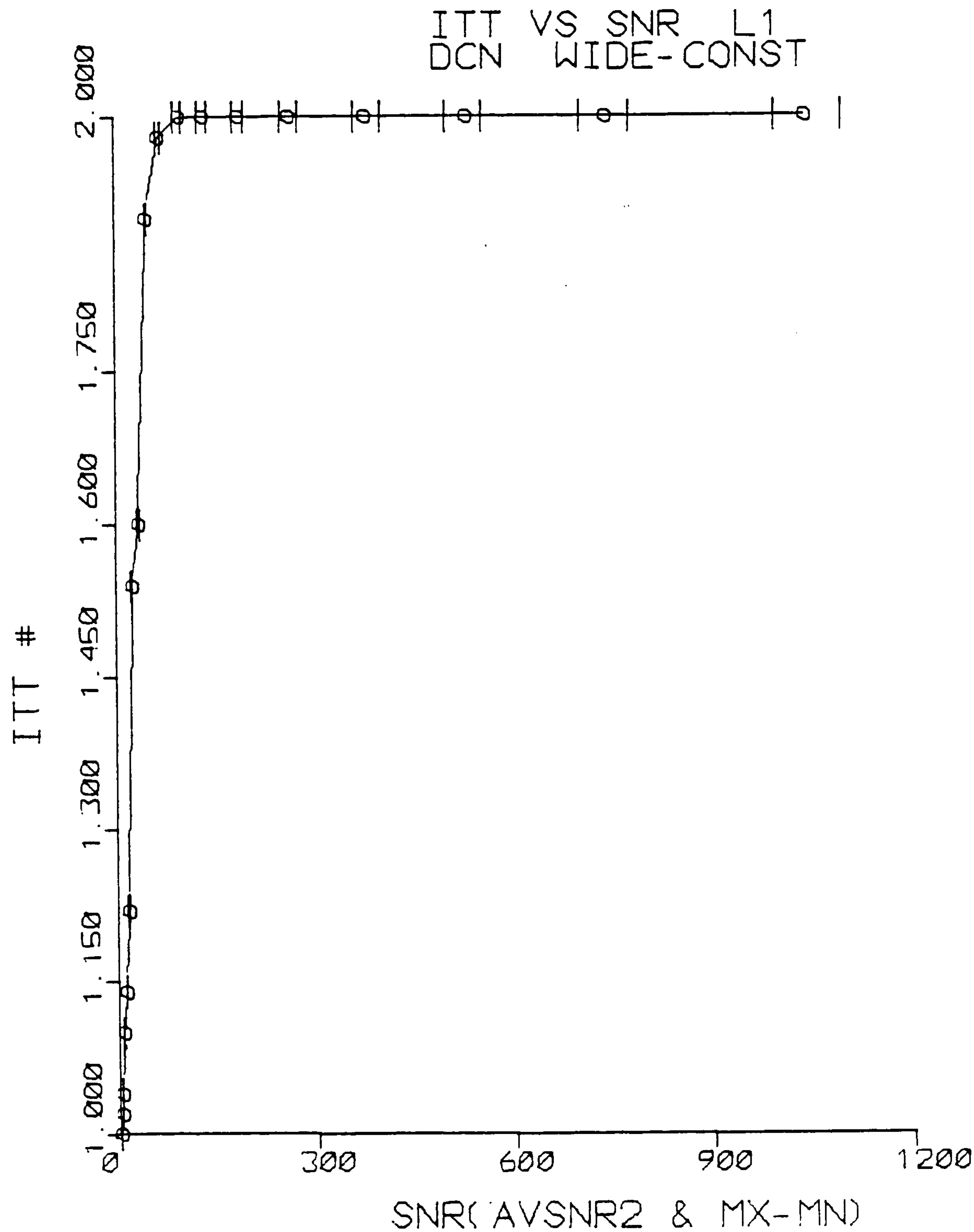

ITT VS SNR L1
DCN WIDE-CONST
ITT #
2.000
1.750
1.600
1.450
1.300
1.150
1.000
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.38)

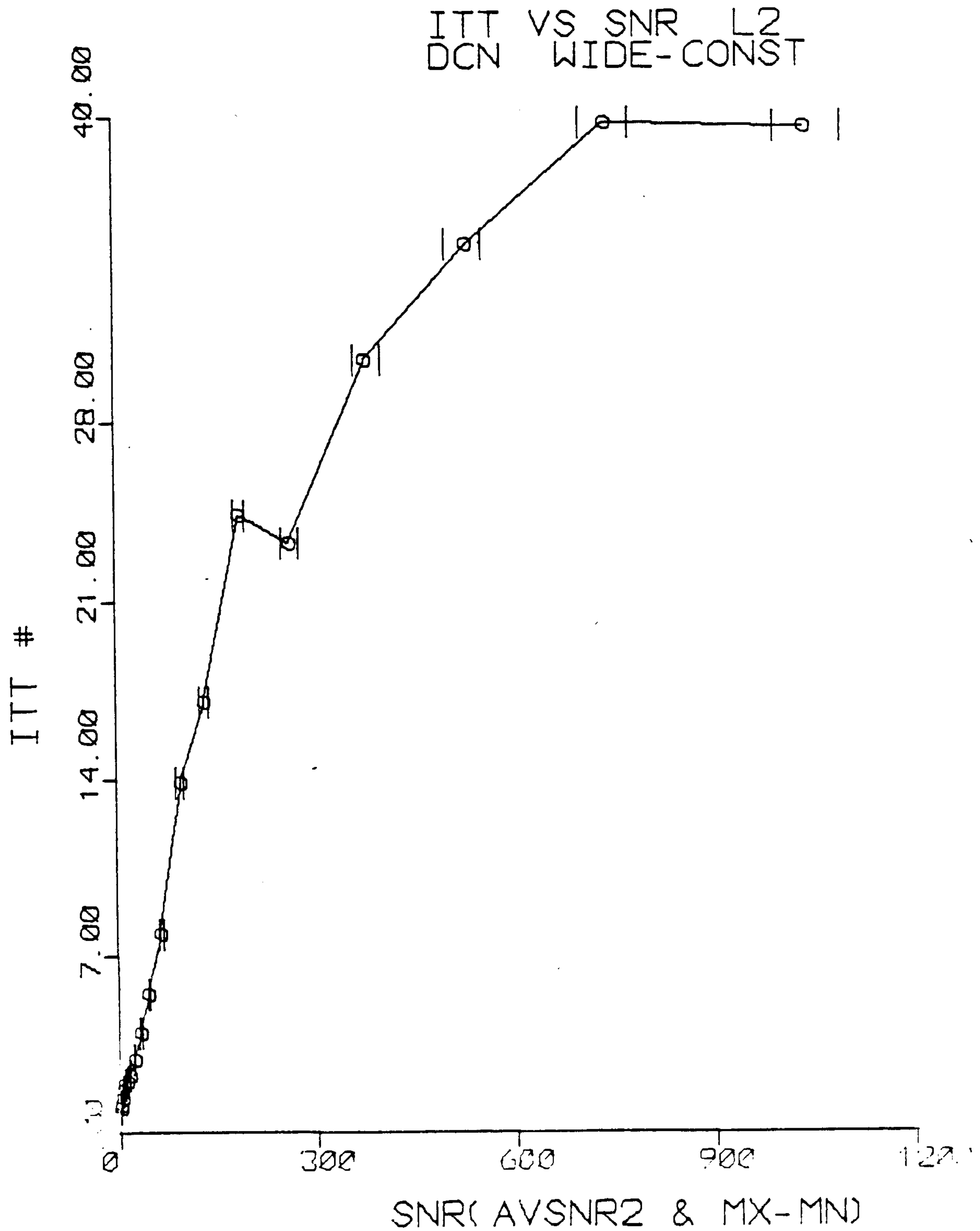

ITT VS SNR L2
DCN WIDE-CONST
ITT #
40.00
28.00
21.00
14.00
7.00
0
300
600
900
SNR(AVSNR2 & MX-MN)

Figure (4.39)

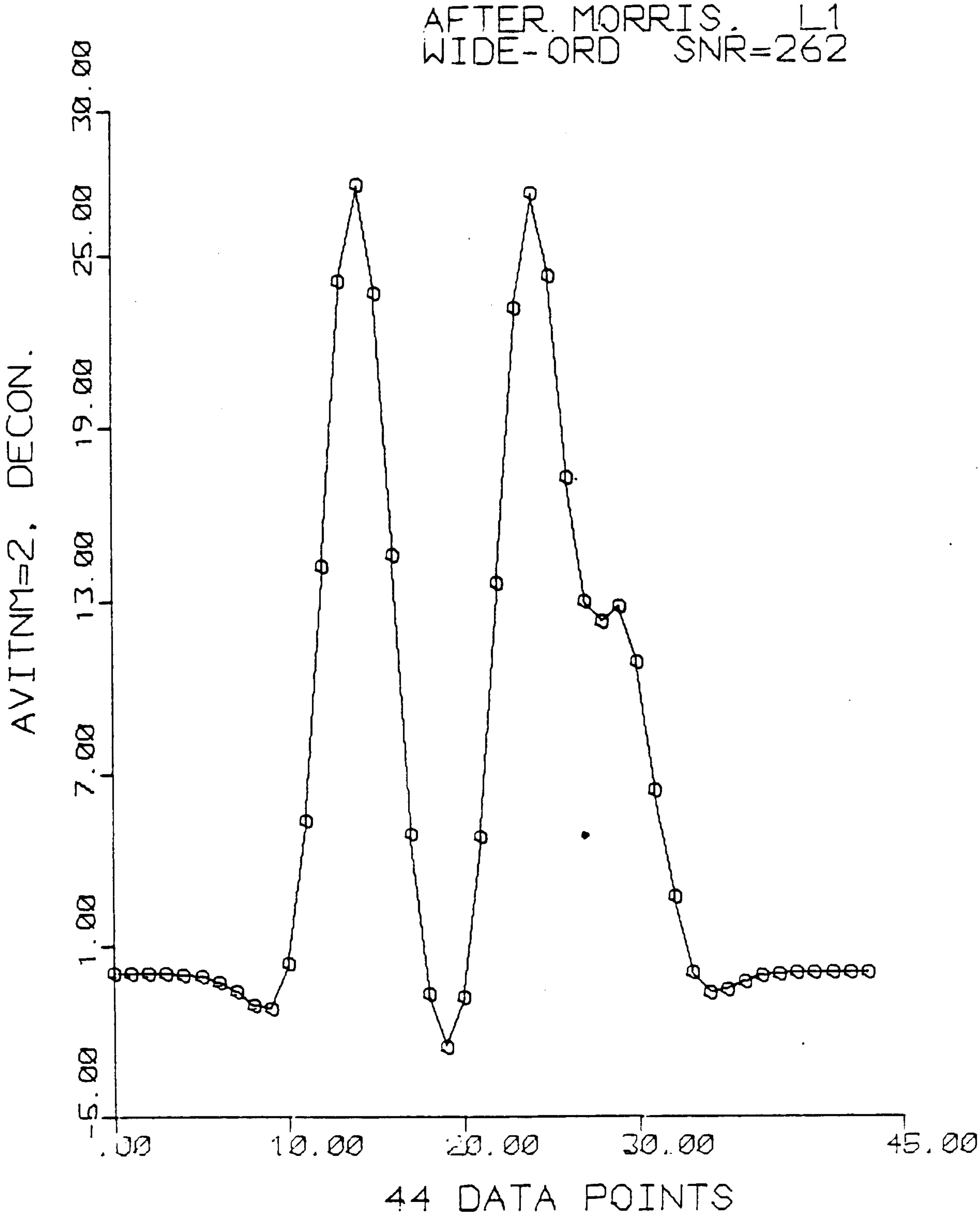

AFTER MORRIS. L1
WIDE-ORD SNR=262
AVITNM=2, DECON.
30.00
25.00
19.00
13.00
7.00
1.00
-5.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.40)

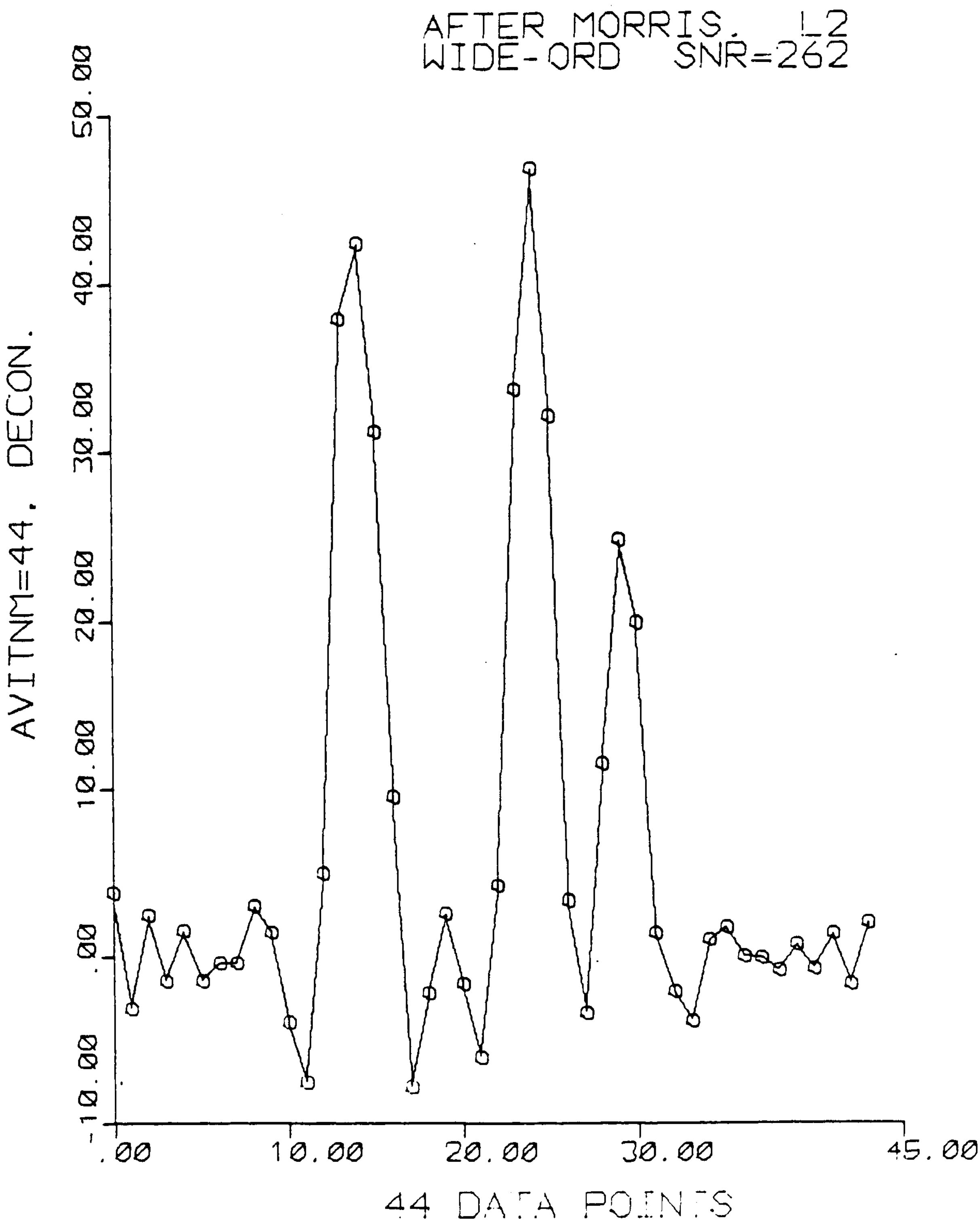

AFTER MORRIS. L2
WIDE-ORD SNR=262
AVITNM=44. DECON.
50.00
40.00
30.00
20.00
10.00
.00
-10.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.41)

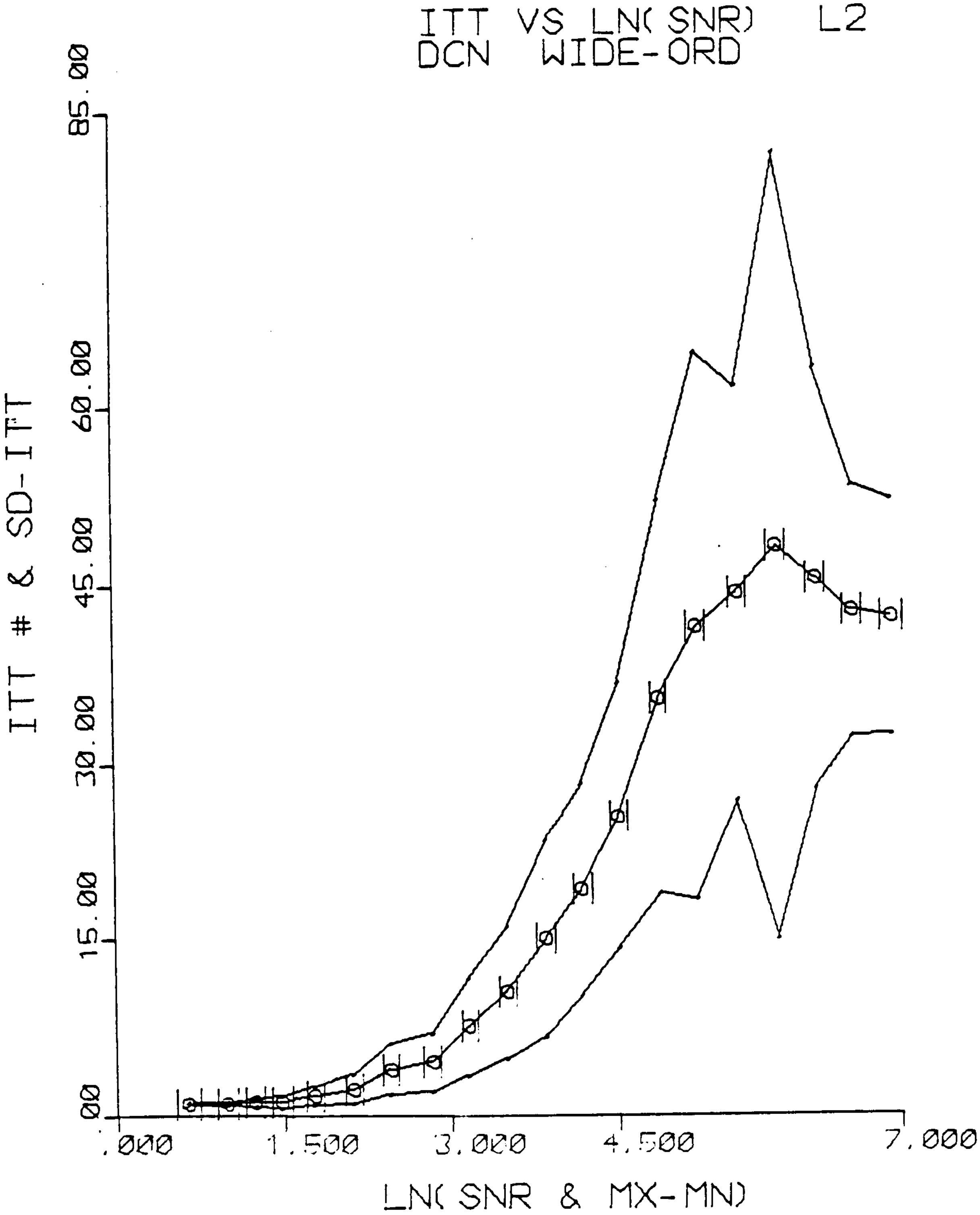

ITT VS LN(SNR) L2
DCN WIDE-ORD
ITT # & SD-ITT
85.00
60.00
45.00
30.00
15.00
.00
.000
1.500
3.000
4.500
7.000
LN(SNR & MX-MN)

Figure (4.42)

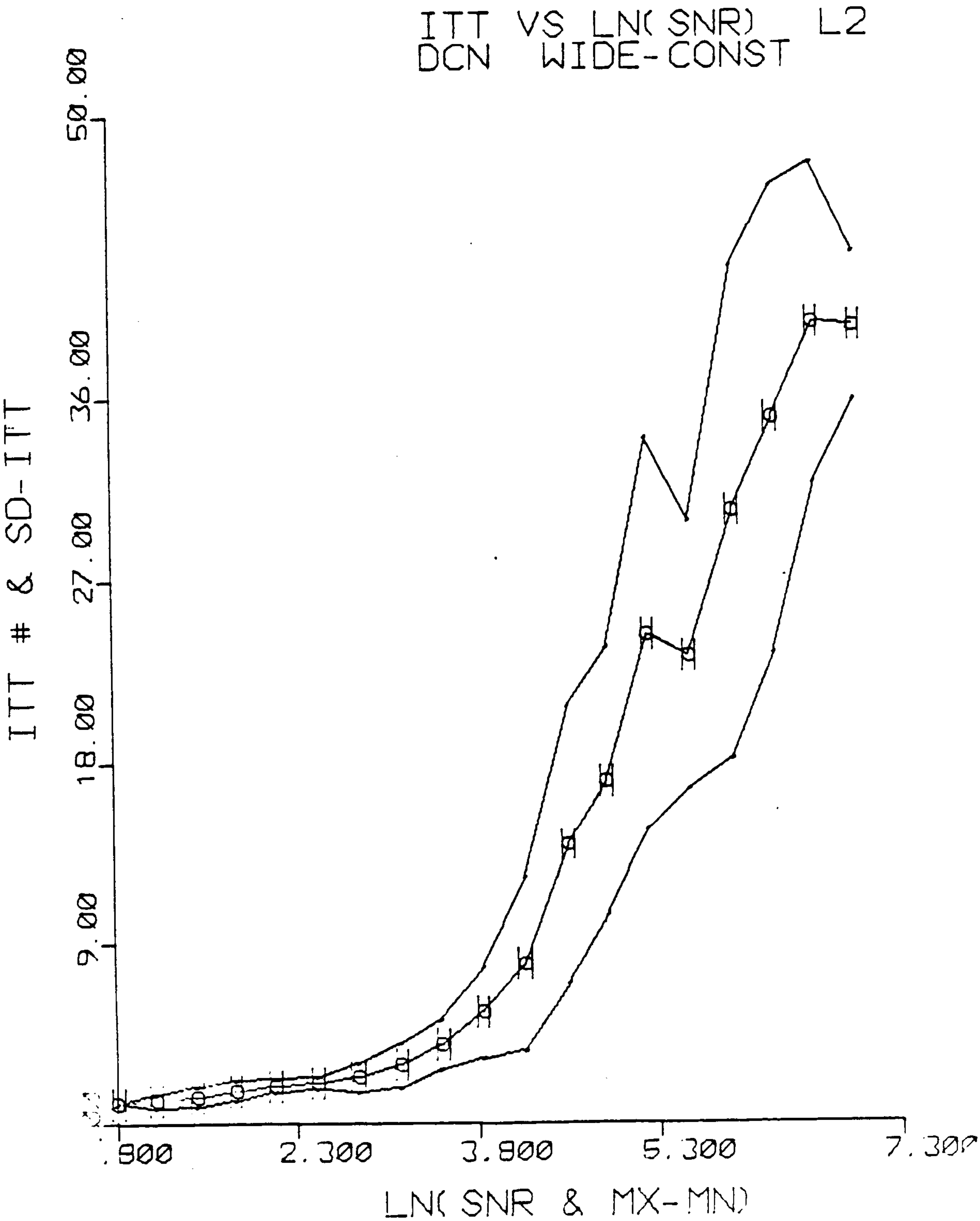

ITT VS LN(SNR) L2
DCN WIDE-CONST
ITT # & SD-ITT
50.00
36.00
27.00
18.00
9.00
.800
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (4.43)

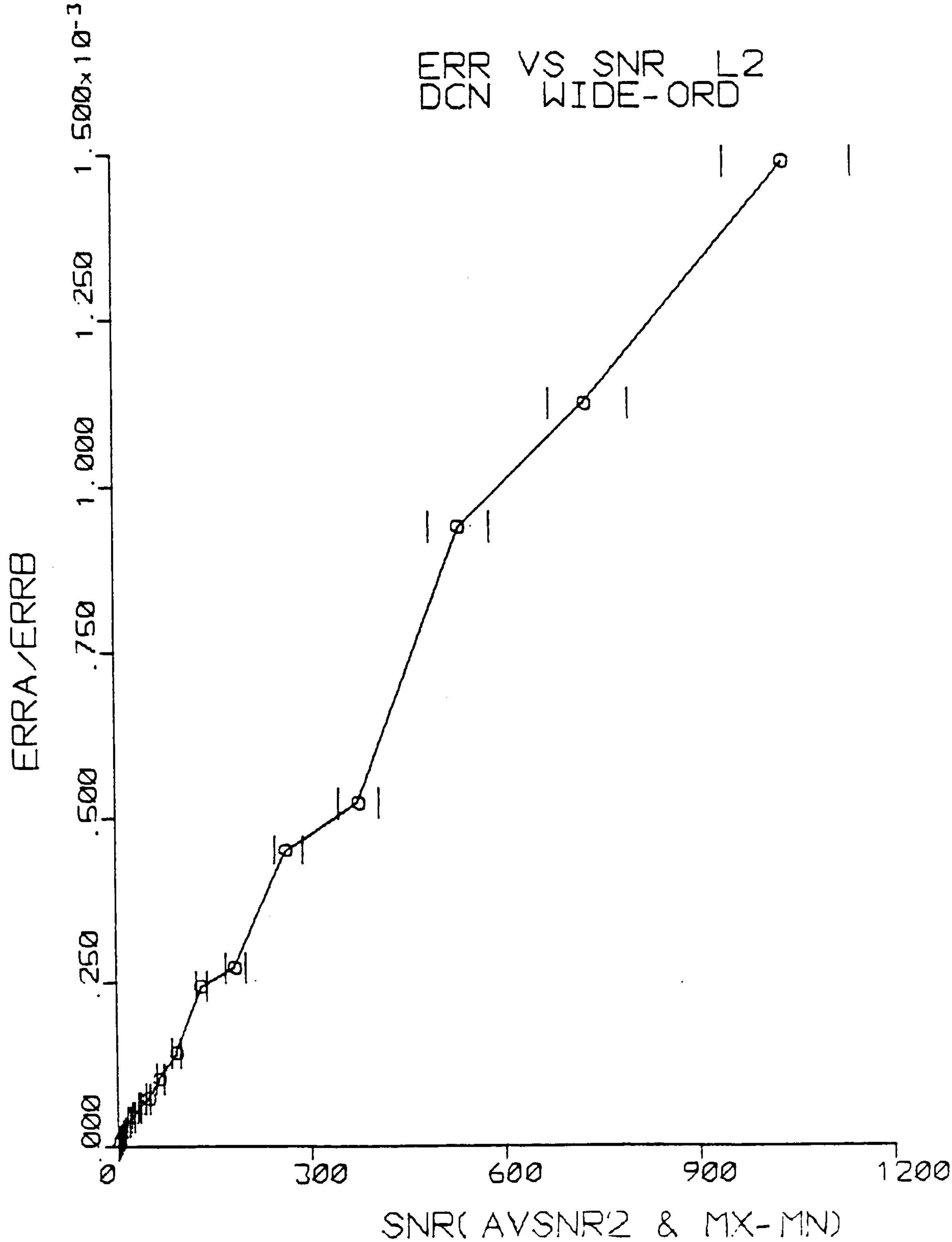

ERR VS SNR L2
DCN WIDE-ORD
1.500x10^-3
1.250
1.000
.750
.500
.250
.000
ERRA/ERRB
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.44)

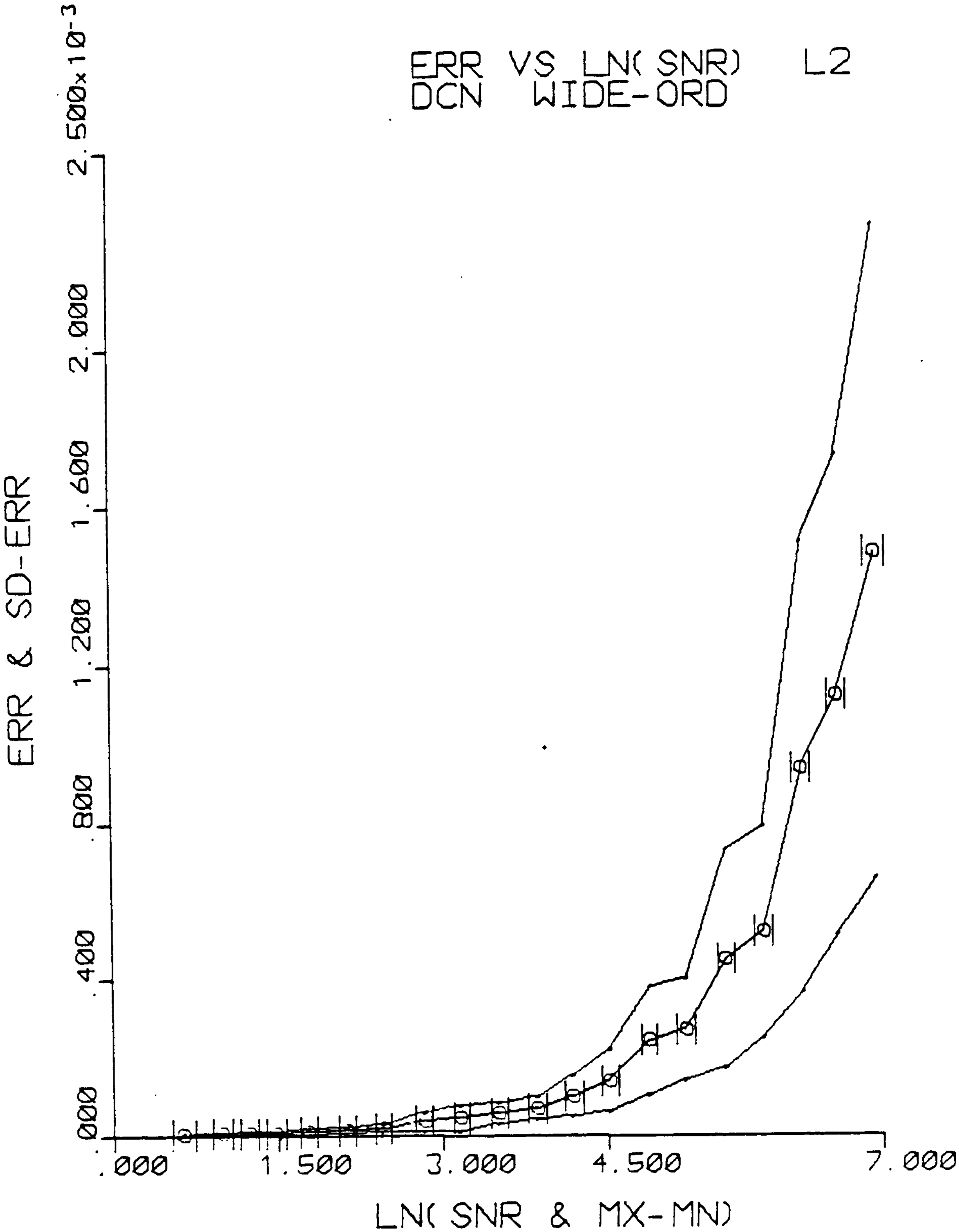

ERR VS LN(SNR) L2
DCN WIDE-ORD
2.500x10^-3
2.000
1.600
1.200
.800
.400
.000
ERR & SD-ERR
.000
1.500
3.000
4.500
7.000
LN(SNR & MX-MN)

Figure (4.45)

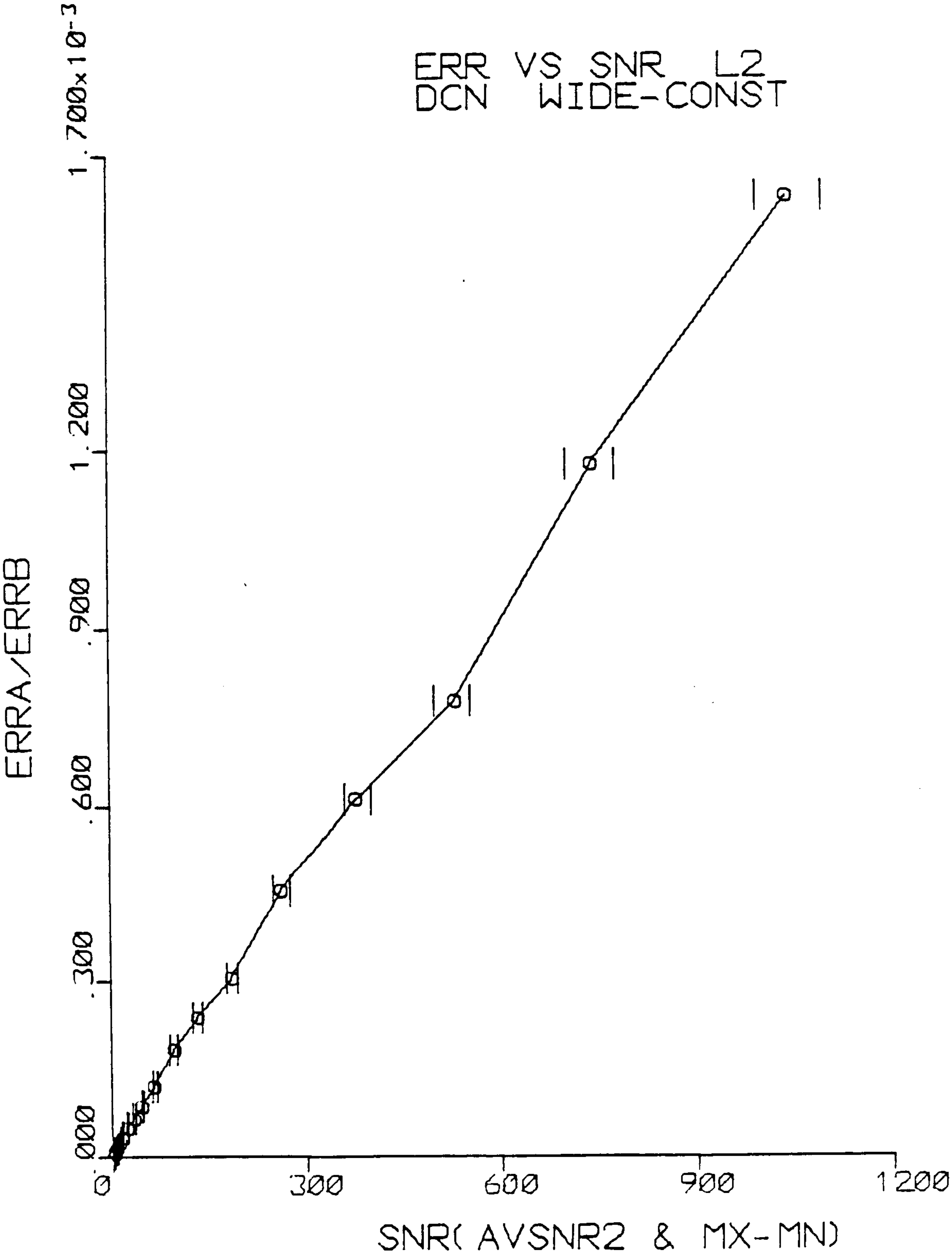

ERR VS SNR L2
DCN WIDE-CONST
ERRA/ERRB
1.700x10^-3
1.200
.900
.600
.300
.000
0
300
600
900
1200
SNR(AVSNR2 & MX-MN)

Figure (4.46)

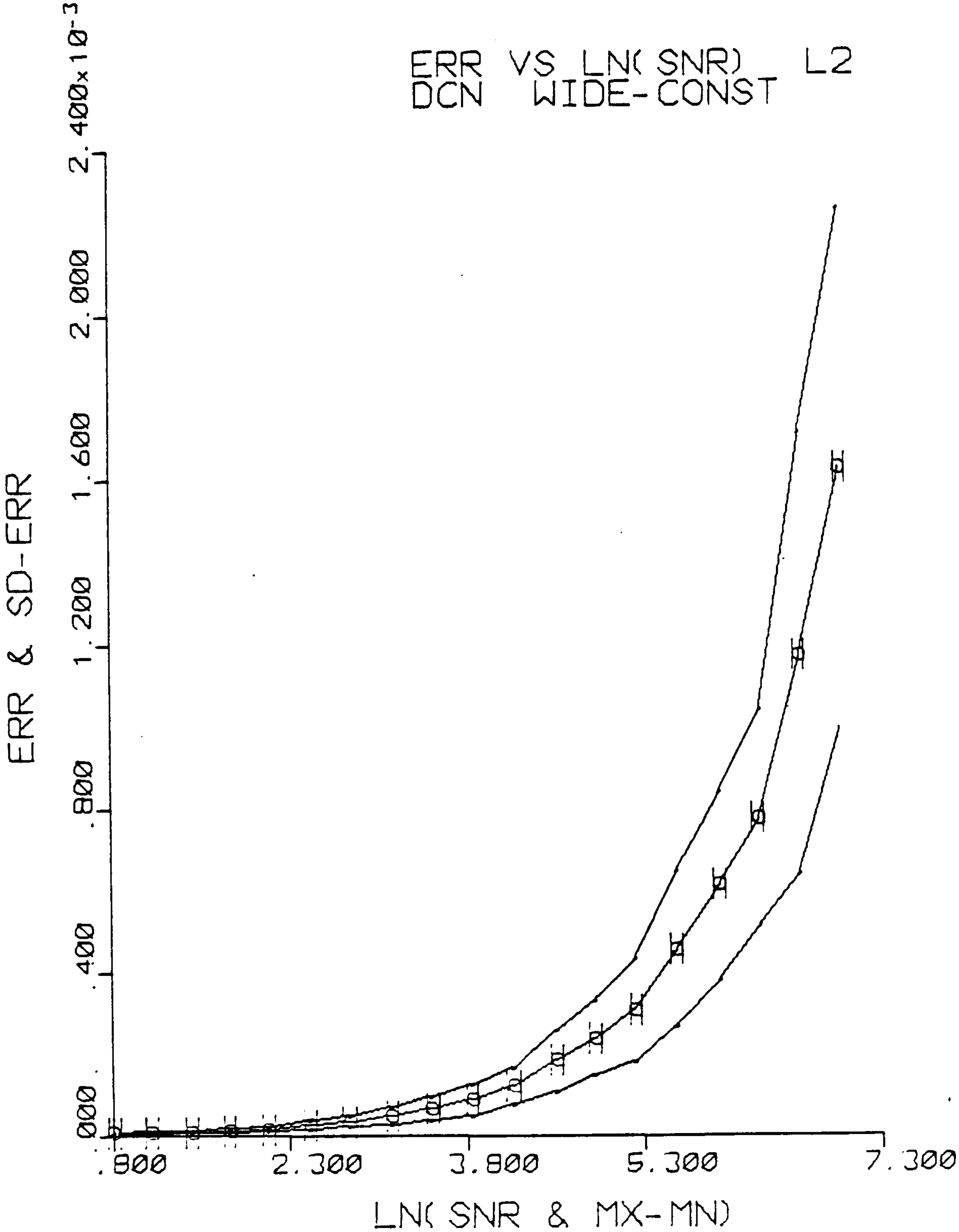

ERR VS LN(SNR) L2
DCN WIDE-CONST
ERR & SD-ERR
2.400x10⁻³
2.000
1.600
1.200
.800
.400
.000
.800
2.300
3.800
5.300
7.300
LN(SNR & MX-MN)

Figure (4.47)

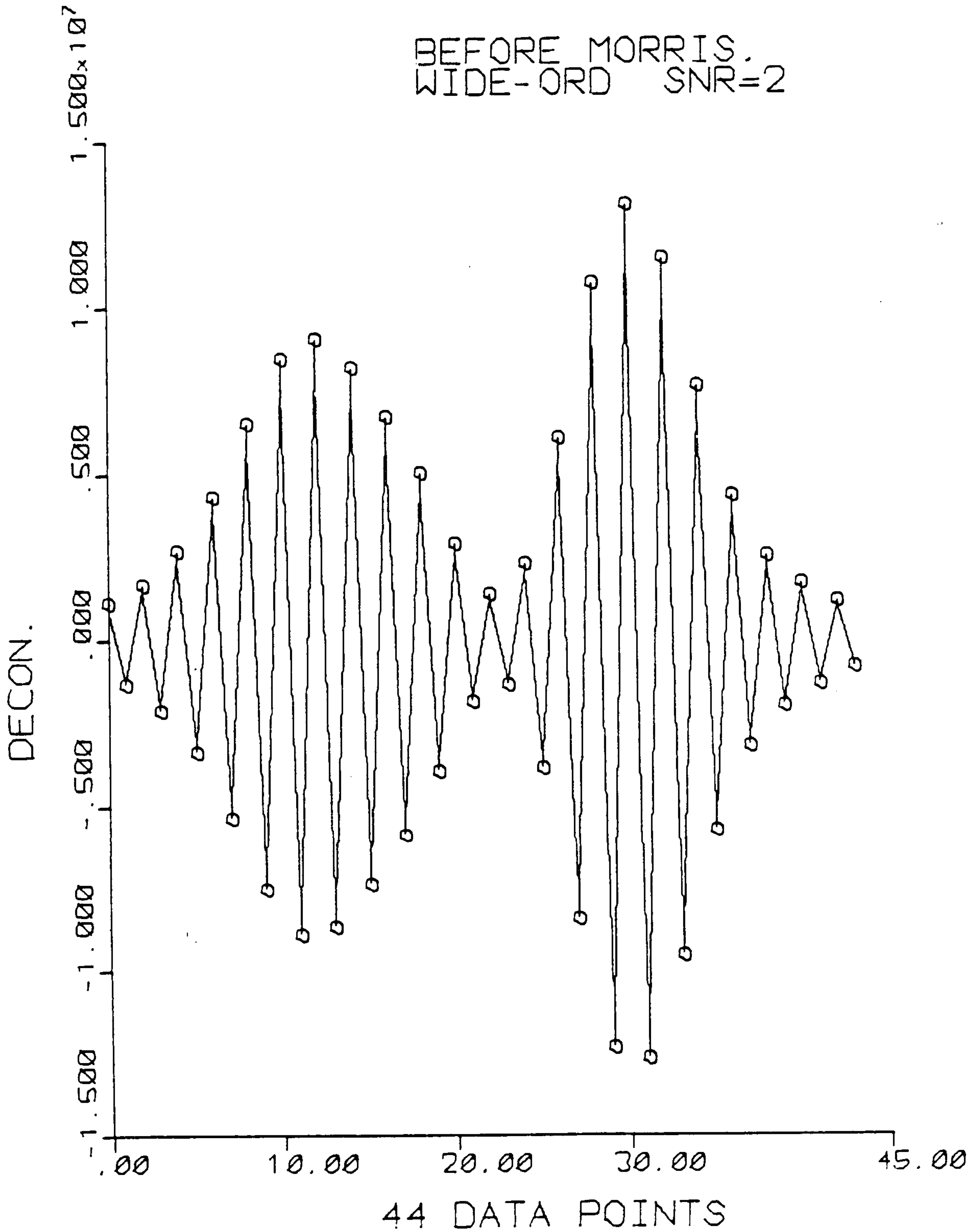

BEFORE MORRIS.
WIDE-ORD SNR=2
DECON.
1.500×10⁷
1.000
.500
.000
-.500
-1.000
-1.500
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.48)

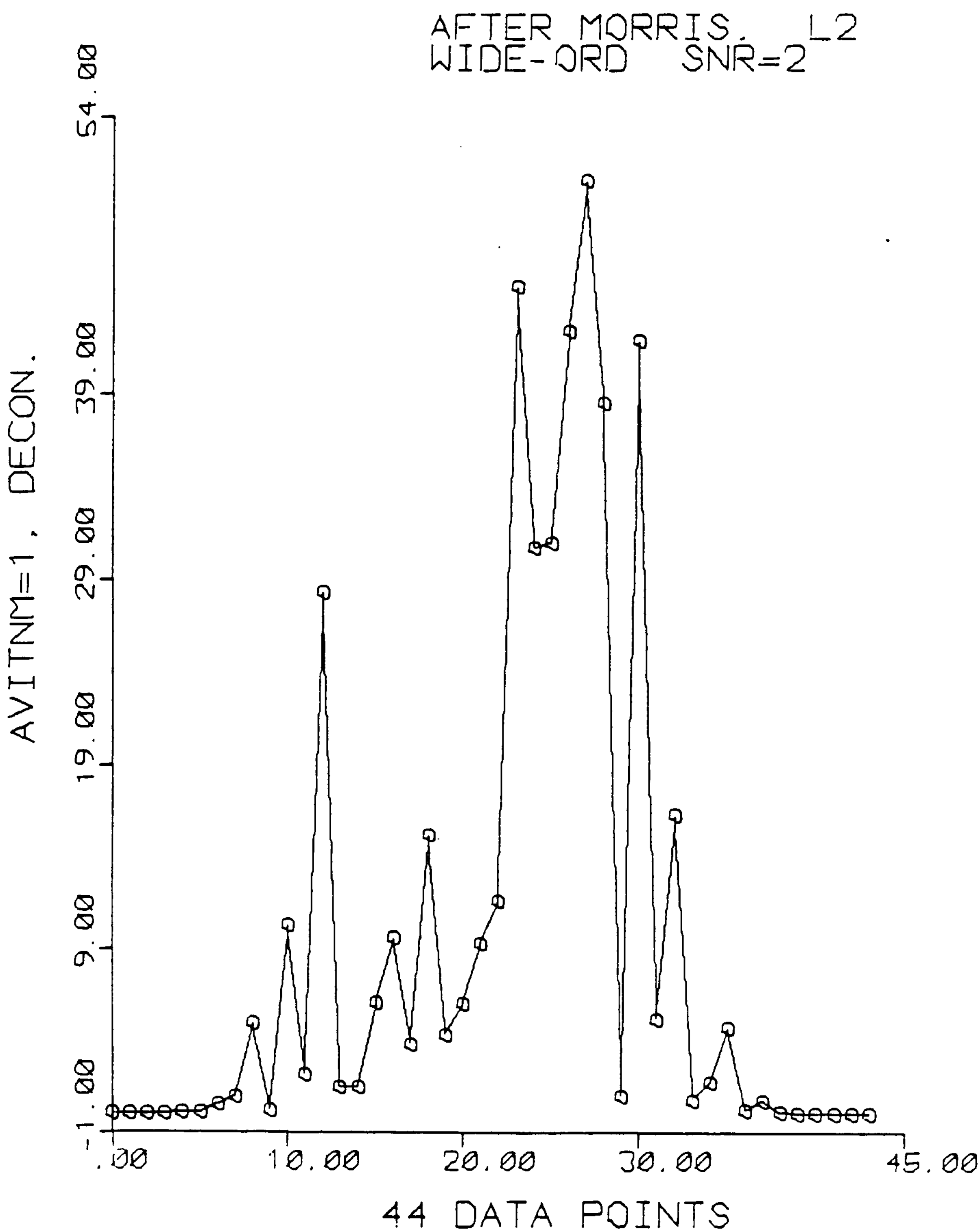

AFTER MORRIS, L2
WIDE-ORD SNR=2
AVITNM=1, DECON.
54.00
39.00
29.00
19.00
9.00
-1.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.49)

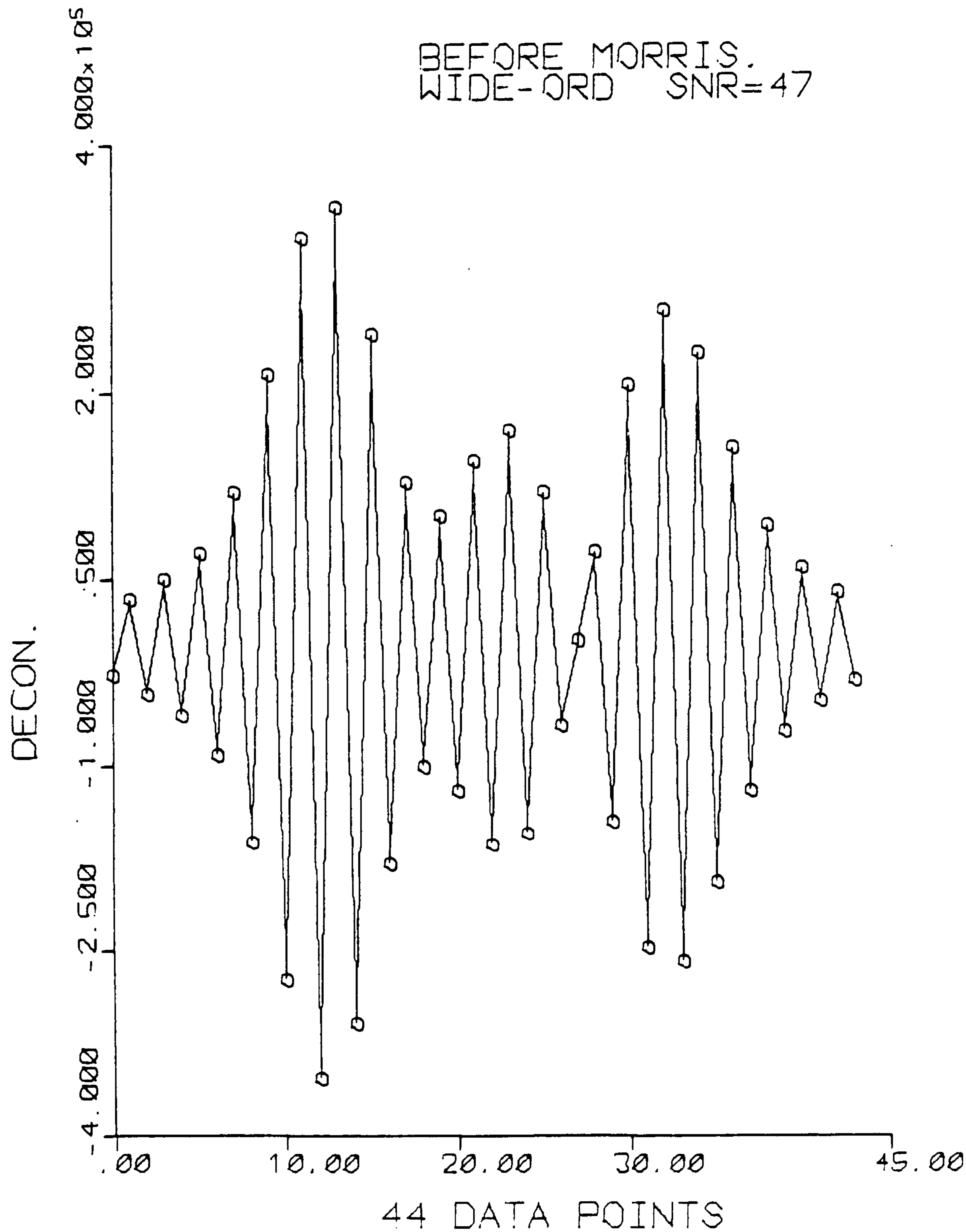

BEFORE MORRIS.
WIDE-ORD SNR=47
4.000×10⁵
2.000
.500
-1.000
-2.500
-4.000
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.50)

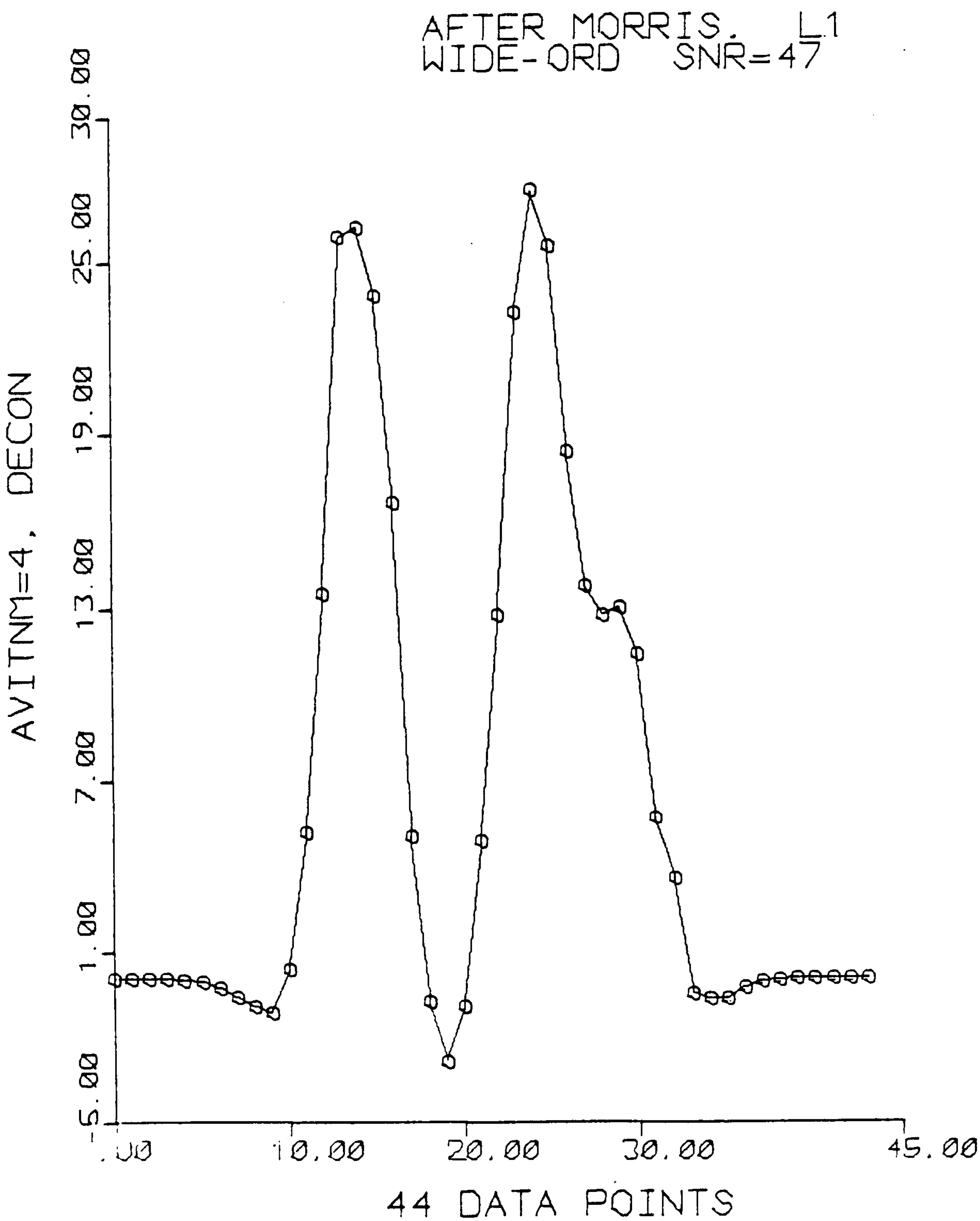

AFTER MORRIS. L1
WIDE-ORD SNR=47
AVITNM=4, DECON
30.00
25.00
19.00
13.00
7.00
1.00
-5.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.51)

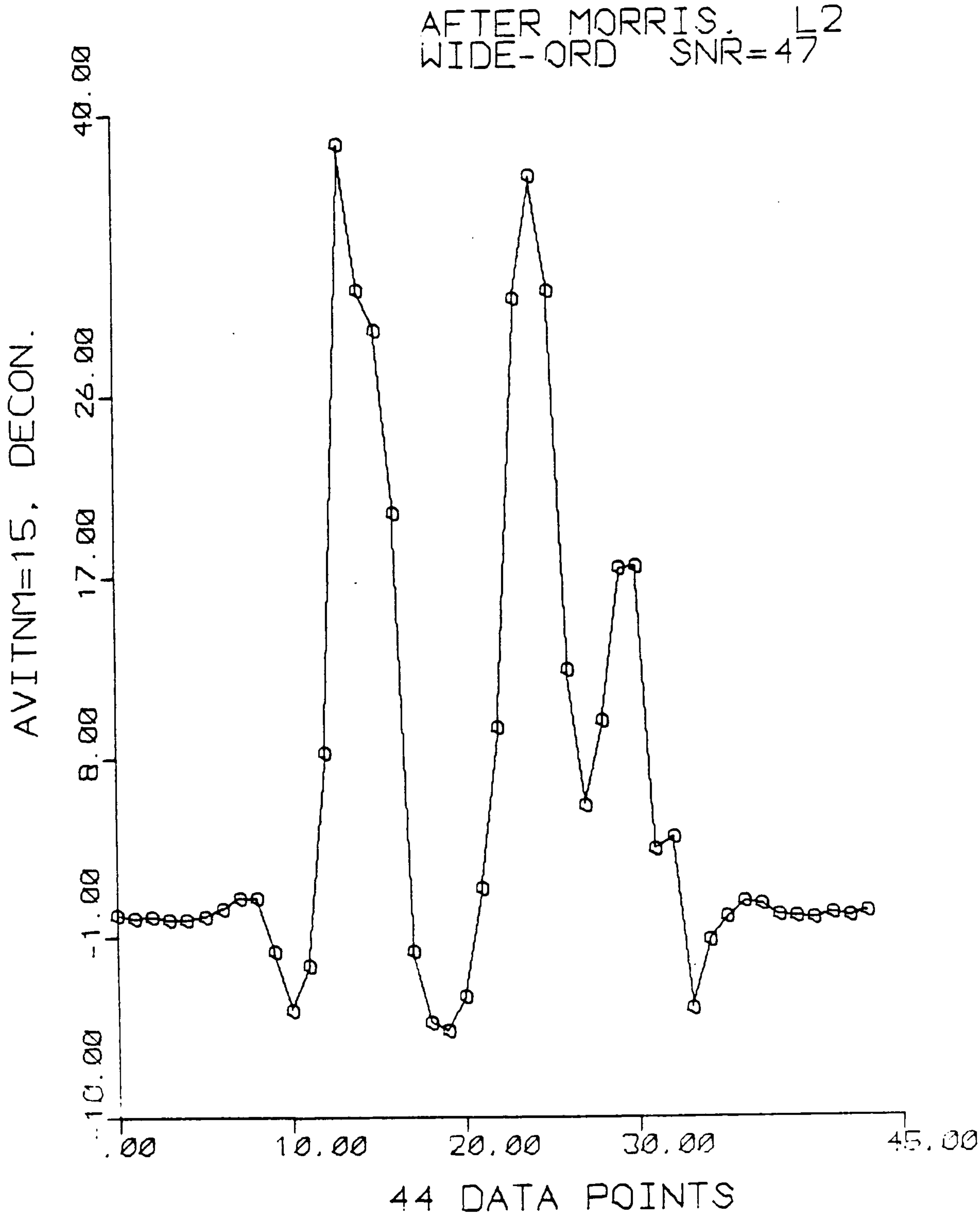

AFTER MORRIS. L2
WIDE-ORD SNR=47
AVITNM=15. DECON.
40.00
26.00
17.00
8.00
-1.00
-10.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.52)

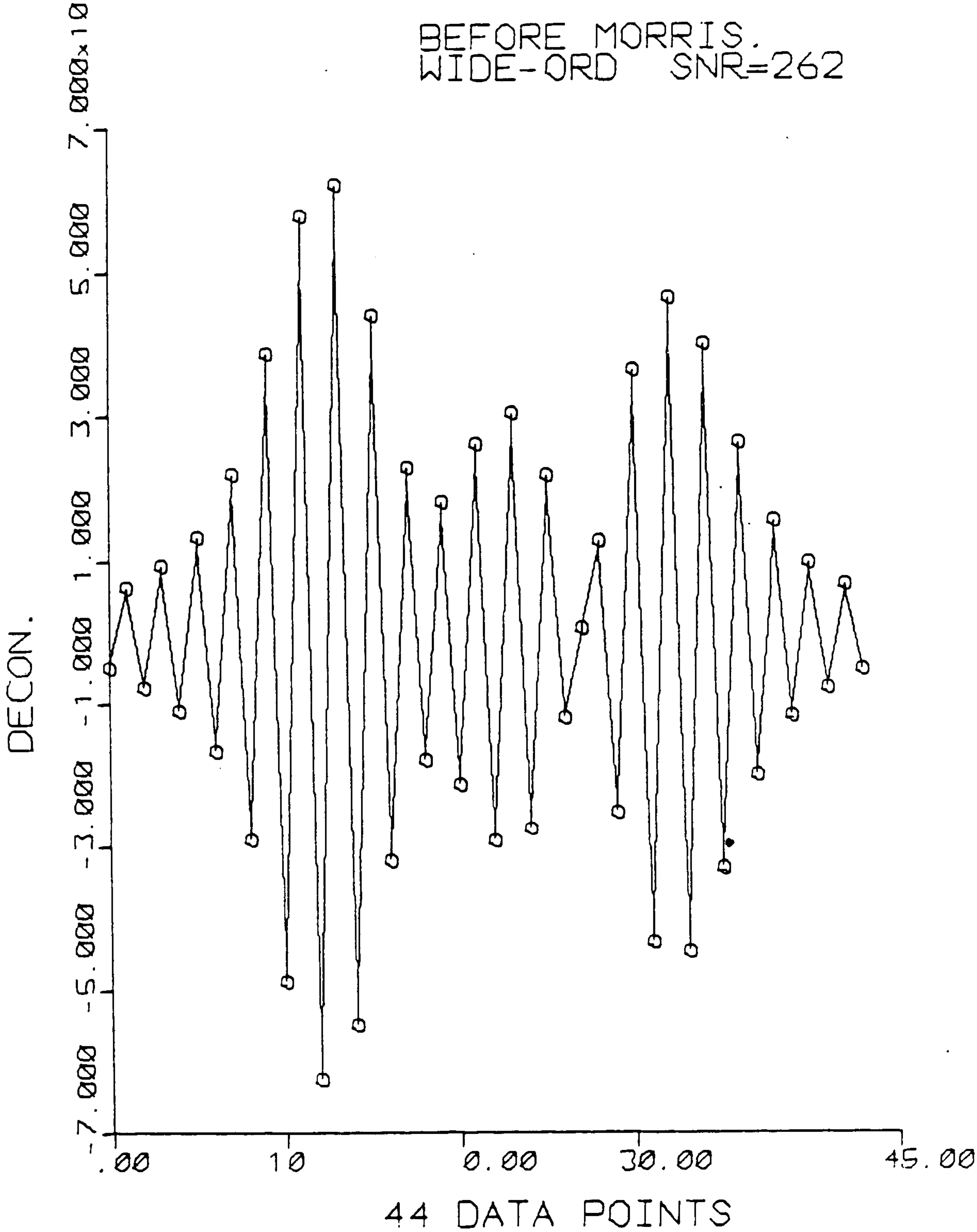

BEFORE MORRIS.
WIDE-ORD SNR=262
DECON.
7.000×10^4
5.000
3.000
1.000
-1.000
-3.000
-5.000
-7.000
.00
10
0.00
30.00
45.00
44 DATA POINTS

Figure (4.53)

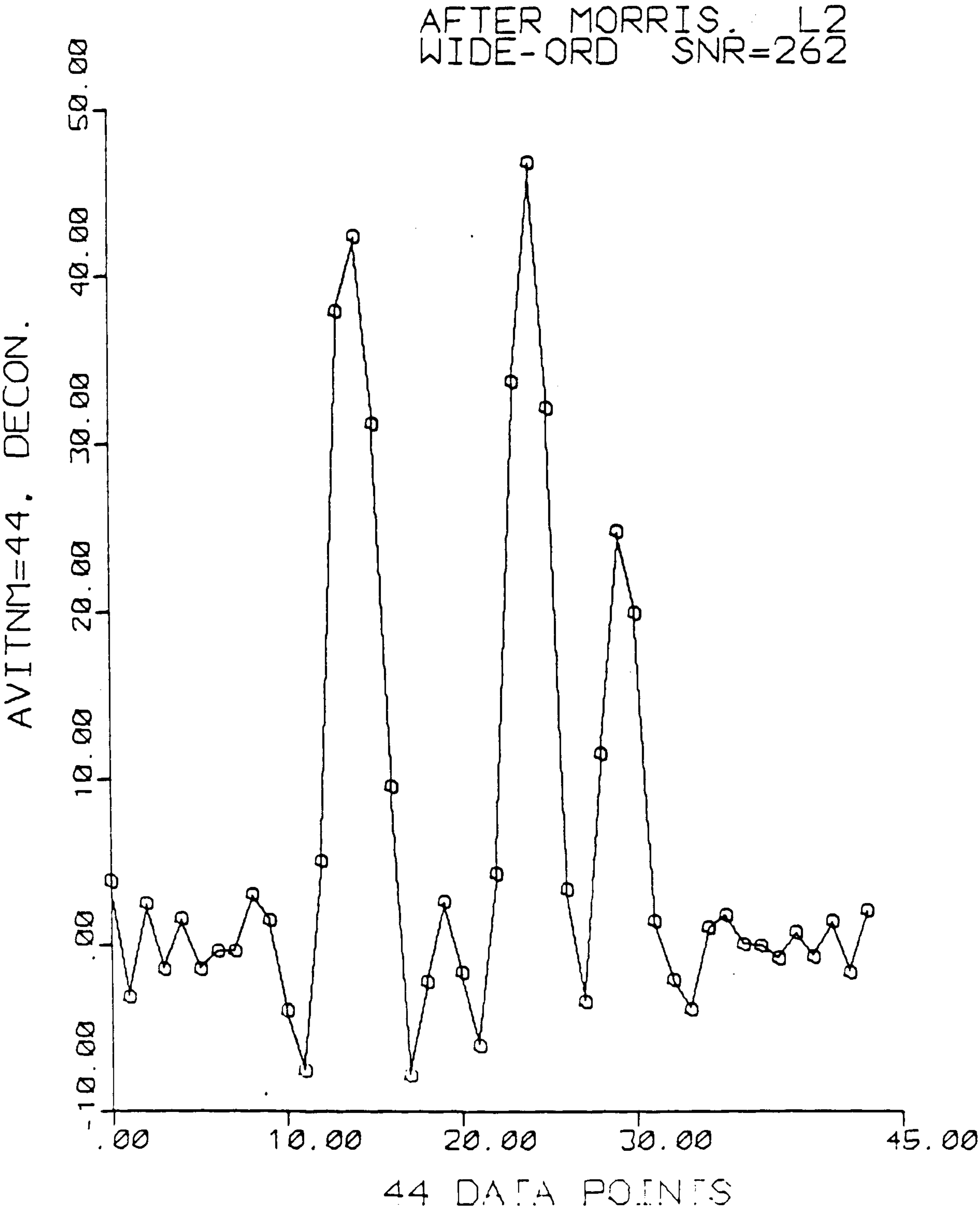

AFTER MORRIS. L2
WIDE-ORD SNR=262
AVITNM=44. DECON.
50.00
40.00
30.00
20.00
10.00
.00
-10.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.54)

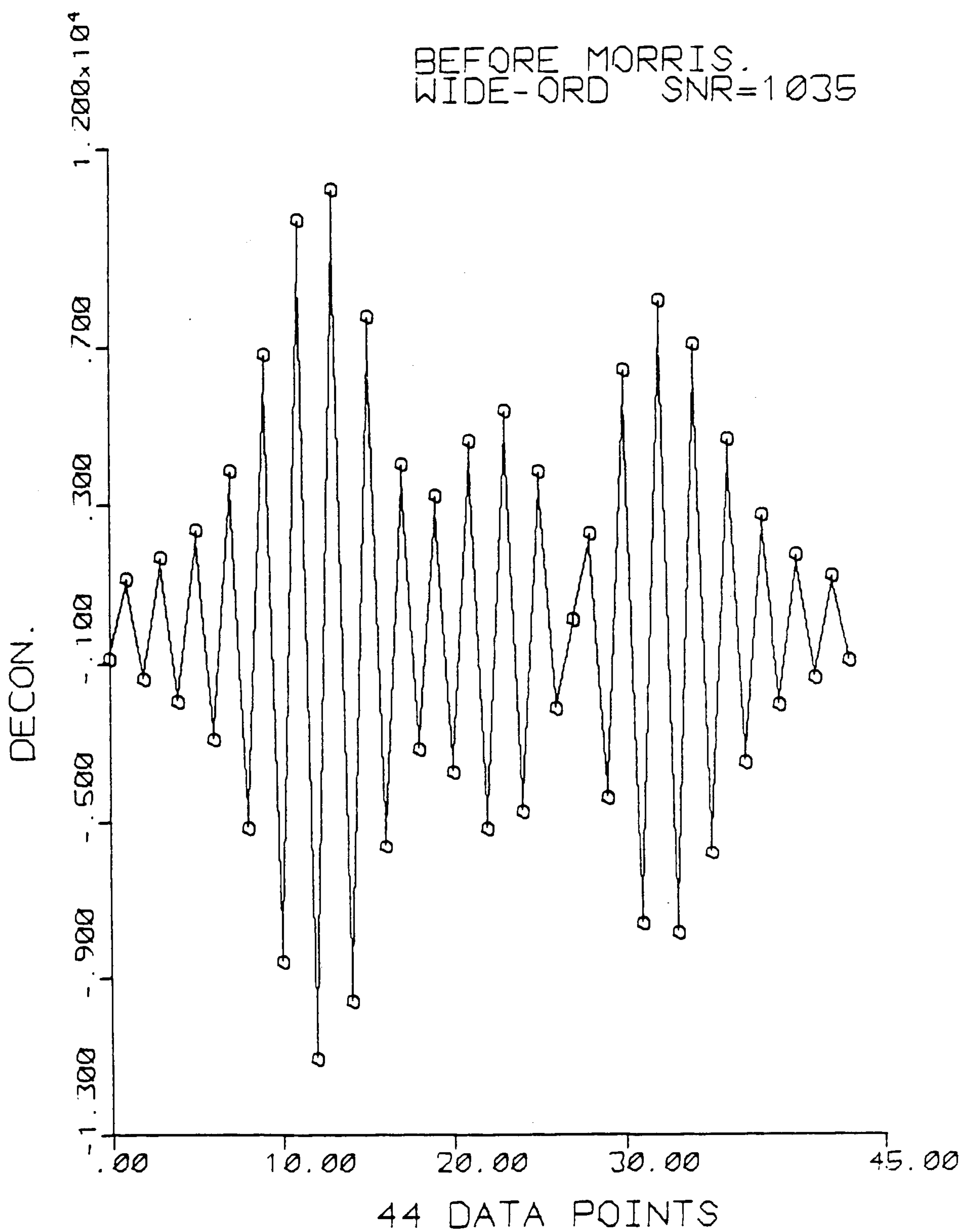

BEFORE MORRIS.
WIDE-ORD SNR=1035
1.200x10⁴
.700
.300
-.100
-.500
-.900
-1.300
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.55)

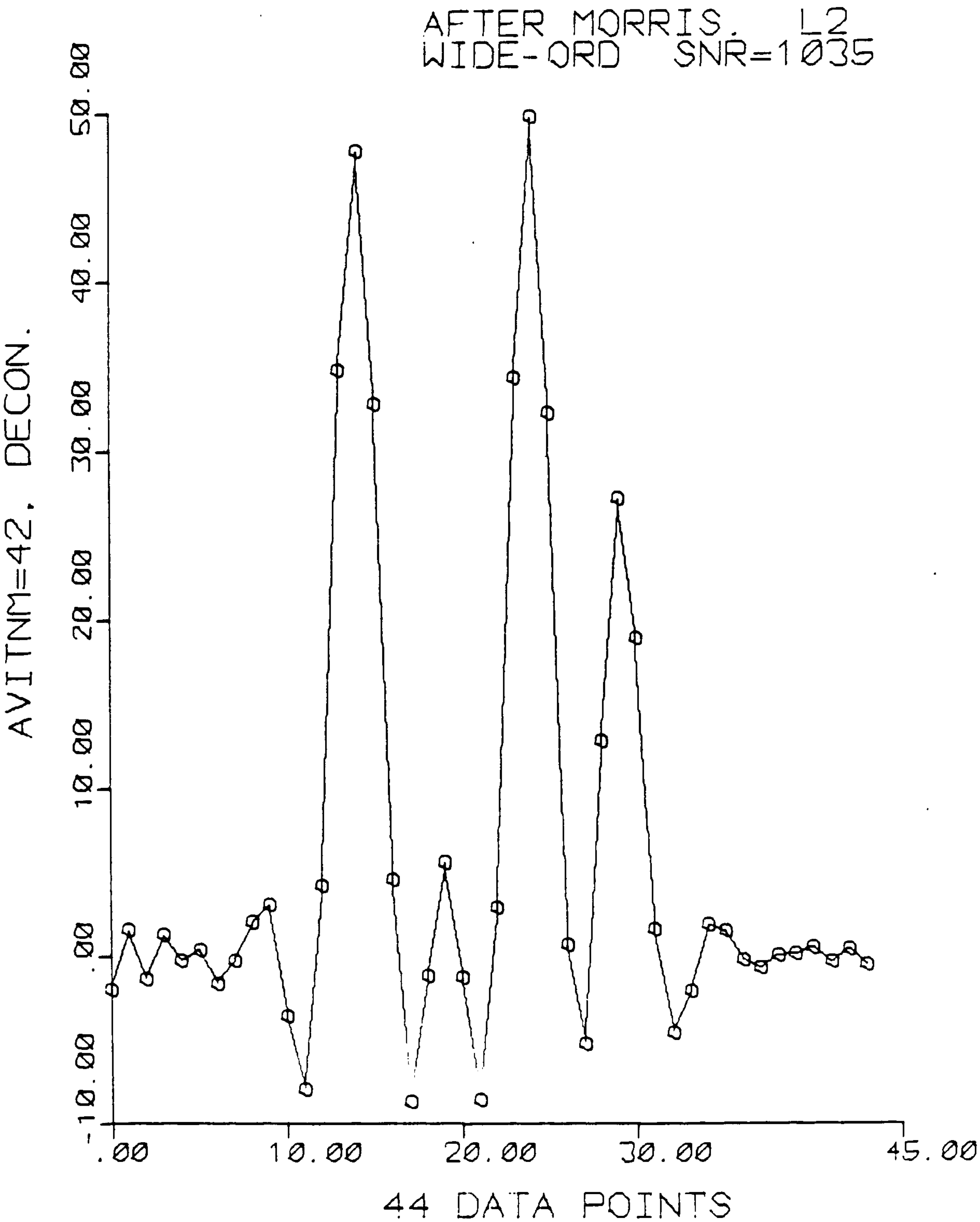

AFTER MORRIS. L2
WIDE-ORD SNR=1Ø35
AVITNM=42. DECON.
5Ø.ØØ
4Ø.ØØ
3Ø.ØØ
2Ø.ØØ
1Ø.ØØ
.ØØ
-1Ø.ØØ
.ØØ
1Ø.ØØ
2Ø.ØØ
3Ø.ØØ
45.ØØ
44 DATA POINTS

Figure (4.56)

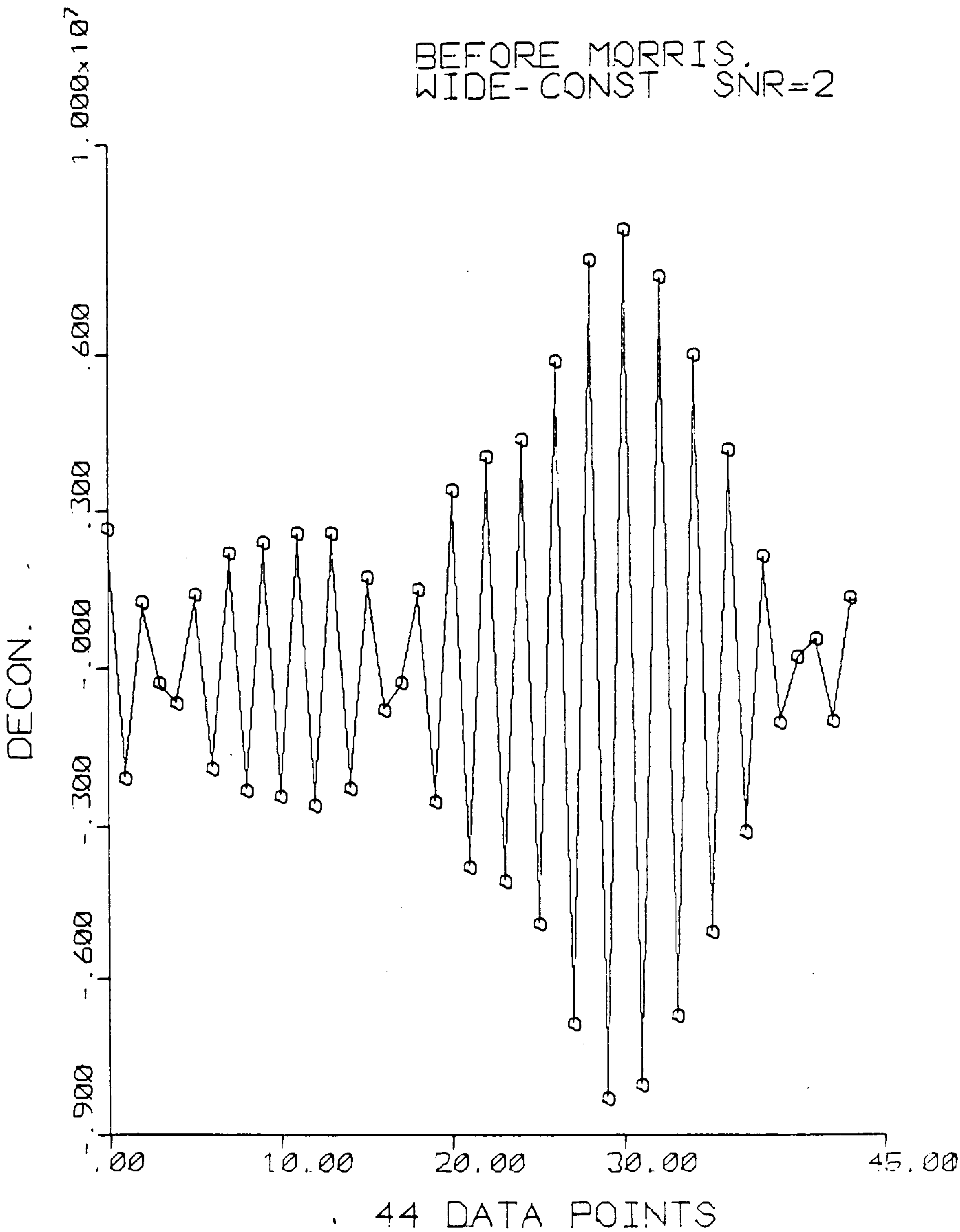

BEFORE MORRIS.
WIDE-CONST SNR=2
1.000×10⁷
.600
.300
.000
-.300
-.600
-.900
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.57)

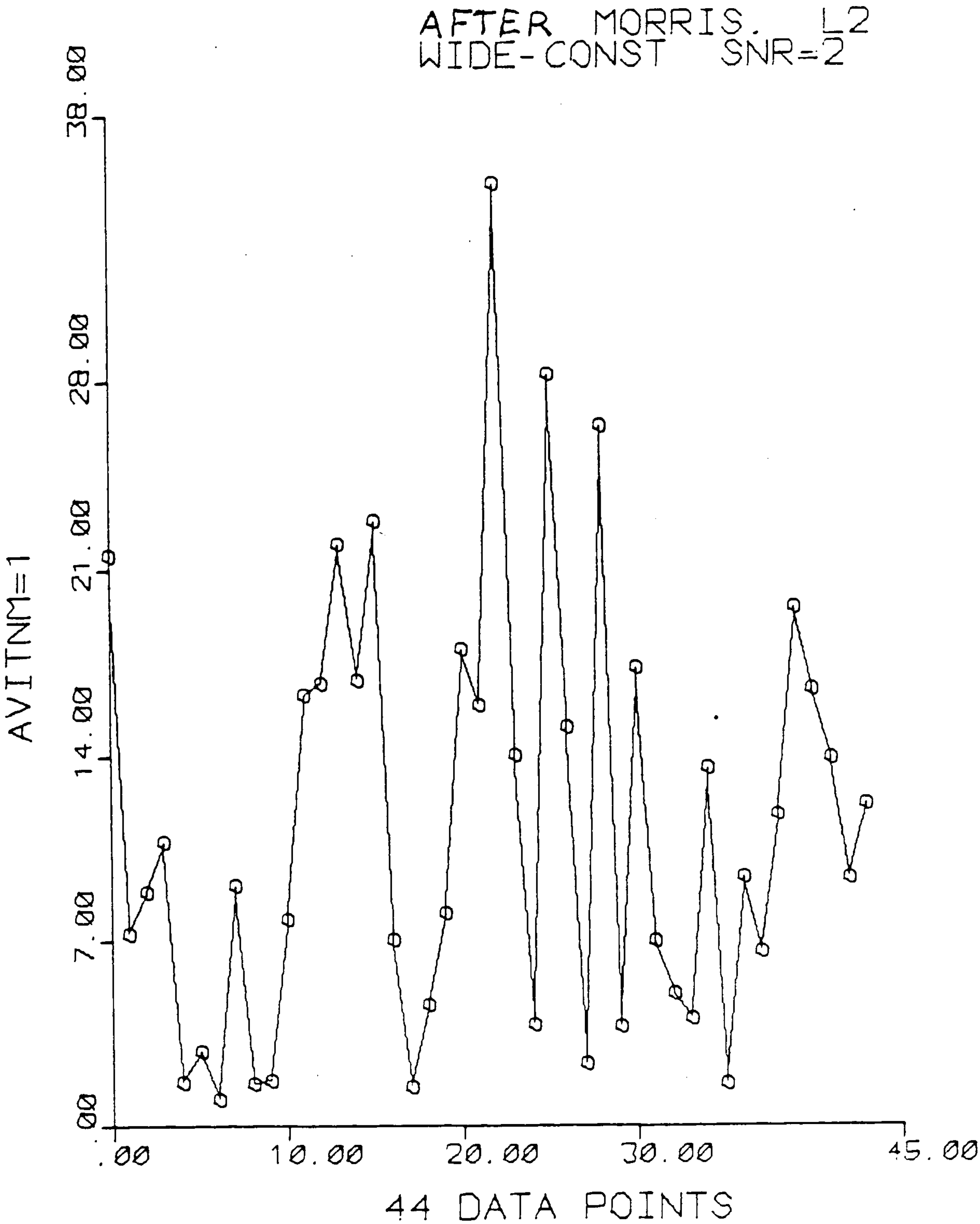

AFTER MORRIS. L2
WIDE-CONST SNR=2
AVITNM=1
38.00
28.00
21.00
14.00
7.00
00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.58)

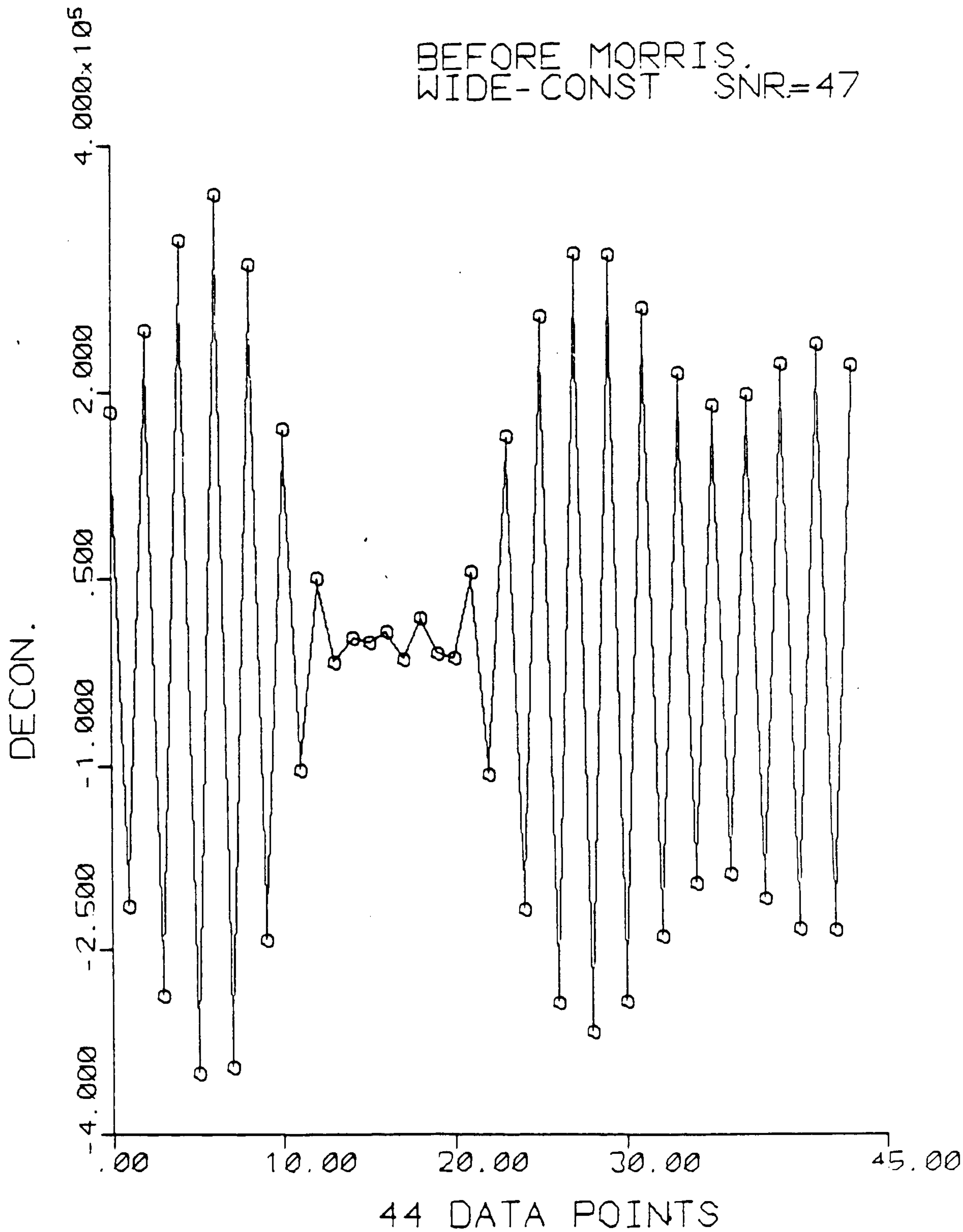

BEFORE MORRIS.
WIDE-CONST SNR=47
4.000x10^5
2.000
.500
-1.000
-2.500
-4.000
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.59)

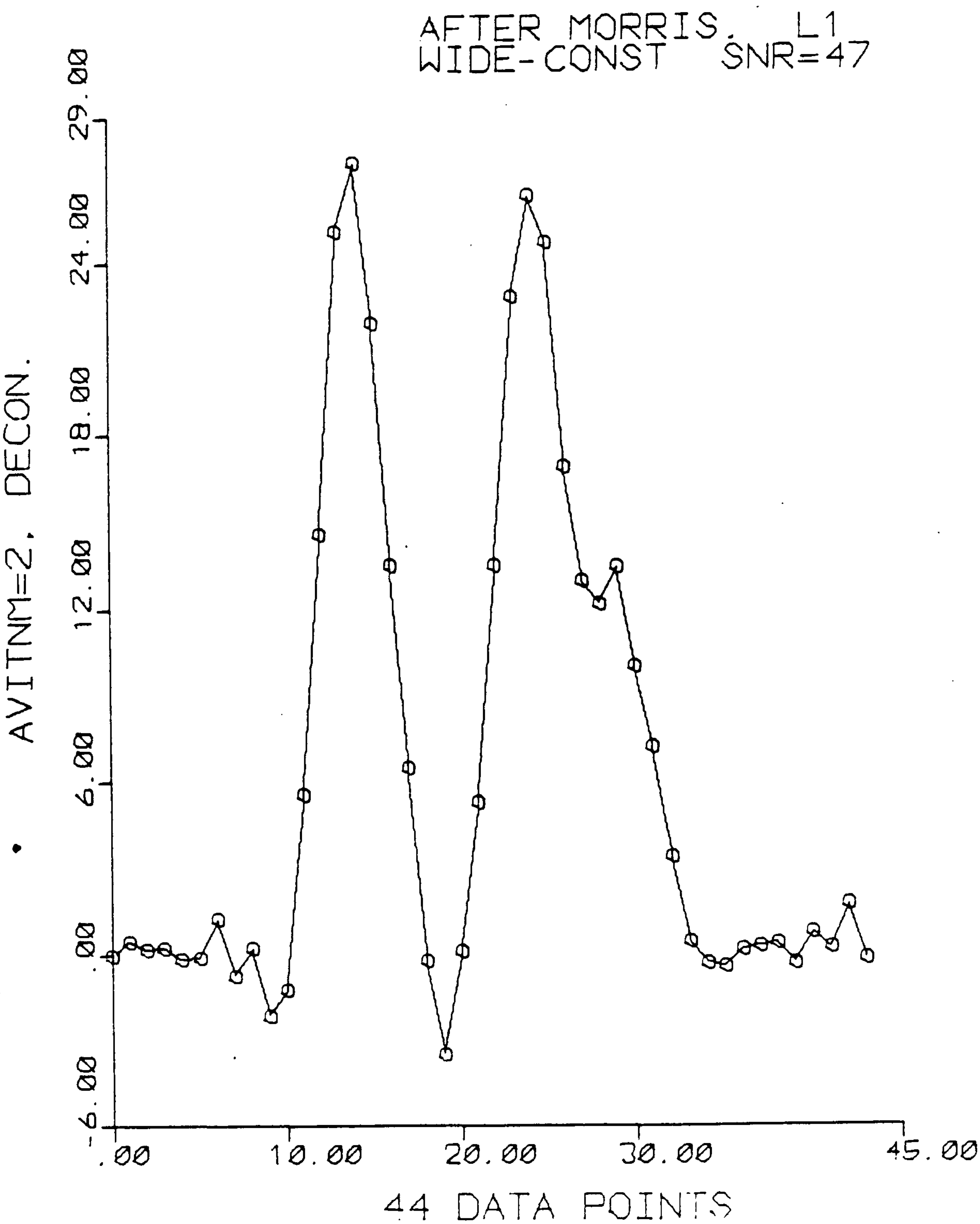

AFTER MORRIS. L1
WIDE-CONST SNR=47
AVITNM=2, DECON.
29.00
24.00
18.00
12.00
6.00
.00
-6.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.60)

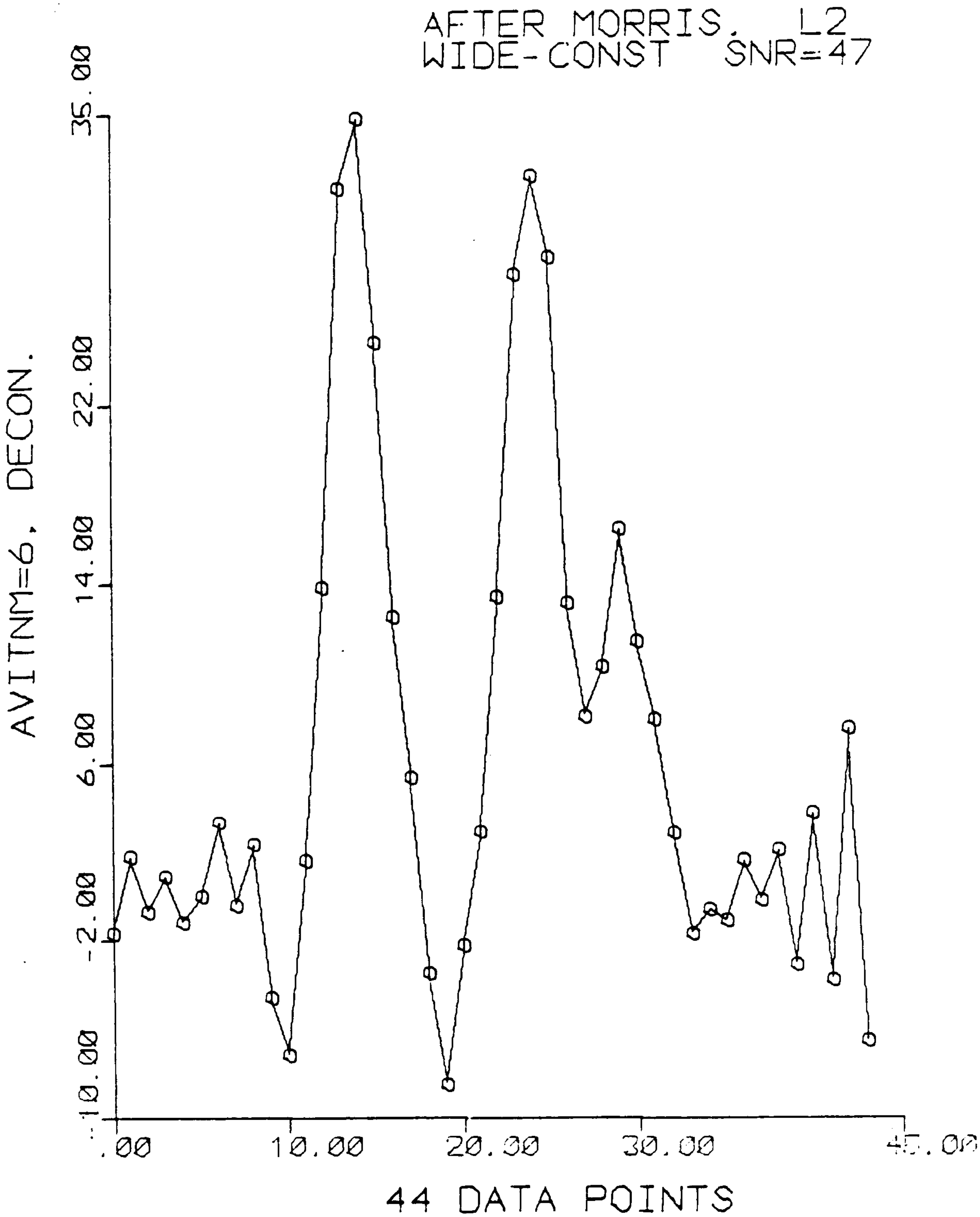

AFTER MORRIS. L2
WIDE-CONST SNR=47
AVITNM=6, DECON.
35.00
22.00
14.00
6.00
-2.00
-10.00
.00
10.00
20.00
30.00
40.00
44 DATA POINTS

Figure (4.61)

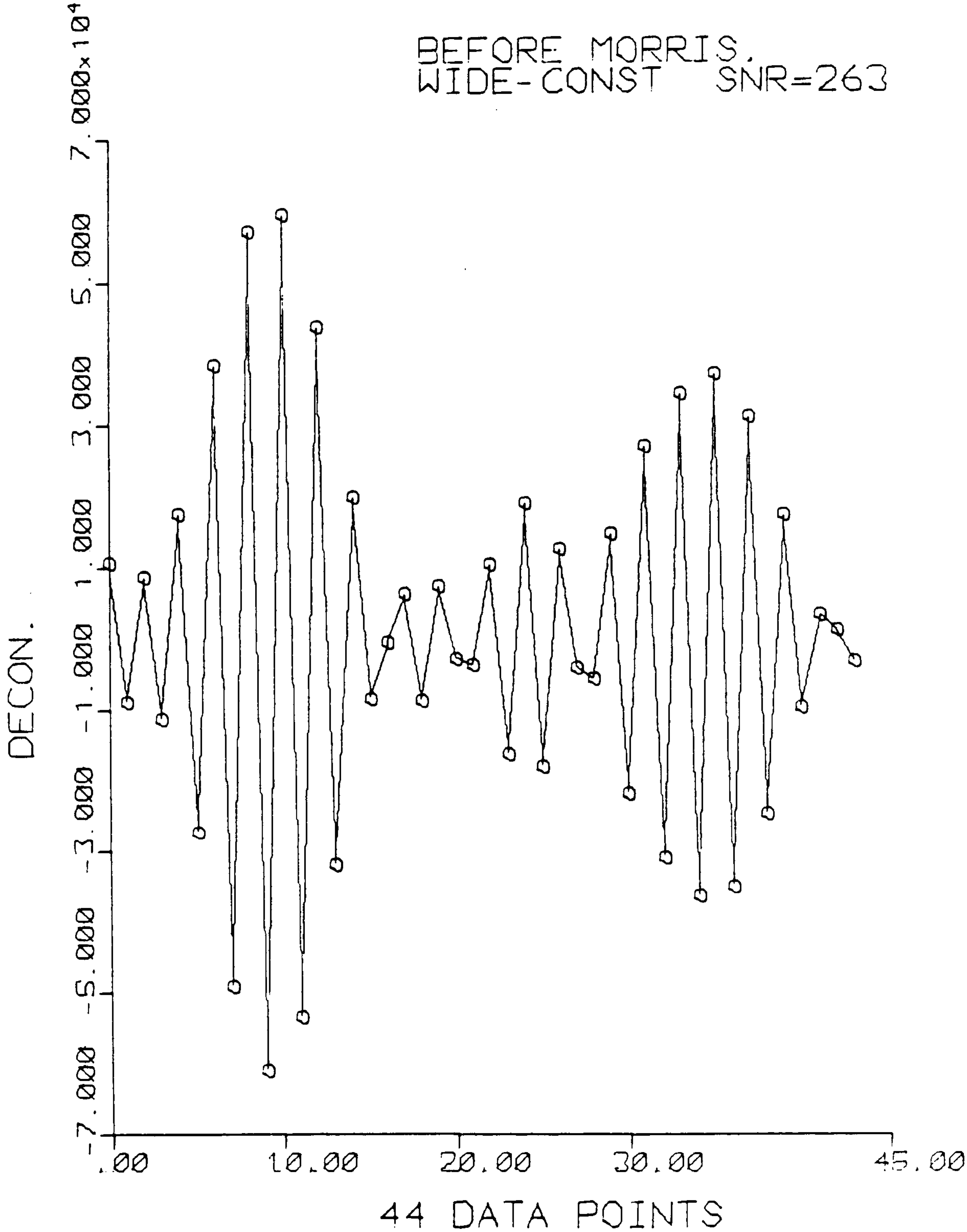
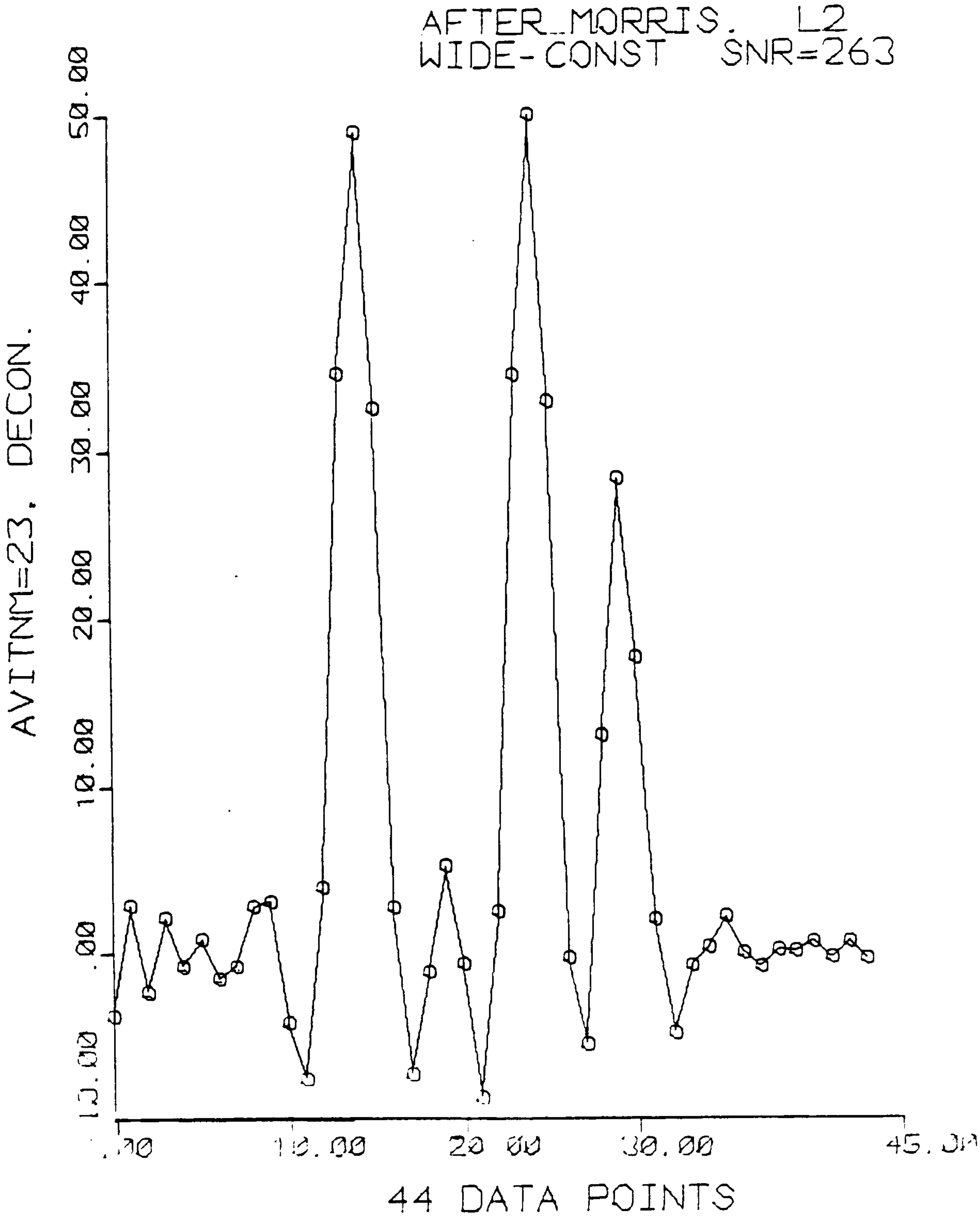

BEFORE MORRIS.
WIDE-CONST SNR=263
7.000×10⁴
5.000
3.000
1.000
-1.000
-3.000
-5.000
-7.000
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.62)



AFTER_MORRIS. L2
WIDE-CONST SNR=263
AVITNM=23. DECON.
50.00
40.00
30.00
20.00
10.00
.00
44 DATA POINTS
10.00
20.00
30.00
45.00

Figure (4.63)

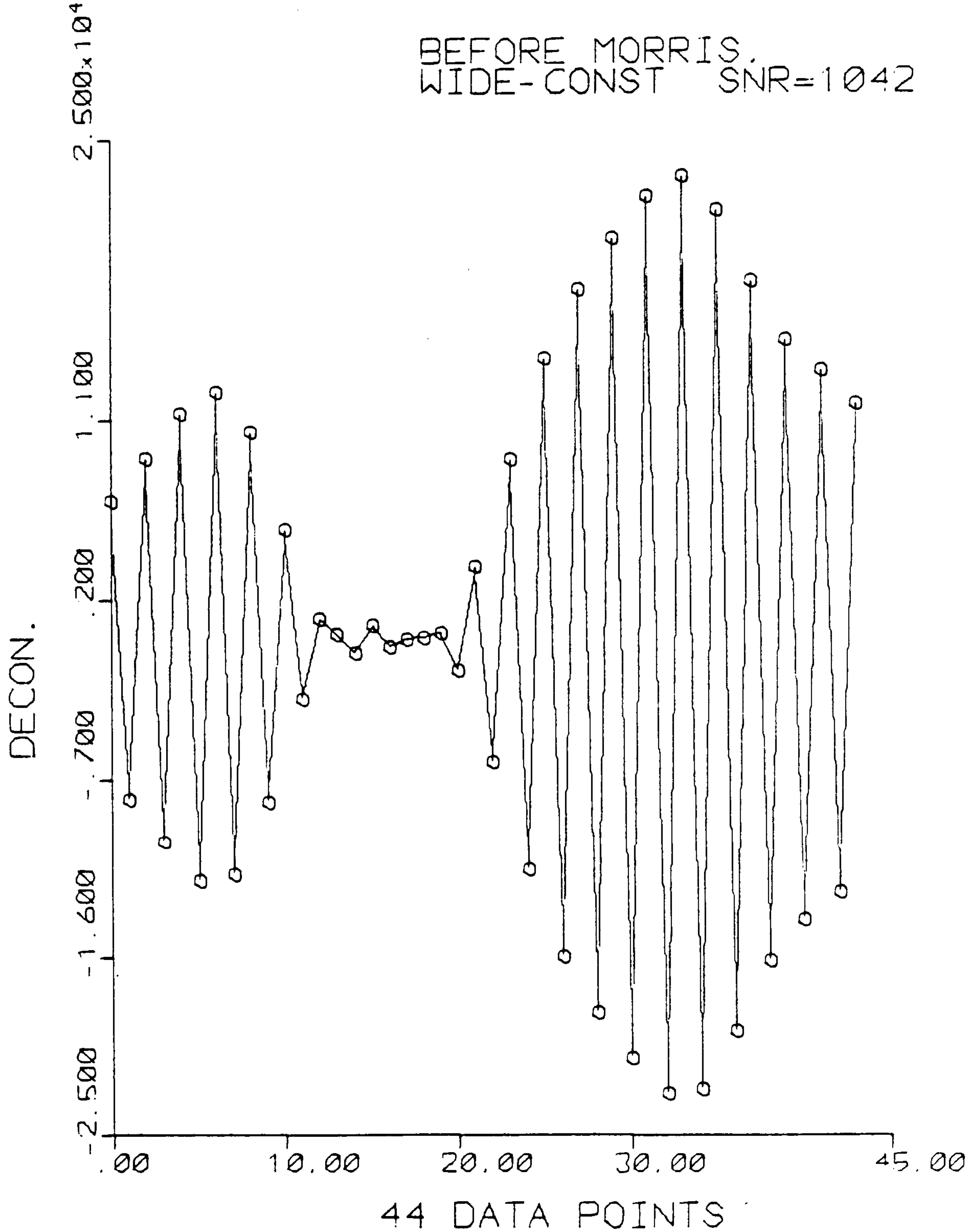

BEFORE MORRIS.
WIDE-CONST SNR=1042
2.500x10⁴
1.100
.200
-.700
-1.600
-2.500
DECON.
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.64)

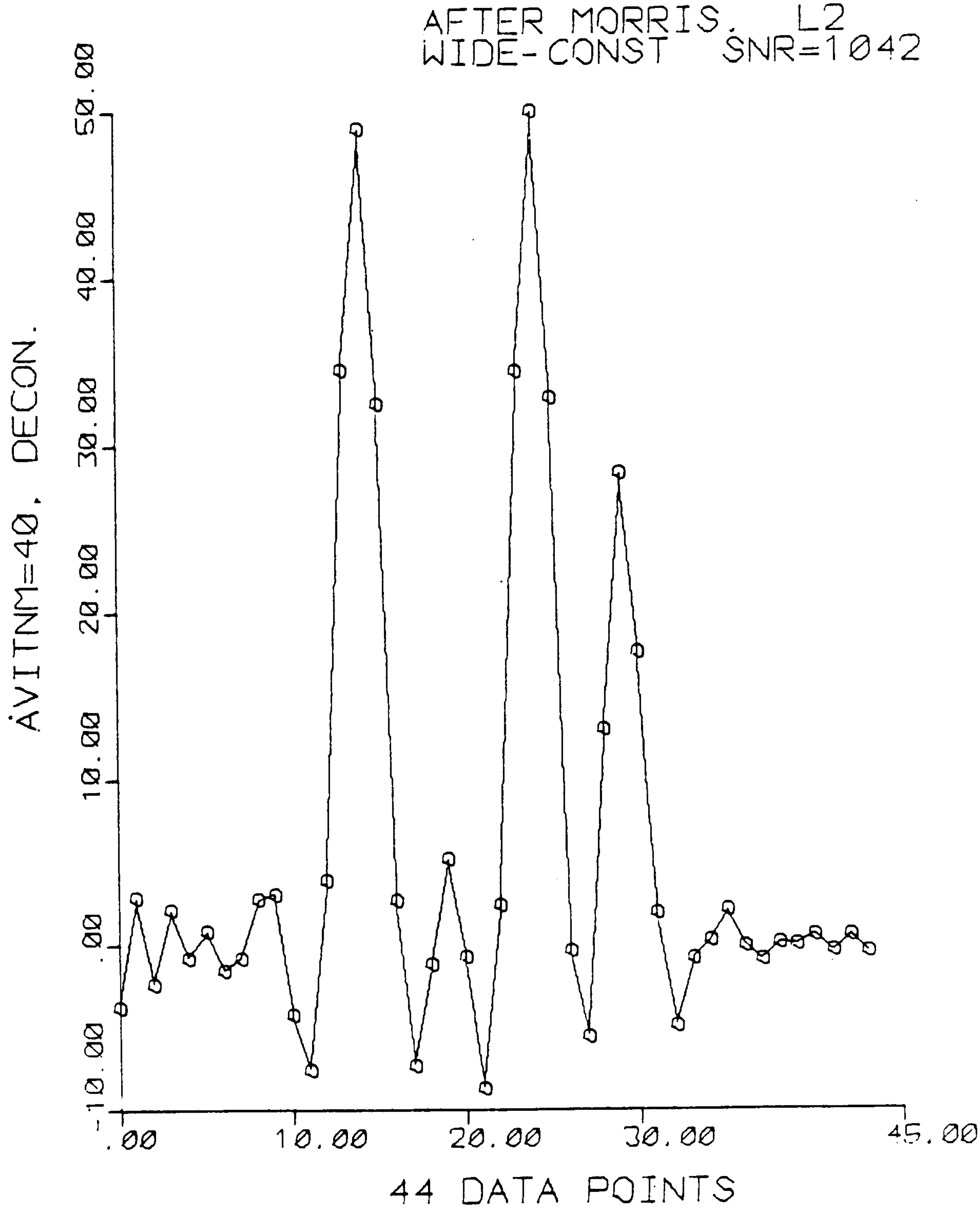
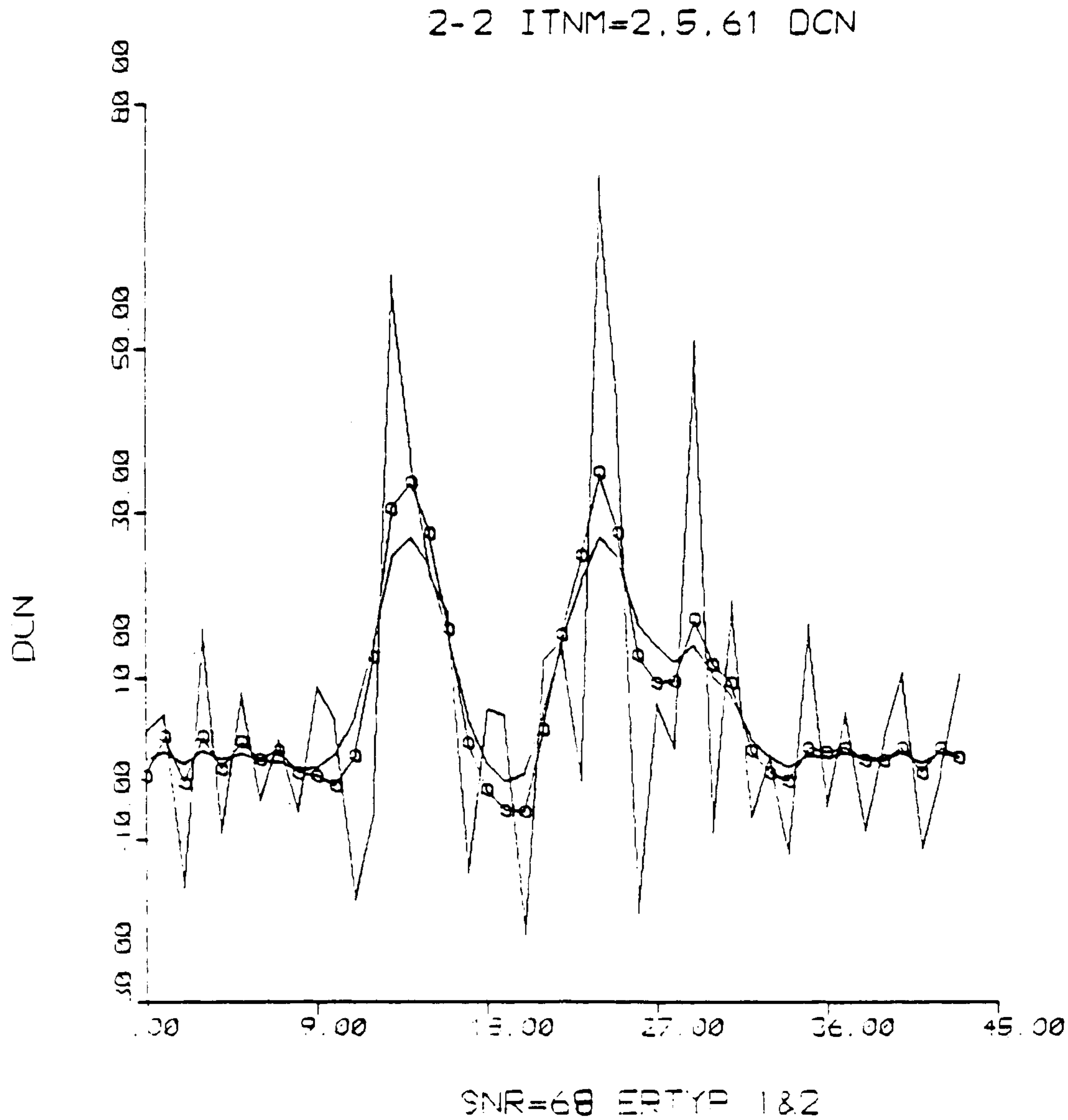

AFTER MORRIS. L2
WIDE-CONST SNR=1042
AVITNM=40. DECON.
50.00
40.00
30.00
20.00
10.00
.00
-10.00
.00
10.00
20.00
30.00
45.00
44 DATA POINTS

Figure (4.65)



CHAPTER V

CONCLUSION

Comparison of the Two Applications of Morrison's Method

As mentioned above, Morrison's smoothing is designed specifically for noise removal prior to deconvolution. In general the error improvement between results before and after Morrison's technique is applied is greater for the deconvolution study. This is especially true for the wide gaussian case as the relatively large number of small magnitude high frequency components in G(s) cause great amplification of noise in deconvolution before Morrison's method is applied.

In the comparison of the optimum iteration results for the wide gaussian ordinate and constant noise L2 norm cases for noise removal alone and noise removal prior to deconvolution, it is obvious that the average iteration numbers are significantly higher for noise removal alone over the full range of the average SNR values. This is a consequence of optimum use of Morrison's method for overall noise removal not corresponding to optimum use prior to deconvolution. When iterations are continued past the optimum for deconvolution, noise at higher frequencies and elsewhere continues to be restored. As deconvolution is most sensitive to noise at frequencies where the magnitudes of G(s) and H(s) are small, the result is greater distortion of the deconvolved result.

In the narrow gaussian study the optimum iteration numbers show a much closer relationship between the noise removal alone and deconvolution studies. The degree of closeness as compared to the wide case result can in all probability be attributed to the fact that G(s) and H(s) for the narrow gaussian contain fewer small-magnitude high-frequency components, and thus have a flatter spectrum. Consequently, Morrison's method restores signal and noise most quickly where G(s) is largest, giving a more even restoration of the low and somewhat higher frequencies. The combination of these two factors is enough to cause slower amplification of noise in deconvolution. Where H(s) is wider, it takes longer for error in regions for which H(s) is small to cause a large percentage error in the deconvolved result.

From the results of the wide and narrow gaussian studies there seems to be a direct relationship between the width of the system's response and the degree of correlation between the noise removal and deconvolution results.

User Application

A user having similar data wishing to apply the results calculated in this study should consult chapter III if optimization for noise removal alone is desired, and chapter IV for optimization prior to deconvolution. The plots of average iteration number and average error improvement versus average SNR are probably the most useful results for a data analyst. Only the SNR of the data need be calculated as decribed in chapter III, and from the iteration plots the corresponding iteration number can be located. Using the plots where the abscissa values are the natural log of average SNR is suggested for lower SNR's for easier interpretation. The exponential of the natural log value must be taken to calculate the SNR value. Choosing an iteration number at the upper limit of one standard deviation above the mean number will correspond to a result with more noise but perhaps more resolution of signal. Choosing an iteration number at the lower limit of one standard deviation below the mean will give a result with less noise but perhaps less resolution of signal. The user should bear in mind that the maximum and minimum number of iterations for optimization at a given SNR, listed in the tables, may also be of interest.

The error curves give the user some idea of how much error improvement can be expected. An error ratio greater than one corresponds to no improvement in error achieved by applying Morrison's noise removal. The analyst will probably not want to apply Morrison's method in this region or even when the error ratio is not much less than one.

Application to van Cittert's Deconvolution

A significant added result of this study is that the optimization of Morrison's method prior to deconvolution corresponds to the optimum use of van Cittert's iterative method of deconvolution applied alone and without constraints. The transform domain representation of van Cittert's method of deconvolution as given by Frieden(1979) is as follows:

$$F_n = (H/G)[1-(1-G)^{n+1}]$$

Comparison to the frequency domain representation of Morrison's technique with deconvolution:

$$H_n/G = [1-(1-G)^n](H/G)$$

shows that the optimum for van Cittert's method occurrs at one less iteration number than for Morrison's technique prior to deconvolution.

Further Research

An interesting study would be to calculate results for a number of gaussians having a greater and more detailed range of widths, and determine if the same behavior found here is magnified and how the behavior depends on width in detail. This may allow one to make a more definitive statement about the results achievable with Morrison's noise removal in relation to the width of the gaussian response.

Another extension to the study performed here would be to determine the optimum use of Morrison's noise removal for data containing a mixture of constant and ordinate-dependent noise. Because of the proportionate contribution of each noise type could be varied, care would have to be taken to select realistic mixtures and to limit the cases so that the amount of data to be summarized does not grow to large.

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APPENDIX

Computer Programs and Documentation

The computer programs used to calculate the results of this study are listed here as well as brief documentation for each program. All programs are written in FORTRAN. The program ERWRAP.FOR was used to calculate the results of Chapter II. Input to the program is the type gaussian used, GTYP, i.e., either narrow or wide, 1 or 2; the length of the output h, M, either 32 or 44 for this study; the length of the gaussian g, N, 9 or 21, followed by the length of the input f, L=24. Next the number of the data file containing h, g, and f is input; followed by the length of the longest length inverse filter, minus one, to be calculated, NT=NT1=4096.

Filters of decreasing length are calculated until a filter of length 33 is attained. The method used to calculate filters of decreasing length is to divide NT1=4096 by a variable labled INDEX. Each time through a loop in the main program INDEX, which has an initial value of one, is multiplied by two. An INDEX of 128 calculates a 33 point filter; a larger INDEX causes termination of the loop and then the output files are produced. A user can change the limits set on the loop to calculate a different range of filter lengths. The results listed in the tables and on the figures of Chapter II were produced from the output files listed in the subroutines OUTERR and OUTCON. The reader may consult these subroutines for a listing of the file numbers.

The results of Chapter III were calculated using the program NOS2B.FOR. Input to the program is the type of gaussian, narrow or wide, 1 or 2, respectively, followed bv the lengths of h and g. Next the number of the input file containing h and g is input; followed by the type noise to added to the data. Type in 1 and ordinate dependent noise is produced; 2 gives constant noise. The maximum and minimum noise scale factor NSF are input to set the limits on the range of SNR's to be calculated. The plots of AVESNR versus $1/(NSF)^{1/2}$ given in Chapter III are useful in choosing effective NSF's. Next the maximum number of Morrison's restorations that can be performed is input; the program has an upper limit of 900 restorations. The results listed in the tables and plots of Chapter III were produced from the output files listed in the subroutine OUTPUT.

The program DECON.FOR was applied in calculating the results of Chapter IV. Input to DECON.FOR is the gaussian type, 1 or 2, the lengths of h, g, and f; followed by the number of the file containing h, g, and f. Next the number of points minus one, NT, of the most accurate length inverse filter to be used in deconvolution is input; i.e., 256 and 128 for the narrow and wide gaussian studies, respectively. The noise type is then input, either 1 or 2, followed by the maximum and minimum NSF's to be used. For the NSF's to use the AVESNR versus $1/(NSF)^{1/2}$ plots of Chapter III are again useful. Next the maximum number of Morrison's iterations that can be performed is input; the program has an upper limit of 900. Iterations will be terminated when the error minimum or convergence of error is attained. The number of data sets to be optimized is input (50 for this study); followed by the number of points the error is to be calculated over, either L=24, or M=32 or 44. The type of error measure used is input; either 1 for the unweighted L1 and L2 norms, or 2 for the weighted measures. Next the convergence criteria defined in Chapter IV is input. The output files contained in the subroutine OUTPUT were used to give all results listed in Chapter IV

In listing the programs the main program of each calculation is given. A complete version. including all subroutines, is given of DECON.FOR. For ERWRAP.FOR the subroutines used to calculate the inverse filter are not included since these subroutines are listed in DECON.FOR. For the program NOS2B.FOR, the subroutines used to add ordinate dependent and constant noise, the subroutines used in smoothing and restoration, and the output subroutine are not given as they are also included in DECON.FOR. In the insertation of subroutines from DECON.FOR into NOS2B.FOR. however, care should be taken as some of the arrays of NOS2B.FOR begin with zero as the first data location and the same arrays used in DECON.FOR begin with one as the first data element. Some minor modifications to the subroutines SMOOTH and RESTOR, and the noise addition subroutines will have to be made.

```
                   PROGRAM ERWRAP.FOR
C
C
           IMPLICIT DOUBLE PRECISION(A-H,O-Z)
           DIMENSION GSMBER(20),GSMQER(20),GSMBHR(20)
           DIMENSION GVARHF(20),GSMBDH(20),GSMQDH(20),FTL(10),
     *     GSMABD(20),GSMSQD(20),GT(8194),GSMQHR(20)
           DIMENSION H(256),G(256),F(256),GTR(4200),HO(4200)
           INTEGER P,Z,ANS,GTYP,OFL,PTINDX
           INDEX = 0
           PTINDX = 1
C
C     ENTER DATA _NUMBER OF POINTS IN GT
C
4          CALL ENTERD(GTYP,N,M,L,G,H,F,NT,INDEX)
C
C     ADD ZEROS WITH PREPGT FOR LENGTH NT _IMG. = 0
C
           CALL PREPGT(GT,NT,N,G)
C
           CALL FFT(GT,NT,-1)
C
C     CALCULATE MAGNITUDE OF TRANSFORM GT
C
           CALL MAGGT(GT,NT)
C
C     CALCULATE 1/TRANSFORM GT
C
           CALL INVTRN(GT,NT)
C
C     BACK TO FUNCTION DOMAIN
C
           CALL FFT(GT,NT,+1)
C
C     SHIFT PEAK
C
           CALL SHIFGT(GT,NT)
C
C     NORMALIZE INVERSE IMPULSE RESPONSE _MAKE SYMETRIC(ODD)
C
           CALL NRMSMR(GT,NT)
C
C     DELETE IMAGINARY PART OF GT
C
           CALL GTREAL(GTR,GT,NT)
C
C     DO CONVOLUTION HO = H * GTR
C
           CALL CONVOL(GTR,H,HO,M,NT)
C
C     OUTPUT CONVOLUTION RESULTS
C
           CALL OUTCON(HO,M,NT-INDEX)
C
```

```
C    CALCULATE ERROR BETWEEN HN´S _F
C
         CALL ERRFHO(F,HO,M,L,NT SMABER,SMSQER,SMABHR,SMSQHR,
      1  VARHF)
C
C    CALCULATE DIFFERENCE BETWEEN HA _HN´S
C
        CALL DIFH(HO,SMBDHM,SMQDHM,INDEX,M,NT,SMABD,SMSQD)
C
C    PLACE ERRORS INTO ARRAYS _OUTPUT RESULTS
C
         CALL SMARAY(SMABER,SMSQER,SMABHR,SMSQHR,VARHF,
      1  GSMBER,GSMQER,GSMBHR,GSMQHR,GVARHF,PTINDX,L,M,
      2  SMBDHM,SMQDHM,GSMBDH,GSMQDH,NT,FTL,SMABD,SMSQD,
      3  GSMABD,GSMSQD)
C
C    GO BACK TO ENTERD TO DO CALCULATIONS FOR NEW GT
C
          INDEX = INDEX * 2
          IF (INDEX.LE.128)GO TO 4
C
C    OUTPUT THE ERROR MEASURES
C
         CALL OUTERR(GSMBER,GSMQER,GSMBHR,GSMQHR,GVARHF,PTINDX,
      1  GSMBDH,GSMQDH,FTL,GSMABD,GSMSQD,GTYP)
C
          RETURN
          END
C
C
C
C
C        ENTER DATA _NUMBER OF POINTS NT
C
         SUBROUTINE ENTERD(GTYP,N,M,L,G,H,F,NT,INDEX)
         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
         DIMENSION G(256),H(256),F(256)
         INTEGER GTYP
1        FORMAT(I)
         IF (INDEX.GT 1)GO TO 10
         INDEX=1
         TYPE 2
2        FORMAT(´ ENTER 1 FOR NARROW G, 2 FOR WIDE G ´)
         ACCEPT 1,GTYP
         CALL INPUT(N,M,L,G,H,F,GTYP)
         TYPE 3
3        FORMAT(´ ENTER NUMBER OF POINTS IN GT1 ´$)
         ACCEPT 1,NT
         NT1=NT
         IF (INDEX.EQ.1)GO TO 20
10       NT=NT1/INDEX
20       RETURN
         END
C
```

```
C        INPUT ENTERS THE DATA
C
         SUBROUTINE INPUT(N,M,L,G,H,F,GTYP)
         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
         DIMENSION H(256),G(256),F(256)
         INTEGER IFL,GTYP
         WRITE(33,105)
         WRITE(40,105)
         WRITE(33,120)GTYP
         WRITE(40,120)GTYP
105      FORMAT(///' TYPE OF G FUNCTION '//)
         TYPE 110
110       FORMAT ('   ENTER SIZE OF H')
         ACCEPT 120,M
120       FORMAT(I)
         TYPE 130
130       FORMAT('  ENTER SIZE OF G,ODD ')
         ACCEPT 120,N
         TYPE 135
135      FORMAT(' ENTER SIZE OF F ')
         ACCEPT 120,L
         TYPE 140
140       FORMAT('  ENTER THE INPUT FILE      ',$)
         ACCEPT 120,IFL
         READ(IFL,160)(H(I),I=1,M)
         READ(IFL,160)(G(I),I=1,N)
         READ(IFL 160)(F(I),I=1,L)
160       FORMAT(4G)
10       FORMAT(G)
         RETURN
         END
C
C        CONVOLUTION PROGRAM
C
         SUBROUTINE CONVOL(GTR,HI,HO,M,NT)
         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
         DIMENSION GTR(4097),HI(256),HO(4140)
         INTEGER A,B,C,D,E,F
C        COMPUTE CONVOLUTION
         K=NT+M
         DO 10 I=1,K
         HO(I)=0.
         A=1
         B=I-M+1
         IF (A.GE.B) C=A
         IF (A LT.B) C=B
         D=I
         E=NT+1
         IF (D.LT E) F=D
         IF (D.GE.E) F=E
         DO 5 J=C,F
         TEMP=GTR(J)*HI(I-J+1)
5        HO(I)=HO(I)+TEMP
10       CONTINUE
```

```
      RETURN
      END
C
C     OUTPUT CONVOLUTION RESULTS-(WITH PLOT)
C
      SUBROUTINE OUTCON(HO,M,NT,INDEX)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION HO(4200)
10    FORMAT(G)
      IF (INDEX.EQ.1)WRITE(51,10)(HO(I),I=1,NT+M)
C      IF (INDEX.EQ.2)WRITE(52,10)(HO(I),I=1,NT+M)
C      IF (INDEX.EQ.4)WRITE(53,10)(HO(I),I=1,NT+M)
C      IF (INDEX.EQ.8)WRITE(54,10)(HO(I',I=1,NT+M)
      IF (INDEX.EQ.16)WRITE(55,10)(HO(I),I=1,NT+M)
      IF (INDEX.EQ.32)WRITE(56,10)(HO(I),I=1,NT+M)
      IF (INDEX.EQ.64)WRITE(57,10)(HO(I),I=1,NT+M)
      IF (INDEX.EQ.128)WRITE(58,10)(HO(I),I=1,NT+M)
      RETURN
      END
C
C     ERROR HO _F
C
      SUBROUTINE ERRFHO(F.HO,M,L,NT,SMABER,SMSQER,SMABHR,
     1 SMSQHR,VARHF)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION  F(256),HO(4200),ABER(100),SQABER(100)
      DIMENSION  HHFER(256),HOFER(4200)
      SMABER=0.
      SMSQER=0.
      SMSBHR=0.
      SMSQHR=0.
      VARHF=0.
C
C    ERROR HN _F, L TERMS
C
      DO 10 I=1,L
      ABER(I)=DABS(HO(M/2+NT/2-L/2+I)-F(I))
      SQABER(I)=(ABER(I))**2
      SMABER=SMABER+ABER(I)
      SMSQER=SMSQER+SQABER(I)
10    CONTINUE
      SMABER=SMABER/L
      SMSQER=SMSQER/L
      WRITE(33,20)
20    FORMAT(///' F - FUNCTION '//)
      WRITE(33,40)(F(I),I=1,L)
      WRITE(33,30)
30    FORMAT(///' L-TERMS OF HN '//)
      WRITE(33,40)(HO(M/2+NT/2-L/2+I),I=1,L)
      WRITE(33,32)
32    FORMAT(///' ABS. ERR. = ABS(F-HN)  , L-TERMS '//)
      WRITE(33,40)(ABER(I),I=1,L)
      WRITE(33,33)
33    FORMAT(///' SUM OF ABS ERROR F _HN ,L-TERMS '//)
```

```
      WRITE(33,40)SMABER
      WRITE(33,35)
35    FORMAT(///' SQ. ABS. ERR.=ABS(F-HN)**2,L-TERMS '//)
      WRITE(33,40)(SQABER(I),I=1,L)
      WRITE(33,37)
37    FORMAT(///' SUM OF SQ. ERROR F _HN ,L-TERMS '//)
      WRITE(33,40)SMSQER
40    FORMAT(8(1PE16.6))
C
C     ERROR HN _F, M TERMS
C
      DO 50 I=1,M/2-L/2
      HHFER(I)=DABS(HO(NT/2+I))
50    CONTINUE
      DO 55 I=1,L
      HHFER(M/2-L/2+I)=ABER(I)
55    CONTINUE
      DO 60 I=1,M/2-L/2
      HHFER(M/2+L/2+I)=DABS(HO(NT/2+M/2+L/2+I))
60    CONTINUE
      WRITE(33,65)
65    FORMAT(///' ABS. ERR. = ABS(F-HN), M-TERMS '//)
      DO 70 I=1,M
      SMABHR=SMABHR+HHFER(I)
      SMSQHR=SMSQHR+HHFER(I)**2
70    CONTINUE
      SMABHR=SMABHR/M
      SMSQHR=SMSQHR/M
      WRITE(33,77)
77    FORMAT(///' SUM OF ABS. ERROR - M TERMS '//)
      WRITE(33,78)
78    FORMAT(///' SUM OF SQ. ERROR - M TERMS '//)
      WRITE(33,40)SMSQHR
C
C     ERROR HN _F ,M+NT TERMS -- VARIANCE
C
      DO 80 I=1,NT/2+M/2-L/2
      HOFER(I)=DABS(HO(I))
80    CONTINUE
      DO 85 I=1,L
      HOFER(NT/2+M/2-L/2+I)=ABER(I)
85    CONTINUE
      DO 90 I=NT/2+M/2+L/2+1,NT+M
      HOFER(I)=DABS(HO(I))
90    CONTINUE
C
C     CALCULATE VARIANCE - NT+M TERMS
C
      DO 100 I=1,NT+M
      VARHF=VARHF+(HOFER(I)**2)
100   CONTINUE
      VARHF=VARHF/(NT+M)
      WRITE(33,105)
105   FORMAT(///' VARIANCE OF HN - NT+M TERMS '//)
```

```
      WRITE(33,40)VARHF
      RETURN
      END
C
C
C
C
C     PLACE SUM'S INTO ARRAY'S
C
      SUBROUTINE SMARAY(SMABER,SMSQER,SMABHR,SMSQHR,VARHF,
     1 GSMBER,GSMQER,GSMBHR,GSMQHR,GVARHF,PTINDX,L,M,
     2 SMBDHM,SMQDHM,GSMBDH GSMQDH NT FTL,SMABD,SMSQD,
     3 GSMABD,GSMSQD)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION GSMBER(20),GSMQER(20),GSMBHR(20)
      DIMENSION GVARHF(20),GSMBDH(20),GSMQDH(20),FTL(10),
     1 GSMABD(20),GSMSQD(20),GSMQHR(20)
      INTEGER PTINDX
      IF (PTINDX.EQ.1)GO TO 5
      GSMBDH(PTINDX-1)=SMBDHM
      GSMQDH(PTINDX-1)=SMQDHM
      GSMABD(PTINDX-1)=SMABD
      GSMSQD(PTINDX-1)=SMSQD
5     GSMBER(PTINDX)=SMABER
      GSMQER(PTINDX)=SMSQER
      GSMBHR(PTINDX)=SMABHR
      GSMQHR(PTINDX)=SMSQHR
      GVARHF(PTINDX)=VARHF
      FTL(PTINDX)=NT+1
      PTINDX=PTINDX+1
      TYPE 10,NT
10    FORMAT(I)
      RETURN
      END
C
C     OUTPUT ERROR MEASURES
C
      SUBROUTINE OUTERR(GSMBER,GSMQER,GSMBHR,GSMQHR,
     1 GVARHF,PTINDX,GSMBDH,GSMQDH,FTL,GSMABD,GSMSQD,
     2 GTYP)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION GSMBER(20),GSMQER(20),GSMBHR(20),GSMQHR(20)
      DIMENSION GVARHF(20),GSMBDH(20),GSMQDH(20),FTL(10),
     1 GSMABD(20),GSMSQD(20)
      DIMENSION SSMBER(20),SSMQER(20),SSMBHR(20),SSMQHR(20)
      DIMENSION SVARHF(20),SSMBDH(20),SSMQDH(20),FTLL(10),
     1 SSMABD(20),SSMSQD(20)
      INTEGER PTINDX,GTYP
      J=PTINDX
      K = PTINDX-1
1     FORMAT(8(1PE16.6))
      DO 2 I=1,K/2
      FTLL(I)=FTL(I)
      SSMBER(I)=GSMBER(I)
```

```
      SSMQER(I)=GSMQER(I)
      SSMBHR(I)=GSMBHR(I)
      SSMQHR(I)=GSMQHR(I)
      SVARHF(I)=GVARHF(I)
      SSMBDH(I)=GSMBDH(I)
      SSMQDH(I)=GSMQDH(I)
      SSMABD(I)=GSMABD(I)
      SSMSQD(I)=GSMSQD(I)
2     CONTINUE
      DO 3 I=1,(K/2)
      FTL(I)=FTL(J-I)
      GSMBER(I)=GSMBER(J-I)
      GSMQER(I)=GSMQER(J-I)
      GSMBHR(I)=GSMBHR(J-I)
      GSMQHR(I)=GSMQHR(J-I)
      GVARHF(I)=GVARHF(J-I)
      IF (I.EQ.1) GO TO 3
      GSMBDH(I-1)=GSMBDH(J-I)
      GSMQDH(I-1)=GSMQDH(J-I)
      GSMABD(I-1)=GSMABD(J-I)
      GSMSQD(I-1)=GSMSQD(J-I)
3     CONTINUE
      DO 4 I=(K/2+1),K
      FTL(I)=FTLL(J-I)
      GSMBER(I)=SSMBER(J-I)
      GSMQER(I)=SSMQER(J-I)
      GSMBHR(I)=SSMBHR(J-I)
      GSMQHR(I)=SSMQHR(J-I)
      GVARHF(I)=SVARHF(J-I)
      GSMBDH(I-1)=SSMBDH(J-I)
      GSMQDH(I-1)=SSMQDH(J-I)
      GSMABD(I-1)=SSMABD(J-I)
      GSMSQD(I-1)=SSMSQD(J-I)
4     CONTINUE
      WRITE(40,5)
5     FORMAT(///' SUM OF ABS ERR, L TERMS: H1,...,HN '//)
      WRITE(40,1)(GSMBER(I),I=1,K)
      WRITE(40,10)
10    FORMAT(///' SUM OF SQ. ERR, L TERMS: H1,...,HN '//)
      WRITE(40,1)(GSMQER(I),I=1,K)
      WRITE(40,15)
15    FORMAT(///' SUM OF ABS ERR. M TERMS: H1,...,HN '//)
      WRITE(40,1)(GSMBHR(I),I=1.K)
      WRITE(40,20)
20    FORMAT(///' SUM OF SQ. ERR, M TERMS: H1,...,HN '//)
      WRITE(40,1)(GSMQHR(I),I=1,K)
      WRITE(40,25)
25    FORMAT(///' VARIANCE OF HN FROM F, NT+M TERMS '//)
      WRITE(40,1)(GVARHF(I),I=1,K)
      WRITE(40,35)
35    FORMAT(///' SUM OF ABS DIF - (HA-HN) - M TERMS '//)
      WRITE(40,1)(GSMBDH(I),I=1.K-1)
      WRITE(40,45)
45    FORMAT(///' SUM OF SQ. DIF - (HA-HN) - M TERMS '//)
```

```
            WRITE(40,1)(GSMQDH(I),I=1,K-1)
C
C*
C*
C  SKIP GRAPH OUTPUT TO KEEP TOO MANY DEVICES
C*
C     PREPARE FOR GRAPH
C         FILE  25 = SUM OF ABS ERR L TERMS
C         FILE  26 = SUM OF SQ. ERR L TERMS
C         FILE  27 = SUM OF ABS ERR M TERMS
C         FILE  28 = SUM OF SQ. ERR M TERMS
C         FILE  29 = VARIANCE OF HN'S
C         FILE  30 = SUM OF ABS DIF HA-HN M TERMS
C         FILE  31 = SUM OF SQ. DIF HA-HN M TERMS
C         FILE  60 = SUM OF ABS DIF HA-HN (NT+M) TERMS
C         FILE  61 = SUM OF SQ. DIF HA-HN (NT+M) TERMS
C
C         WRITE(25,50)(FTL(I),GSMBER(I),I=1,K)
C         WRITE(26,50)(FTL(I),GSMQER(I),I=1,K)
C         WRITE(27,50)(FTL(I),GSMBHR(I),I=1,K)
C         WRITE(28,50)(FTL(I),GSMQHR(I),I=1,K)
           WRITE(29,50)(FTL(I),GVARHF(I),I=1,K)
          WRITE(30,50)(FTL(I),GSMBDH(I),I=1,K-1)
          WRITE(31,50)(FTL(I),GSMQDH(I),I=1,K-1)
          WRITE(60,50)(FTL(I),GSMABD(I),I=1,K-1)
          WRITE(61,50)(FTL(I),GSMSQD(I),I=1,K-1)
50        FORMAT(2G)
11        FORMAT(3(1PE15.6))
12        FORMAT(2(1PE15.6))
          IF (GTYP.EQ.1) WRITE(41,69)
69        FORMAT(///15X,'NARROW GAUSSIAN')
          IF (GTYP.EQ.2) WRITE(41,70)
70        FORMAT(///16X,'WIDE GAUSSIAN')
          WRITE(41,71)
71        FORMAT(///2X,'FILTER LENGTH',5X,'SMABER/L',7X,'
     *SMSQER/L'//)
          WRITE(41,11)(FTL(I),GSMBER(I),GSMQER(I),I=1,K)
          WRITE(41,72)
72        FORMAT(///2X,'FILTER LENGTH',5X,'SMABER/M',7X,'
     *SMSQER/M'//)
           WRITE(41,11)(FTL(I),GSMBHR(I),GSMQHR(I),I=1,K)
           WRITE(41,73)
73         FORMAT(///2X,'FILTER LENGTH',2X,'SMSQER/(NT+M)'//)
           WRITE(41,12)(FTL(I),GVARHF(I),I=1,K)
          IF(GTYP.EQ.1) WRITE(41,69)
          IF(GTYP EQ.2) WRITE(41,70)
           WRITE(41,74)
74        FORMAT(///2X,'FILTER LENGTH',5X,'SMABDF/M',7X,'
     *SMSQDF/M'//)
           WRITE(41,11)(FTL(I),GSMBDH(I),GSMQDH(I),I=1,K-1)
          WRITE(41,75)
75        FORMAT(///2X,'FILTER LENGTH',2X,'SMABDF/(NT+M)',
     *2X,'SMSQDF/(NT+M)'//)
          WRITE(41,11)(FTL(I),GSMABD(I),GSMSQD(I),I=1.K-1)
```

```
C
60       RETURN
         END
C
C       DIFH  -  DIFFERENCE BETWEEN HA _HN
C
        SUBROUTINE DIFH(HO,SMBDHM,SMQDHM,INDEX,M,NT SMABD,
      1 SMSQD)
        IMPLICIT DOUBLE PRECISION(A-H,O-Z)
        DIMENSION HO(4200),HA(4200),ADFMHN(100),ADNT(5000)
        IF (INDEX.EQ.1)GO TO 10
        IF (INDEX.GT.1)GO TO 20
10      DO 15 I=1,M+NT
15      HA(I)=HO(I)
        GO TO 100
20      SMBDHM=0.
        SMQDHM=0.
        SMABD=0.
        SMSQD=0.
        DO 25 I=1,M
        ADFMHN(I)=DABS(HA((NT/2)*INDEX+I)-HO(NT/2+I))
        SMBDHM=SMBDHM+ADFMHN(I)
        SMQDHM=SMBDHM+ADFMHN(I)**2
25      CONTINUE
         DO 30 I=1,NT+M
         ADNT(I)=DABS(HA((NT/2)*(INDEX-1)+I)-HO(I))
         SMABD=SMABD+ADNT(I)
         SMSQD=SMSQD+ADNT(I)**2
30       CONTINUE
         SMBDHM=SMBDHM/M
         SMQDHM=SMQDHM/M
        SMABD=SMABD/(NT+M)
        SMSQD=SMSQD/(NT+M)
100     RETURN
        END
```

```
                 PROGRAM NOS2B.FOR
C
C
        DIMENSION H(0/255),G(0/255),HP(0/255),HZ(0/511),
     * HN(0/511),ER(500),HOLD(0/511),ERR(100,5),
     * OPTER(100,30,2),SVSNR2(100,30),ERIT(900,2),
     * ADDNS(50),MXSNR(50),MNSNR(50),OPTIT(100,30,2),
     * AVITNM(40,2),SDITNM(40,2),ERBFM(100,30,2),AVSNR2(50)
        INTEGER P,Z,ANS,GTYP,OFL,SNRNO2,Q
        REAL MXSNR,MNSNR,MINER1,MINER2
        L = 0
C       ENTER THE DATA
        TYPE 5
5        FORMAT(' ENTER 1 FOR NAR. G,2=WIDE')
        ACCEPT 20,GTYP
        CALL INPUT(N,M,H,G)
C           ADD NOISE
        TYPE 10
10       FORMAT(' CHOOSE 1 FOR ORD DEP NOISE,2=CONSTANT')
        ACCEPT 20,ANS
20       FORMAT(I)
45      CALL SCFCTR(SF,SFMIN K,L)
50       IF (ANS.EQ.1) CALL ORDNOI(H HZ,HP,SF,RMS
     * , SNR,M,N)
         IF (ANS.EQ.2) CALL CONST(H,HZ,HP,SF
     * ,RMS,SNR,M,N)
         IF (ANS.EQ.3) CALL BOTH(H,HZ,HP,SF,RMS,
     * SNR,M,N)
C
C  CALCULATE AVERAGE SNR FOR 100 NOISE ADDITIONS _SD --
C  CONTINUE ADDING NOISE -- FOR 100 WITHIN +/-.5SD RANGE
C  SMOOTH _RESTORE -- CALCULATE ERROR AT EACH ITERATION
C
         CALL ERROR(K,M,N,H,ER SNR,L,ERR,SF,OPTIT SVSNR2,
     *   SNRNO2,NM2K,ADDNS,HP,G,HZ,NMRES,OPTER,ERBFM)
       IF (K.LE.100)GO TO 50
       IF (SNRNO2.LT.100)GO TO 50
       IF (SF.GT.SFMIN)GO TO 45
         CALL OUTPUT(ERR,L,NM2K,OPTIT,SNRNO2,SVSNR2,GTYP,
     *   ANS,ADDNS,OPTER,ERBFM)
         STOP
         END
C
C         INPUT ENTERS THE DATA
C
         SUBROUTINE INPUT(N,M,H,G)
         DIMENSION H(0/255),G(0/255)
         INTEGER IFL
         TYPE 110
110       FORMAT ('   ENTER SIZE OF H')
         ACCEPT 120,M
120       FORMAT(I)
         TYPE 130
130       FORMAT('  ENTER SIZE OF G,ODD')
```

```
      ACCEPT 120,N
      M=M-1
      N=N-1
      TYPE 140
140    FORMAT('  ENTER THE INPUT FILE    ',$)
      ACCEPT 120,IFL
      READ(IFL,160)(H(I),I=0,M)
      READ(IFL,160)(G(I),I=0,N)
160    FORMAT(4G)
      RETURN
      END
C
C        ENTER SCALE FACTORS
C
      SUBROUTINE SCFCTR(SF,SFMIN,K,L)
      IF (L.GT 1`GO TO 47
      TYPE 30
30    FORMAT(' ENTER MAX NOISE SCALE FACTOR ')
      ACCEPT 40.SF
      TYPE 31
31    FORMAT(' ENTER MIN NOISE SCALE FACTOR ')
      ACCEPT 40,SFMIN
40    FORMAT(G)
      K=1
      L=1
      GO TO 50
47    SF=SF/2.0
      K=1
50    RETURN
      END
C
C
C     SMOOTH, RESTORE _ERROR AT EACH ITERATION
C
C
      SUBROUTINE SMRSER(N,M,HP,G,HN,K,L HOLD,HZ,H NMRES,
     * OPTIT,SNRNO2,OPTER)
      DIMENSION H(0/255),HP(0/255),HN(0/511`,HZ(0/255`,
     * G(0/255),HOLD(0/511` OPTIT'100,30,2),ERIT'900,2),
     * OPTER(100,30,2)
      INTEGER P,Q,SNRNO2
      REAL MINER1,MINER2
C
      IF (SNRNO2.GT.1.OR.L.GT.1) GO TO 60
C
      TYPE 55
55    FORMAT(' ENTER MAX NUMBER OF RESTORATIONS ')
      ACCEPT 58,NMRES
58    FORMAT(I)
C
      IF (NMRES.EQ.0) GO TO 70
C
C     SMOOTH AND RESTORE EACH HP
C
```

```
60        ITNM=1
62        IF (ITNM.GT.NMRES) GO TO 70
C
          IF (ITNM.GT.1) GO TO 65
          CALL SMOOTH(N,M,HP,G,HN)
          GO TO 66
C
65        CALL RESTOR(N,M.G,HN,HOLD,HZ)
C
C         CALCULATE ERROR AT EACH ITERATION
C
66        CALL ERRITR(N,M,ITNM,NMRES.H,HN,K,L,ERIT,OPTIT,
     *    SNRNO2,OPTER)
C
          ITNM=ITNM+1
68        FORMAT(G)
69        FORMAT(4(I4))
          GO TO 62
70        TYPE 69,NMRES,ITNM,K,L
          RETURN
          END
C
C         CALCULATE ERROR AT EACH ITERATION
C
          SUBROUTINE ERRITR(N,M,ITNM,NMRES,H,HN,K,L,ERIT,OPTIT,
     *    SNRNO2,OPTER)
          DIMENSION ERIT(900,2),OPTIT(100,30,2),H(0/255),
     *    HN(0/511),OPTER(100,30,2)
          INTEGER P,Q,SNRNO2
          REAL MINER1,MINER2
30        FORMAT(I)
40        FORMAT(1PE16.8)
          IF (ITNM.GT.1) GO TO 10
          I1=0
          I2=0
          IND=0
10        P=N/2
          SUM=0.
          SIGMA=0.
          DO 50 I=0,M
          Q=I+P
          TEMP=H(I)-HN(Q)
          SUM=SUM+ABS(TEMP)
          SIGMA=SIGMA+TEMP*TEMP
50        CONTINUE
          ERIT(ITNM,1)=SUM/(M+1)
          ERIT(ITNM,2)=SQRT(SIGMA/(M+1))
          IF (ITNM.GT.1)GO TO 80
          MINER1=ERIT(1,1)
          OPITN1=1
          MINER2=ERIT(1,2)
          OPITN2=1
80        IF (ITNM.EQ.1) GO TO 70
          IF (I1.EQ.1)GO TO 200
```

```
      IF (ERIT(ITNM,1).LE.MINER1) MINER1=ERIT(ITNM,1)
      IF (ERIT(ITNM,1).EQ.MINER1) OPITN1=ITNM
      IF (ERIT(ITNM,1).GE.ERIT(ITNM-1,1)) I1=1
   DERIT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))/ERIT(ITNM-1,1)
       ERT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))
       IF (DERIT1.LE.0.0001.OR.ERT1.LE.0.0001) I1=1
200   IF (I2.EQ.1) GO TO 300
      IF (ERIT(ITNM,2).LE.MINER2) MINER2=ERIT(ITNM,2)
      IF (ERIT(ITNM,2).EQ.MINER2) OPITN2=ITNM
      IF (ERIT(ITNM,2).GE.ERIT(ITNM-1,2)) I2=1
   DERIT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))/ERIT(ITNM-1,2)
       ERT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))
       IF (DERIT2.LE.0.0001.OR.ERT2.LE.0.0001) I2=1
300   IF (I1.EQ.1.AND.I2.EQ.1) IND=1
      IF (IND.NE.1.AND.ITNM.NE.NMRES) GO TO 70
      ITNM=NMRES
      OPTIT(SNRNO2,L,1)=OPITN1
      OPTIT(SNRNO2,L,2)=OPITN2
      OPTER(SNRNO2,L,1)=MINER1
      OPTER(SNRNO2,L,2)=MINER2
75    FORMAT(8(1PE16.8))
77    FORMAT(G)
70    RETURN
      END
C
C
C     ERRORS
C
C
      SUBROUTINE ERROR(K,M,N,H,ER,SNR,L,ERR,SF,OPTIT,SVSNR2,
     * SNRNO2,NM2K,ADDNS,HP,G,HZ,NMRES,OPTER,ERBFM)
      DIMENSION H(0/255),ER(500),ERR(100,5),OPTIT(100,30,2),
     * SVSNR2(100,30),ADDNS(50),HP(0/255),HN(0/511),G(0/255),
     * HZ(0/255),HOLD(0/511),OPTER(100,30,2),ERBFM(100,30,2)
      REAL MINER1,MINER2
      INTEGER P,O,SNRNO2
      ER(K)=SNR
        K = K+1
        IF (K.LE.100)GO TO 60
C
C  OUTPUT RESULTS _AVESNR,VARSNR,SDSNR
C
        K = K-1
      IF (K.GT.100)GO TO 100
      AVESNR=0.
      VARSNR=0.
      SDSNR=0.
      SNRNO2=0
      DO 50 I=1,K
50    AVESNR=AVESNR+ER(I)
      AVESNR=AVESNR/K
      DO 52 I=1,K
52    VARSNR=VARSNR+((ER(I)-AVESNR)**2)
      VARSNR=VARSNR/K
```

```
          SDSNR=SQRT(VARSNR)
C
C    CALCULATE   OF SNR'S IN SDSNR RANGE _DO CALCULATIONS
C
          SNRMX2=AVESNR+SDSNR/2
          SNRMN2=AVESNR-SDSNR/2.
100       IF (K.LE.100)GO TO 105
          IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2)SNRNO2=
     *    SNRNO2+1
          IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2)SVSNR2
     *(SNRNO2,L)=ER(K)
          IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2) CALL SMRSER
     *(N,M,HP,G,HN,K,L,HOLD,HZ,H,NMRES,OPTIT,SNRNO2,OPTER)
          IF (ER(K).LT.SNRMN2.OR.ER(K).GT.SNRMX2) GO TO 53
C
C     CALCULATE ERROR BEFORE MORRISON
C
          TEMP=0.
          SUM=0.
          SIGMA=0.
          DO 200 I=0,M
          TEMP=H(I)-HP(I)
          SUM=SUM+ABS(TEMP)
          SIGMA=SIGMA+TEMP**2
200       CONTINUE
          ERBFM(SNRNO2,L 1)=SUM/(M+1)
          ERBFM(SNRNO2,L,2)=SQRT(SIGMA/(M+1))
C
C
          TYPE 650
650       FORMAT(/' IN ERROR '/)
          TYPE 57,OPTIT(SNRNO2,L,1)
          TYPE 57,OPTIT(SNRNO2,L 2)
C
C
53        IF (SNRNO2.LE.100)NM2K=K
          IF (SNRNO2.LT.100)GO TO 59
          IF (SNRNO2 EQ.100)GO TO 65
54        FORMAT(I)
55         FORMAT(8(1PE16.8))
57         FORMAT(G)
105        ERR(L,1)=SF
           ERR(L,2)=AVESNR
           ERR(L 5)=SDSNR
59         K=K+1
           IF (SNRNO2.LT.100)GO TO 60
65         ADDNS(L)=NM2K
C
           TYPE 68
68         FORMAT(/////'   OF SNR S COMPLETED ')
67         TYPE 54,L
C
           L=L+1
60         RETURN
```

END

```
                PROGRAM DECON.FOR
C
C
      DOUBLE PRECISION GT,GTH,DATA,GTR
      DIMENSION ER(500),HOLD(512),ERR(30,5),ADDNS(30),
     * MXSNR(30),
     * SVSNR2(200,30),ERIT(900,2),AVSNR2(30),MNSNR(30),
     * OPTIT(100,30,20),
     * AVITNM(30,2),SDITNM(30,2),OPTER(100,30,2),
     * ERBFM(100,30,2),
     * H(256),G(256),F(256),GTR(1025),HO(1500),GT(2050),
     * HZ(512),HN(256),HP(256),HAF(1500),HBF(1500),FE(256)
      INTEGER P Z,ANS,GTYP,SNRNO2,ERTYP
      REAL MXSNR,MNSNR,MINER1,MINER2
      LI=0
C
C   ENTER DATA _NUMBER OF POINTS IN GT
C
      CALL ENTERD(GTYP N,M L G,H,F,NT,SF,SFMIN,ANS,NMRES,
     * NMSNR,NMERWD,ERTYP,CON,CON1)
C
C   ADD ZEROS WITH PREPGT FOR LENGTH NT _IMG. = 0
C
      CALL PREPGT(GT,NT,N,G)
C
      CALL FFT(GT,NT,-1)
C
C   CALCULATE MAGNITUDE OF TRANSFORM GT
C
      CALL MAGGT(GT,NT)
C
C   CALCULATE 1/TRANSFORM GT
C
      CALL INVTRN(GT,NT)
C
C   BACK TO FUNCTION DOMAIN
C
      CALL FFT(GT,NT,+1)
C
C   SHIFT PEAK
C
      CALL SHIFGT(GT,NT)
C
C   NORMALIZE INVERSE IMPULSE RESPONSE _MAKE SYMETRIC(ODD)
C
      CALL NRMSMR(GT,NT)
C
C   DELETE IMAGINARY PART OF GT
C
      CALL GTREAL(GTR,GT,NT)
C
C     G-INV IS NOW CALCULATED --- WILL NOW ADD NOISE TO H
C
C   CREATE FE TO WEIGHT ERROR BY F - IF ERTYP EQUALS 2
```

```
C
          IF (ERTYP.EQ.2) CALL WEIGHT(F,L,M,FE)
C
C         CALCULATE AVERAGE SNR FOR 100 NOISE ADDITIONS _SD
C         CONTINUE ADDING NOISE -- FOR NMSNR WITHIN +/-.5SD
C
45        CALL SCFCTR(SF,SFMIN,K,LI)
50        IF (ANS.EQ.1) CALL ORDNOI(H HZ,HP,SF,RMS
     * , SNR,M,N)
          IF (ANS.EQ.2) CALL CONST(H,HZ,HP,SF
     * ,RMS,SNR,M,N)
          IF (ANS.EQ.3) CALL BOTH(H,HZ,HP,SF,RMS,
     * SNR,M,N)
C
C         DO DECONVOLUTION BEFORE MORRIS. AND AFTER MORRIS.
C         AT EACH ITTERATION _CALC. ERROR OF DECONVOLVED
C         RESULT BY COMPARING TO F-INPUT
C
          CALL ERROR(K,M N,H,ER,SNR,LI,ERR,SF,OPTIT SVSNR2,
     *    HN,SNRNO2 MM2K,ADDNS,HP,G,HZ,NMRES,OPTER,ERBFM,NT,
     *    L,GTR,F,MRS,NMSNR,NMERWD,ERTYP,FE,CON,CON1)
C
C
        IF (K.LE.100)GO TO 50
        IF (SNRNO2.LT.NMSNR)GO TO 50
        IF (SF.GT.SFMIN)GO TO 45
C
C
          CALL OUTPUT(ERR,LI NM2K,OPTIT,SNRNO2,SVSNR2,GTYP.
     *    ANS,ADDNS,OPTER,ERBFM)
          STOP
          END
C
C
C
C
C         ENTER DATA _NUMBER OF POINTS NT
C
          SUBROUTINE ENTERD(GTYP,N,M,L,G,H,F,NT,SF,SFMIN,
     *    ANS NMRES,NMSNR,NMERWD,ERTYP,CON,CON1)
          DIMENSION G(256),H(256),F(256)
          INTEGER GTYP ANS,ERTYP
1         FORMAT(I)
          TYPE 2
2         FORMAT(' ENTER 1 FOR NARROW G -- 2 FOR WIDE G ')
          ACCEPT 1,GTYP
          CALL INPUT(N,M,L,G,H,F GTYP)
          TYPE 3
3         FORMAT(' ENTER NUMBER OF POINTS IN G-INV ')
          ACCEPT 1.NT
          TYPE 4
4         FORMAT(' CHOOSE 1 FOR ORD DEP NOISE,2=CONSTANT ')
          ACCEPT 1,ANS
          TYPE 5
```

```
5       FORMAT(' ENTER MAX NOISE SCALE FACTOR ')
        ACCEPT 40,SF
        TYPE 6
6       FORMAT(' ENTER MIN NOISE SCALE FACTOR ')
        ACCEPT 40,SFMIN
        TYPE 7
7       FORMAT(' ENTER MAX NUMBER OF RESTORATIONS ')
        ACCEPT 1,NMRES
        TYPE 8
8       FORMAT(' ENTER NUMBER OF SNR IN +/- .5SD RANGE ')
        ACCEPT 1,NMSNR
        TYPE 9
9       FORMAT(' ENTER ERROR WINDOW SIZE -- L OR M ')
        ACCEPT 1,NMERWD
        TYPE 10
10      FORMAT(' TYPE 1 FOR L1 _L2 ERROR,2 FOR ERROR
     *  WEIGHTED BY F')
        ACCEPT 1,ERTYP
        TYPE 11
11      FORMAT(' CHOOSE CONVERGENCE CRITERION =
     *  (Ei-(Ei-1))/Ei-1) ')
        ACCEPT 40,CON
        TYPE 12
12      FORMAT(' CHOOSE CONVERGENCE CRITERION =
     *  (Ei-(Ei-1)) ')
        ACCEPT 40,CON1
40      FORMAT(G)
        RETURN
        END
C
C        INPUT ENTERS THE DATA
C
        SUBROUTINE INPUT(N,M,L,G,H,F GTYP)
        DIMENSION H(256),G(256),F(256)
        INTEGER IFL,GTYP
        TYPE 110
110      FORMAT ('   ENTER SIZE OF H')
        ACCEPT 120,M
120      FORMAT(I)
        TYPE 130
130      FORMAT('  ENTER SIZE OF G,ODD ')
        ACCEPT 120,N
        TYPE 135
135     FORMAT(' ENTER SIZE OF F ')
        ACCEPT 120,L
        TYPE 140
140      FORMAT('  ENTER THE INPUT FILE     ',$)
        ACCEPT 120,IFL
        READ(IFL 160)(H(I),I=1,M)
        READ(IFL,160)(G(I),I=1,N)
        READ(IFL,160)(F'I),I=1,L)
160      FORMAT(4G)
        RETURN
        END
```

```
C
C       PREPGT
C
        SUBROUTINE PREPGT(GT,NT,N G)
        DOUBLE PRECISION GT
        DIMENSION GT(2050),G(256)
        DO 1 I=1,N
        GT(2*I-1) = G(I)
1       GT(2*I) = 0.0
        DO 2 I=N+1,NT
        GT(2*I-1)=0.0
2       GT(2*I)=0.0
        RETURN
        END
C
C       MAGGT
C
        SUBROUTINE MAGGT(GT NT)
        DOUBLE PRECISION GT
        DIMENSION GT(2050)
        DO 1 I=1,NT
        GT(2*I-1)=DSQRT((GT(2*I-1)**2)+(GT(2*I)**2))
1       GT(2*I)=0.0
        RETURN
        END
C
C       1/TRANS. GT
C
        SUBROUTINE INVTRN(GT NT)
        DOUBLE PRECISION GT
        DIMENSION GT(2050)
        DO 10 I=1,NT
        IF (GT(2*I-1).EQ.0)GO TO 5
        GT(2*I-1)=1./GT(2*I-1)
        GO TO 10
5       GT(2*I-1)=0.
10      CONTINUE
        RETURN
        END
C
C       SHIFT-GT
C
        SUBROUTINE SHIFGT(GT,NT)
        DOUBLE PRECISION GT,GTH
        DIMENSION GT(2050),GTH(1024)
        DO 1 I=1,NT
1       GTH(I)=GT(I)
        DO 5 I=1 NT
5       GT(I)=GT(NT+I)
        DO 10 I=1,NT
10      GT(NT+I)=GTH(I)
        RETURN
        END
C
```

```
C       NRMSMR
C
        SUBROUTINE NRMSMR(GT,NT)
        DOUBLE PRECISION GT
        DIMENSION GT(2050)
        DO 5 I=1.2*NT
5       GT(I)=GT(I)/NT
C       MAKE INV. IMPULSE RES. SYMETRIC
        GT(1)=GT(1)/2.0
        GT(2*NT+1)=GT(1)
        RETURN
        END
C
C       GT REAL
C
        SUBROUTINE GTREAL(GTR,GT,NT)
        DOUBLE PRECISION GT,GTR
        DIMENSION GTR(1025),GT(2050)
        DO 10 I=1,NT+1
        GTR(I)=GT(2*I-1)
10      CONTINUE
        RETURN
        END
C
C          FFT SUBROUTINE
C
        SUBROUTINE FFT(DATA,NN ISIGN)
        DOUBLE PRECISION DATA,TEMPR,TEMPI,THETA,DSINTH,
     * WR,WI,WSTPR,WSTPI
        DIMENSION DATA(2050)
        INTEGER N,NN,ISIGN
        N=2*NN
        J=1
        DO 5 I=1 N,2
        IF (I.GE.J) GOTO 2
1        TEMPR=DATA(J)
        TEMPI=DATA(J+1)
        DATA(J)=DATA(I)
        DATA(J+1)=DATA(I+1)
        DATA(I)=TEMPR
        DATA(I+1)=TEMPI
2        M=N/2
3        IF (J.LE.M) GO TO 5
4        J=J-M
        M=M/2
        IF (M.GE.2) GO TO 3
5        J=J+M
        MMAX=2
6        IF (MMAX.GE.N) GO TO 10
7        ISTEP=2*MMAX
        THETA=6.2831853/FLOAT(ISIGN*MMAX)
        DSINTH=DSIN(THETA/2 )
        WSTPR=-2.*DSINTH*DSINTH
        WSTPI=DSIN(THETA)
```

```
      WR=1.
      WI=0.
      DO 9 M=1,MMAX,2
      DO 8 I=M,N,ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
      DATA(I)=DATA(I)+TEMPR
8      DATA(I+1)=DATA(I+1)+TEMPI
      TEMPR=WR
      WR=WR*WSTPR-WI*WSTPI+WR
9      WI=WI*WSTPR+TEMPR*WSTPI+WI
      MMAX=ISTEP
      GO TO 6
   10 RETURN
      END
C
C     CREATE FE TO WEIGHT ERROR BY F
C
      SUBROUTINE WEIGHT(F,L,M,FE)
      DIMENSION F(256),FE(256)
      DO 10 I=1,M/2-L/2
10    FE(I)=1.
      DO 20 I=1,L
      IF (F(I).LT.1) FE(I+M/2-L/2)=1.
      IF (F(I).GE.1) FE(I+M/2-L/2)=F(I)
20    CONTINUE
      DO 30 I=M/2+L/2+1,M
30    FE(I)=1.
      RETURN
      END
C
C     DE-CONVOLUTION PROGRAM
C
      SUBROUTINE DECONV(GTR,HI,HO,M,NT,N,MRS)
      DOUBLE PRECISION GTR,DPHI,DPHO,TEMP
      DIMENSION GTR(1025),HI(256),HO(1500),DPHI(256),
     * DPHO(1500)
      INTEGER A,B,C,D,E,F
C     COMPUTE CONVOLUTION
      IF (MRS.EQ.0) J=M
      IF (MRS.GT.0) J=M+N-1
      DO 1 I=1,J
1     DPHI(I)=HI(I)
      IF (MRS.EQ.0) K=NT+M
      IF (MRS.GT.0) K=NT+M+N-1
      DO 10 I=1,K
      DPHO(I)=0.
      A=1
      IF (MRS.EQ.0) B=I-M+1
      IF (MRS.GT.0) B=I-M-N+2
      IF (A.GE.B) C=A
```

```
      IF (A.LT.B) C=B
      D=I
      E=NT+1
      IF (D.LT.E) F=D
      IF (D.GE.E) F=E
      DO 5 J=C,F
      TEMP=GTR(J)*DPHI(I-J+1)
5     DPHO(I)=DPHO(I)+TEMP
      HO(I)=DPHO(I)
10    CONTINUE
      RETURN
      END
C
C
C        ENTER SCALE FACTORS
C
      SUBROUTINE SCFCTR(SF,SFMIN,K,LI)
      IF (LI.GT.1)GO TO 47
      K=1
      LI=1
      GO TO 50
47    SF=SF/2.0
      K=1
50    RETURN
      END
C
C        ORDNOI ADDS ORDINATE DEPENDENT NOISE
C
      SUBROUTINE ORDNOI(H,HZ,HP,SF,RMS,SNR,M,N)
      DIMENSION H(256),HZ(256),HP(256)
      REAL MAXIM
      INTEGER Q,L
      Q=(N+1)/2
      RMS=0.
      MAXIM=H(1)
      DO 210 I=1,M
      SD =SQRT( SF * H(I))
      IF(H(I).LT..0000001)  SD =SQRT( SF * .0000001)
      CALL GAUSS(SD,H(I),HP(I))
      IF (H(I).GT.MAXIM) MAXIM=H(I)
      IF (HP(I).LT.0.) HP(I)=-HP(I)
      L=I+Q-1
      HZ(L)=HP(I)
      RMS=(HP(I)-H(I))**2+RMS
210    CONTINUE
      RMS=SQRT(RMS/(M))
      IF (RMS.EQ.0.) GOTO 215
      SNR=MAXIM/RMS
215    RETURN
      END
C
C         CONST ADDS CONSTANT NOISE
C
      SUBROUTINE CONST(H,HZ,HP,SF,RMS,SNR,M,N)
```

```
      DIMENSION H(256),HZ(512),HP(256)
      REAL MAXIM
      INTEGER Q,L
      Q=(N+1)/2
      RMS=0.
      MAXIM=H(1)
      DO 230 I=1,M
      IF (H(I).GT.MAXIM) MAXIM=H(I)
      SD=SQRT(SF)
      CALL GAUSS(SD,H(I),HP(I))
      IF (HP(I).LT.0.) HP(I)=-HP(I)
      L=I+Q-1
      HZ(L)=HP(I)
      RMS=(HP(I)-H(I))**2+RMS
230    CONTINUE
      RMS=SQRT(RMS/(M))
      IF (RMS.EQ.0.) GO TO 235
      SNR=MAXIM/RMS
235    RETURN
      END
C
C
C     GAUSS COMPUTES RANDOM NUMBERS
C
      SUBROUTINE GAUSS(S,AM,V)
      A=0.0
      DO 1 I=1,12
    1 A=A+RAN(1)
      V=(A-6.0)*S + AM
      RETURN
      END
C
C
C     SMOOTH, RESTORE _ERROR AT EACH ITERATION
C
C
      SUBROUTINE SMRSER(N,M,HP,G,K,LI,HOLD,HZ,H,NMRES,
     * OPTIT,SNRNO2,OPTER,L,GTR,F,NT MRS,HN,NMERWD,ERTYP,
     * FE,CON,CON1)
      DOUBLE PRECISION GTR
      DIMENSION H(256),HP(256),HN(256),HZ(256),G(256),
     * GTR(1025),HOLD(512),OPTIT(100,30,2),ERIT(900,2),
     * OPTER(100,30,2),HAF(1500),F(256),FE(256)
      INTEGER P,Q,SNRNO2,ERTYP
      REAL MINER1,MINER2
C
C      TYPE 1
C1     FORMAT(/' IN SMRSER '/)
C
      IF (NMRES.EQ.0) GO TO 70
C
C     SMOOTH AND RESTORE EACH HP
C
      ITNM=1
```

```
62      IF (ITNM.GT.NMRES) GO TO 70
C
        IF (ITNM.GT.1) GO TO 65
        CALL SMOOTH(N,M,HP ^,HN)
        GO TO 66
C
65      CALL RESTOR(N M.G,HN,HOLD,HZ)
C
C       CALCULATE ERROR AT EACH ITERATION
C
66      MRS=ITNM
        CALL DECONV(GTR,HN HAF,M,NT,N,MRS)
C
C
C
        CALL ERRITR(N M,ITNM,NMRES,H,HAF,K,LI,ERIT,OPTIT,
     *  SNRNO2,OPTER,L,F,NT NMERWD,ERTYP,FE,CON,CON1)
C
        ITNM=ITNM+1
C
C
C
68      FORMAT(G)
69      FORMAT(5(I4))
        GO TO 62
70      RETURN
        END
C
C        SMOOTH DOES THE INITIAL SMOOTHING, AND STORES
C       THE RESULT IN HN  ---   HN=H*G
C
        SUBROUTINE SMOOTH(N,M,HP,G,HN)
        DIMENSION HP(256),G(256),HN(256)
        INTEGER A,B,C,D,E,F
405      FORMAT(4G)
        DO 420 I=1,M+N-1
        HN(I)=0.
        A=1
        B=I-N+1
        CALL MAX(A,B.C)
        D=I
        E=M
        CALL MIN(D,E,F)
        DO 410 J=C,F
        TEMP=HP(J)*G(I-J+1)
        HN(I)=HN(I)+TEMP
410      CONTINUE
420      CONTINUE
        RETURN
        END
C
C          MAX RETURNS THE LARGR VALUE
C
        SUBROUTINE MAX(A,B C)
```

```
      IF (A.GT.B) C=A
      IF (A.LT.B) C=B
      IF (A.EQ.B) C=A
      RETURN
      END
C
C        MIN RETURNS THE SMALLER VALUE
C
      SUBROUTINE MIN(D,E F)
      IF (D.GT.E) F=E
      IF (D.LT.E) F=D
      IF (D.EQ.E) F=E
      RETURN
      END
C
C       RESTORE DOES RESTORING ITERATIONS
C         HOLD=HN-1
C         HN=HOLD+(HZ-HOLD)*G
C
      SUBROUTINE RESTOR(N,M,G,HN,HOLD,HZ)
      DIMENSION S(512),V(1000),HP(256),G(256),HN(256),
     * HOLD(512),HZ(512)
      INTEGER P
      P=(N-1)/2
C
      DO 300 I=1,M+N-1
      S(I)=HZ(I)-HN(I)
300    HOLD(I)=HN(I)
C         DO CONVOLUTION  V=S*G
      DO 330 I=1,M+2*N-2
      V(I)=0.
      A=1
      B=I-N+1
      CALL MAX(A,B,C)
      D=I
      E=M+N-1
      CALL MIN (D,E,F)
      DO 320 J=C,F
      TEMP=S(J)*G(I-J+1)
320    V(I)=V(I)+TEMP
330    CONTINUE
C          ASSEMBLE HN,  HN=HOLD + V
      DO 340 I=1,M+N-1
340    HN(I)=HOLD(I)+V(I+P)
      RETURN
      END
C
C
C     CALCULATE ERROR AT EACH ITERATION
C
      SUBROUTINE ERRITR(N M,ITNM,NMRES,H HAF,K,LI,ERIT,
     * OPTIT,SNRNO2,OPTER,L,F,NT NMERWD,ERTYP,FE,CON,CON1)
      DIMENSION ERIT(900,2),OPTIT(100,30,2),H(256),
     * HAF(1500),F(256),OPTER(100,30,2),HAGR(50,2),FE(256)
```

```
      INTEGER P O,SNRNO2,ERTYP
      REAL MINER1,MINER2
      IF (ITNM.GT.1) GO TO 10
      I1=0
      I2=0
      IND=0
10    P=((N-1)/2)+NT/2
      SUM=0.
      SIGMA=0.
C
      IF (ERTYP.EQ.1) GO TO 45
C
C   CALCULATE ERROR 1 _2 WEIGHTED BY F
C
      IF (NMERWD.EQ.L) GO TO 42
      DO 41 I=1,M/2-L/2
      SUM=SUM+ABS(HAF(I+P))*FE(I)
      SIGMA=SIGMA+(HAF(I+P)**2)*FE(I)
41    CONTINUE
42    DO 43 I=(M/2-L/2+1),(M/2+L/2)
      TEMP=HAF(I+P)-F(I-M/2+L/2)
      SUM=SUM+ABS(TEMP)*FE(I)
      SIGMA=SIGMA+(TEMP**2)*FE(I)
43    CONTINUE
      IF (NMERWD.EQ.L) GO TO 59
      DO 44 I=M/2+L/2+1,M
      SUM=SUM+ABS(HAF(I+P))*FE(I)
      SIGMA=SIGMA+(HAF(I+P)**2)*FE(I)
44    CONTINUE
      GO TO 59
C
C   CALCULATE ERROR 1 _2
C
45    IF (NMERWD.EQ.L) GO TO 52
      DO 50 I=1,(M/2-L/2)
      SUM=SUM+ABS(HAF(I+P))
      SIGMA=SIGMA+HAF(I+P)**2
50    CONTINUE
52    DO 54 I=(M/2-L/2+1),(M/2+L/2)
      TEMP=HAF(I+P)-F(I-M/2+L/2)
      SUM=SUM+ABS(TEMP)
      SIGMA=SIGMA+TEMP**2
54    CONTINUE
      IF (NMERWD.EQ.L) GO TO 59
      DO 58 I=(M/2+L/2+1),M
      SUM=SUM+ABS(HAF(I+P))
      SIGMA=SIGMA+HAF(I+P)**2
58    CONTINUE
C
C   STORE ERROR EACH ITERATION
C
59    ERIT(ITNM,1)=SUM/NMERWD
      ERIT(ITNM,2)=SQRT(SIGMA/NMERWD)
      IF (ITNM.GT.1)GO TO 80
```

```
C
C   FIND OPTIMUM ITERATION
C
        MINER1=ERIT(1,1)
        OPITN1=1
        MINER2=ERIT(1,2)
        OPITN2=1
80      IF (ITNM.EQ.1) GO TO 100
        IF (I1.EQ.1)GO TO 200
C
C   CHECK FOR MIN. ERROR 1
C
        IF (ERIT(ITNM,1).LE.MINER1) MINER1=ERIT(ITNM,1)
        IF (ERIT(ITNM,1).EQ.MINER1) OPITN1=ITNM
        IF (ERIT(ITNM,1).GE.ERIT(ITNM-1,1)) I1=1
C
C   CONVERGENCE CRITERION ERROR 1
C
     DERIT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))/ERIT(ITNM-1,1)
         ERT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))
          IF (DERIT1.LE.CON.OR.ERT1.LE.CON1) I1=1
C
C   PLOT _PRINT OPT. DECON. FOR ERROR L1
C
C        IF (I1.EQ.1) GO TO 15
100     DO 11 I=1,M
11      HAGR(I,1)=HAF(I+NT/2+(N-1)/2)
        IF (ITNM.EQ.1) GO TO 150
        GO TO 200
C15      WRITE(50,21)(HAGR(I,1),I=1,M)
        IT1=ITNM-1
C        WRITE(40,23)LI,SNRNO2,IT1
C        WRITE(40,22)(HAGR(I,1),I=1,M)
21      FORMAT(G)
22      FORMAT(8(1PE16.8))
23      FORMAT(/' DECON AT OPT. L1',3I8/)
C
C
C
200     IF (I2.EQ.1) GO TO 300
C
C   CHECK FOR MIN. ERROR 2
C
        IF (ERIT(ITNM,2).LE.MINER2) MINER2=ERIT(ITNM,2)
        IF (ERIT(ITNM,2).EQ.MINER2) OPITN2=ITNM
        IF (ERIT(ITNM,2).GE.ERIT(ITNM-1,2)) I2=1
C
C   CONVERGENCE CRITERION ERROR 2
C
     DERIT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))/ERIT(ITNM-1,2)
         ERT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))
          IF (DERIT2.LE.CON.OR.ERT2.LE.CON1) I2=1
C
C   PLOT _PRINT OPT. DECON. FOR ERROR L2
```

```
C
C        IF (I2.EQ.1) GO TO 25
150     DO 31 I=1,M
31      HAGR(I,2)=HAF(I+NT/2+(N-1)/2)
        IF (ITNM.EQ.1) GO TO 70
        GO TO 300
C25      WRITE(51,21)(HAGR(I,2),I=1,M)
        IT2=ITNM-1
C        WRITE(41,33)LI,SNRNO2,IT2
C        WRITE(41,22)(HAGR(I,2),I=1,M)
33      FORMAT(/' DECON AT OPT. L2',3I8/)
C
C
C
300     IF (I1.EQ.1.AND.I2.EQ.1) IND=1
        IF (IND.NE.1.AND.ITNM.NE.NMRES) GO TO 70
C
C   END ITERATIONS AND STORE RESULTS
C
        ITNM=NMRES
        OPTIT(SNRNO2,LI,1)=OPITN1
        OPTIT(SNRNO2,LI,2)=OPITN2
        OPTER(SNRNO2,LI,1)=MINER1
        OPTER(SNRNO2,LI,2)=MINER2
C
C
70      RETURN
        END
C
C
C       ERRORS
C
C
        SUBROUTINE ERROR(K,M,N,H,ER,SNR,LI,ERR,SF,OPTIT,
     *  SVSNR2,HN,SNRNO2,NM2K,ADDNS,HP,G,HZ,NMRES,OPTER,
     *  ERBFM,NT,L,GTR,F,MRS,NMSNR,NMERWD,ERTYP,FE,CON,CON1)
        DOUBLE PRECISION GTR
        DIMENSION H(256),ER(500),ERR(30,5),OPTIT(100,30,2),
     *  HN(256),SVSNR2(100,30),ADDNS(30),HP(256),G(256),
     *  F(256),GTR(1025),HZ(256),HOLD(512),HBF(1500),
     *  OPTER(100,30,2),ERBFM(100,30,2),FE(256)
        REAL MINER1,MINER2
        INTEGER P,Q,SNRNO2,ERTYP
        ER(K)=SNR
         K = K+1
         IF (K.LE.100)GO TO 60
C
C  OUTPUT RESULTS _AVESNR,VARSNR,SDSNR
C
         K = K-1
        IF (K.GT.100)GO TO 100
        AVESNR=0.
        VARSNR=0.
        SDSNR=0.
```

```
      SNRNO?=0
      DO 50 I=1,K
50    AVESNR=AVESNR+ER(I)
      AVESNR=AVESNR/K
      DO 52 I=1,K
52    VARSNR=VARSNR+((ER(I)-AVESNR)**2)
      VARSNR=VARSNR/K
      SDSNR=SQRT(VARSNR)
C
C   CALCULATE   OF SNR'S IN SDSNR RANGE _DO CALCULATIONS
C
      SNRMX2=AVESNR+SDSNR/2.
      SNRMN2=AVESNR-SDSNR/2.
100   IF (K.LE.100)GO TO 105
      IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2)SNRNO2=
     * SNRNO2+1
      IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2)SVSNR2
     * (SNRNO2,LI'=ER'")
      IF (ER(K).GE.SNRMN2.AND.ER(K).LE.SNRMX2) CALL
     * SMRSER(N,M,HP,G,K,LI,HOLD,HZ,H,NMRES,OPTIT,SNRNO2,
     * OPTER,L,GTR,F,NT,MRS,HN,NMERWD,ERTYP,FE,CON,CON1)
      IF 'ER(K).LT.SNRMN2.OR.ER(K).GT.SNRMX2) GO TO 53
C
C CALC. ERROR BEFORE MORRIS. BY CONVOL. NOISY H _G-INV
C
C
      MRS=0
      CALL DECONV(GTR,HP,HBF,M,NT,N,MRS)
C
C
C
      TEMP=0.
      SUM=0.
      SIGMA=0.
C
      IF 'ERTYP.EQ.1) GO TO 88
C
C   CALCULATE ERROR 1 _2 WEIGHTED BY F
C
      IF 'NMERWD.EQ.L) GO TO 82
      DO 81 I=1,M/^-r/2
      SUM=SUM+ABS(HBF(I+NT/2))*FE(I)
      SIGMA=SIGMA+(HBF(I+NT/2)**2)*FE(I)
81    CONTINUE
82    DO 83 I=(M/2-L/2+1),(M/2+L/2)
      TEMP=HBF(I+NT/2)-F(I-M/2+L/2)
      SUM=SUM+ABS(TEMP)*FE(I)
      SIGMA=SIGMA+(TEMP**2)*FE(I)
83    CONTINUE
      IF 'NMERWD.EQ.L) GO TO 410
      DO 84 I=M/2+L/2+1,M
      SUM=SUM+ABS(HBF(I+NT/2))*FE'I'
      SIGMA=SIGMA+(HBF(I+NT/2)**2)*FE'I)
84    CONTINUE
```

```
          GO TO 410
C
C COMPARE DECON RESULT TO F-INPUT OVER H OR F - WINDOW
C
88        IF (NMERWD.EQ.L) GO TO 210
          DO 200 I=1,(M/2-L/2)
          SUM=SUM+ABS(HBF(I+NT/2))
          SIGMA=SIGMA+HBF(I+NT/2)**2
200       CONTINUE
210       DO 300 I=(M/2-L/2+1),(M/2+L/2)
          TEMP=HBF(I+NT/2)-F(I-M/2+L/2)
          SUM=SUM+ABS(TEMP)
          SIGMA=SIGMA+TEMP**2
300       CONTINUE
          IF (NMERWD.EQ.L) GO TO 410
          DO 400 I=(M/2+L/2+1),M
          SUM=SUM+ABS(HBF(I+NT/2))
          SIGMA=SIGMA+HBF(I+NT/2)**2
400       CONTINUE
C
C   STORE ERROR
C
410       ERBFM(SNRNO2,LI 1)=SUM/NMERWD
          ERBFM(SNRNO2,LI,2)=SQRT(SIGMA/NMERWD)
C
53        IF (SNRNO2.LE.NMSNR)NM2K=K
          IF (SNRNO2.LT.NMSNR)GO TO 59
          IF (SNRNO2.EQ.NMSNR)GO TO 65
54        FORMAT(I)
55         FORMAT(8(1PE16.8))
57         FORMAT(G)
105        ERR(LI,1)=SF
           ERR(LI,2)=AVESNR
           ERR(LI 5)=SDSNR
59         K-K+1
           IF (SNRNO2.LT.NMSNR)GO TO 60
65         ADDNS(LI)=NM2K
C
           TYPE 68
68         FORMAT(/'   OF SNR S COMPLETED ')
67         TYPE 54,LI
C
           LI=LI+1
60         RETURN
           END
C
C             OUTPUT
C
           SUBROUTINE OUTPUT(ERR,LI,NM2K,OPTIT,SNRNO2,SVSNR2.
      *    GTYP,ANS,ADDNS,OPTER,ERBFM)
           DIMENSION ERR(30,5),SVSNR2(100,30),MXIT'30,2),
      *    AVSNR2(30),ADDNS(30),MXSNR(30),MNSNR(30),
      *    OPTER'100,30,2),ERBFM(100,30,2),AVERNM(30,2),
      *    OPTIT(100,30,2),AVITNM(30,2),MNIT(30,2),MXER(30,2),
```

```
     *   MNER(30,2),SDMXER(30,2),SDMNER(30,2),SDMXIT(30,2),
     *   SDMNIT(30,2),SDERNM(30,2),SDITNM(30,2),
     *   ERR1(30),ERRL(30)
         INTEGER SNRNO2,GTYP,ANS
         REAL MXSNR,MNSNR,MXER,MNER,MXIT,MNIT
         LI=LI-1
C         WRITE(30,10)
         WRITE(35,10)
C         WRITE(36,10)
10       FORMAT(///' G - TYPE '//)
C         WRITE(30,70)GTYP
         WRITE(35,70)GTYP
C         WRITE(36,70)GTYP
C         WRITE(30,12)
         WRITE(35,12)
C         WRITE(36,12)
12       FORMAT(///' NOISE - TYPE '//)
C         WRITE(30,70)ANS
         WRITE(35,70)ANS
C         WRITE(36,70)ANS
         WRITE(35,14)
14       FORMAT(///' USING 100 NOISE ADDITIONS '////)
         WRITE(35,2)
2        FORMAT(//,8X,'NSF          AVESNR',10X,'SDSNR'//)
         WRITE(35,38)(ERR(I,1),ERR(I,2),ERR(I,5),I=1,LI)
37       FORMAT(5(1PE16.8))
38       FORMAT(3(1PE16 8))
40       FORMAT(8(1PE16 8))
C         WRITE(45,60)(ERR'I,1),I=1,LI)
C         WRITE(46,60)(ERR(I,2),I=1,LI)
         WRITE(35,42)
42       FORMAT(///' TOTAL   OF SNR IN RANGE '//)
         WRITE(35,70)SNRNO2
C
C CALC. NEW AVERAGE USING SNR IN GIVEN RANGE AND AVE IT
C    CALC. ERROR AFTER MOR. / ERROR BEFORE MOR.
C
         DO 50 I=1,LI
C
C    PRINT ERROR AFTER MORRIS
C
C         WRITE(36,51)
C51       FORMAT(//' ERROR AFTER MORRIS. '/)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTER(J,I,1),J=1.SNRNO2)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTER(J,I,2),J=1.SNRNO2)
C
C
         AVSNR2(I)=0.
         AVITNM(I,1)=0.
         AVITNM(I,2)=0.
         AVERNM(I,1)=0.
         AVERNM(I,2)=0.
```

```
      DO 47 J=1,SNRNO2
      OPTER(J I,1)=(OPTER(J,I,1)/ERBFM(J,I,1))
      OPTER(J,I,2)=(OPTER(J,I,2)/ERBFM(J,I,2))
      AVSNR2(I)=AVSNR2(I)+SVSNR2(J,I)
      AVITNM(I,1)=AVITNM(I,1)+OPTIT(J.I 1)
      AVITNM(I,2)=AVITNM(I,2)+OPTIT(J,I,2)
      AVERNM(I,1)=AVERNM(I,1)+OPTER(J,I,1)
      AVERNM(I,2) AVERNM(I,2)+OPTER(J I,2)
47    CONTINUE
      AVSNR2(I)=AVSNR2(I)/SNRNO2
      AVITNM(I,1)=AVITNM(I,1)/SNRNO2
      AVITNM(I,2)=AVITNM(I,2)/SNRNO2
      AVERNM(I,1)=AVERNM(I,1)/SNRNO2
      AVERNM(I,2)=AVERNM(I.2)/SNRNO2
C
C  CALC. SD OF AVERAGE ITERATION NUMBER _SD OF ERROR
C
      SDITNM(I,1)=0.
      SDITNM(I,2)=0.
      SDERNM(I,1)=0.
      SDERNM(I,2)=0.
      DO 45 J=1,SNRNO2
      DIF1=OPTIT(J,I,1)-AVITNM(I,1)
      DIF2=OPTIT(J,I,2)-AVITNM(I,2)
      DF1=OPTER(J I,1)-AVERNM(I,1)
      DF2=OPTER(J,I,2)-AVERNM(I,2)
      SDERNM(I,1)=SDERNM(I,1)+DF1**2
      SDERNM(I,2)=SDERNM(I,2)+DF2**2
      SDITNM(I,1)=SDITNM(I.1)+DIF1**2
      SDITNM(I,2)=SDITNM(I.2)+DIF2**2
45    CONTINUE
      SDITNM(I,1)=SDITNM(I,1)/SNRNO2
      SDITNM(I,2)=SDITNM(I,2)/SNRNO2
      SDERNM(I,1)=SDERNM(I,1)/SNRNO2
      SDERNM(I,2)=SDERNM(I,2)/SNRNO2
      SDERNM(I.1)=SQRT(SDERNM(I,1))
      SDERNM(I,2)=SQRT(SDERNM(I,2))
      SDITNM(I,1)=SQRT(SDITNM(I,1))
      SDITNM(I,2)=SQRT(SDITNM(I,2))
C
C  OUTPUT AVESNR _SNR'S IN +/- RANGE
C
C      WRITE(30,210)
C210   FORMAT(///' AVESNR FOR SNRNO2 '//)
C      WRITE(30,40)AVSNR2(I)
C      WRITE(30,46)
C46    FORMAT(///' SNR S IM +/- .5SD RANGE '//)
C      WRITE(30,40)(SVSNR2(K,I),K=1.SNRNO2)
C
C  CALC. MAX _MIN OF SNRNO2 SNR'S, OPTIT'S _OPTER'S IN
C  RANGE
      MXSNR(I)=SVSNR2(1,I)
      MNSNR(I)=SVSNR2(1,I)
      MXIT(I,1)=OPTIT(1,I,1)
```

```
      MNIT(I,1)=OPTIT(1,I,1)
      MXIT(I,2)=OPTIT(1,I,2)
      MNIT(I,2)=OPTIT(1,I,2)
      MXER(I,1)=OPTER(1,I,1)
      MNER(I,1)=OPTER(1,I,1)
      MXER(I,2)=OPTER(1,I,2)
      MNER(I,2)=OPTER(1,I,2)
      DO 55 K=2.SNRNO2
      IF 'SVSNR^'K,I).GE "XSNR'I))MXSNR(I)=SVSNR2(K,I)
      IF (SVSNR2(K,I).LE.MNSNR(I))MNSNR(I)=SVSNR2(K,I)
   IF (OPTIT(K,I,1).GE.MXIT(I,1)) MXIT(I,1)=OPTIT(K,I,1)
   IF (OPTIT(K,I,1).LE.MNIT(I,1)) MNIT(I,1)=OPTIT(K.I,1)
   IF (OPTIT'K,I,2).GE.MXIT(I,2)) MXIT(I 2`=OPTIT(K,I,2)
   IF '^"TIT' ,I,2).LE.MNIT(I,2)) MNIT(I,2)=OPTIT(K,I,2)
   IF (OPTER(K,I,1).GE.MXER(I,1)) MXER(I,1)=OPTER(K,I,1)
   IF (OPTER(K,I,1).LE.MNER(I,1)) MNER(I,1)-OPTER(K,I,1)
   IF (OPTER(K,I,2).GE MXER(I,2)) MXER(I,2)=OPTER(K,I,2)
   IF (OPTER(K,I,2).LE.MNER(I,2)) MNER(I,2)=OPTER(K,I,2)
55    CONTINUE
50    CONTINUE
C
C
C
      WRITE(35,72)
72    FORMAT(///' NUMBER OF AVERAGE SNR"S '//)
      WRITE(35,70)LI
      WRITE(35,77)
77    FORMAT(///' NEW AVE USING SNR IN +/-.5SD RANGE '//)
      WRITE(35,87)
87    FORMAT('          NSF              AVESNR              MAXSNR
     *        MINSNR               NS ADD '//)
      WRITE(35,37)(ERR(I,1),AVSNR2(I),MXSNR(I),MNSNR(I),
     * ADDNS(I),I=1,LI)
      WRITE(35,74)
74 FORMAT(///' OPT. ITER. -SD-MAX _MIN-FOR   OF SNR '//)
      WRITE(35,75)
75    FORMAT(/7X,'AVSNR2',8X,'ITERATION1 ',7X,'IT1SD',7X,
     * 'ITERATION2 ',6X,'IT2SD'//)
      WRITE(35,37)(AVSNR2(I),AVITNM(I 1`,SDITNM(I,1),
     * AVITNM(I,2),SDITNM(I,2),I=1,LI)
      WRITE(35,165)
165FORMAT(///5X,'AVE ITER  1',5X,'MIN ITER 1',6X,'MAX ITER 1',
     * 5X.'AVE ITER  2',5X,'MIN ITER 2',6X,'MAX ITER 2'//)
      WRITE(35,177)(AVITNM(I,1),MNIT(I,1),MXIT(I,1),
     * AVITNM(I,2),MNIT(I,2),MXIT(I,2),I=1,LI)
      WRITE(35,76)
76    FORMAT(///' ERROR 1 _2 AT OPTIMUM ITERATION '//)
      WRITE(35,176)
176   FORMAT(/7X,'AVSNR2' 1^X.'ERROR  1',8X,'SD ERR1',8X,
     * 'ERROR  2',8X,'SD ERR2'//)
      WRITE(35,37)(AVSNR2(I),AVERNM(I,1),SDERNM(I 1),
     * AVERNM(I,2),SDERNM(I,2),I=1.LI)
      WRITE(35,178)
178 FORMAT(///6X,'ERROR  1',7X,'MIN ERR1',8X,'MAX ERR1',8X,
```

```
     *   'ERROR  2',7X,'MIN ERR2',8X,'MAX ERR2'//)
         WRITE(35 177)(AVERNM(I,1),MNER(I.1),MXER(I,1),
     *   AVERNM(I,2),MNER(I,2),MXER(I,2),I=1,LI)
177      FORMAT(6(1PE16.8))
C
C    CALCULATE ITT   _ERROR (+ _-) SD
C
         DO 90 I=1,LI
         SDMXIT(I,1)=AVITNM(I.1)+SDITNM(I.1)
         SDMXIT(I,2)=AVITNM(I,2)+SDITNM(I,2)
         SDMNIT(I,1)=AVITNM(I,1)-SDITNM(I,1)
         SDMNIT(I,2)=AVITNM(I,2)-SDITNM(I,2)
         SDMXER(I,1)=AVERNM(I,1)+SDERNM(I,1)
         SDMXER(I,2)=AVERNM(I,2)+SDERNM(I,2)
         SDMNER(I,1)=AVERNM(I,1)-SDERNM(I,1)
         SDMNER(I,2)=AVERNM(I,2)-SDERNM(I,2)
90       CONTINUE
C
C    PLOT OF ITERATION   _ERROR VS SNR, MAX _MIN OF SNR
C    STANDARD DEVIATION OF ERROR _ITTERATION
C
         WRITE(40,61)(MNSNR(I),AVERNM(I,1),I=1,LI)
         WRITE(41,61)(MNSNR(I`,AVERNM(I 2),I=1,LI)
         WRITE(42,61)(MXSNR(I),AVERNM(I,1),I=1,LI)
         WRITE(43,61)(MXSNR'I),AVERNM(I,2),I=1,LI)
         WRITE(44,61)(MNSNR(I),AVITNM(I,1),I=1,LI)
         WRITE(45,61)(MNSNR(I),AVITNM(I,2),I=1,LI`
         W.... ...61)(MXSNR'I),AVITNM(I 1),I=1,LI)
         WRITE'47,61)(MXSNR(I),AVITNM(I,2),I=1,LI)
         WRITE(48,61)(AVSNR2(I),SDMXER(I 1),I=1,LI)
         WRITE(49,61)(AVSNR2(I),SDMXER(I,2),I=1,LI)
         WRITE(50 61)(AVSNR2(I),SDMNER(I,1),I=1,LI)
         WRITE(51,61)(AVSNR2(I),SDMNER(I,2),I=1,LI)
C
C   CLOSE FILES
C
          CLOSE(UNIT=40)
          CLOSE'UNIT=41)
          CLOSE(UNIT=42)
          CLOSE(UNIT=43)
          CLOSE'UNIT=44)
          CLOSE(UNIT=45)
          CLOSE'UNIT=`6)
          CLOSE'....
          CLOSE UNIT=48)
          CLOSE(UNIT=49)
          CLOSE(UNIT=50)
          CLOSE(UNIT=51)
C
         WRITE(52,61)(AVSNR2(I),SDMXIT(I,1),I=1,LI)
         WRITE(53,61)(AVSNR2(I),SDMXIT(I,2),I=1,LI)
         WRITE(54 61)(AVSNR2(I),SDMNIT(I,1),I=1,LI)
         WRITE(55,61)(AVSNR2(I),SDMNIT(I,2),I=1,LI)
C
```

```
C     PLOT OF ITERATION   , _ERROR VS SNR
C
         WRITE(56,61)(AVSNR2(I),AVERNM(I,1),I=1,LI)
         WRITE(57,61)(AVSNR2(I),AVERNM(I,2),I=1,LI)
         WRITE(58,61)(AVSNR2(I),AVITNM(I,1),I=1,LI)
         WRITE(59,61)(AVSNR2(I),AVITNM(I,2),I=1,LI)
C
C    CLOSE FILES
C
          CLOSE(UNIT=52)
          CLOSE(UNIT=53)
          CLOSE(UNIT=54)
          CLOSE(UNIT=55)
          CLOSE(UNIT=56)
          CLOSE(UNIT=57)
          CLOSE(UNIT=58)
          CLOSE(UNIT=59)
C
C
C    PLOT AVESNR VS LN(SF) _1/SQRT(SF)
C
C          DO 80 I=1,LI
C          ERRL(I)=ALOG(ERR(I,1))
C          ERR1(I)=1./SQRT(ERR(I,1))
C80        CONTINUE
CC
C          WRITE(60,61)(ERRL(I),AVSNR2(I),I=1,LI)
C          WRITE(61,61)(ERR1(I),AVSNR2(I),I=1,LI)
CC
C          CLOSE(UNIT=60)
C          CLOSE(UNIT=61)
C
C
C PLOT AVERAGE ITT  VS LN(AVSNR2) _ITT SD'S _LN(MX-MN SNR)
C
          DO 95 I=1 LI
          AVSNR2(I)=ALOG(AVSNR2(I))
          MXSNR(I)=ALOG(MXSNR(I))
          MNSNR(I)=ALOG(MNSNR(I))
95        CONTINUE
C
          WRITE(31,61)(AVSNR2(I),AVERNM(I,1),I=1 LI)
          WRITE(32,61)(AVSNR2(I),AVERNM(I,2),I=1,LI)
          WRITE(33,61)(AVSNR2(I),SDMXER(I,1),I=1,LI)
          WRITE(34,61)(AVSNR2(I),SDMXER(I,2),I=1,LI)
          WRITE(37,61)(AVSNR2(I),SDMNER(I,1),I=1,LI)
          WRITE(30,61)(AVSNR2(I),SDMNER(I,2),I=1,LI)
          WRITE(38,61)(AVSNR2(I),AVITNM(I,1),I=1,LI)
          WRITE(39,61)(AVSNR2(I),AVITNM(I,2),I=1,LI)
          WRITE(60,61)(AVSNR2(I),SDMXIT(I,1),I=1,LI)
          WRITE(61,61)(AVSNR2(I),SDMXIT(I,2),I=1,LI)
          WRITE(62,61)(AVSNR2(I),SDMNIT(I,1),I=1,LI)
          WRITE(63,61)(AVSNR2(I),SDMNIT(I,2),I=1,LI)
C
```

```
        WRITE(33,61)(MNSNR(I),AVERNM(I,1),I=1,LI)
        WRITE(34,61)(MNSNR(I),AVERNM(I 2),I=1,LI)
        WRITE(37,61)(MXSNR(I),AVERNM(I,1),I=1,LI)
        WRITE(30,61)(MXSNR(I),AVERNM(I,2),I=1,LI)
        WRITE(60,61)(MNSNR(I),AVITNM(I,1),I=1,LI)
        WRITE(61,61)(MNSNR(I),AVITNM(I,2),I=1,LI)
        WRITE(62,61)(MXSNR'I),AVITNM(I,1),I=1,LI)
        WRITE(63,61)(MXSNR'I),AVITNM(I,2),I=1,LI)
C
C
C   PRINT OUT OPTIT 1 _2 AND OPTER 1 _2
C
C         DO 400 I=1,LI
C         WRITE(36,52)
C52       FORMAT(//' OPTIMUM ITERATION NUMBER '/)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTIT(J,I,1),J=1,SNRNO2)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTIT(J,I,2),J=1,SNRNO2)
C         WRITE(36,53)
C53 FORMAT(//' ERROR AFTER MORRIS / ERROR BEFORE MORRIS '/)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTER(J,I,1),J=1,SNRNO2)
C         WRITE(36,70)I
C         WRITE(36,40)(OPTER(J,I,2),J=1,SNRNO2)
C400       CONTINUE
C
78        FORMAT(2(1PE16.8))
60        FORMAT(G)
61        FORMAT(2G)
          TYPE 73
73        FORMAT(' NUMBER OF AVERAGE SNR"S '//)
          TYPE 70,LI
70        FORMAT(I)
          RETURN
          END
```

VITA

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Table Of Contents

Chapter I : Introduction 1

Chapter II : Inverse Filter 3

Chapter III: Morrison Noise Removal Alone 12

Chapter IV: Morrison Noise Removal For Deconvolution . 75

Chapter V: Effect Of A Scaled Input 132

Chapter VI: Comparison Between Different Inputs 183

Chapter VII: Conclusion 193

References 196

Appendex 200

Vita 232

List OF Tables

Table . . . . page

(3.1) :Narrow Ordinate SNR 23

(3.2) :Narrow Constant SNR 24

(3.3) :Wide Ordinate SNR 25

(3.4) :Wide Constant SNR 26

(3.5) :Narrow Ordinate Iteration 27

(3.6) :Narrow Ordinate Iteration 28

(3.7) :Narrow Constant Iteration 29

(3.8) :Narrow Constant Iteration 30

(3.9) :Wide Ordinate Iteration 31

(3.10) :Wide Ordinate Iteration 32

(3.11) :Wide Constant Iteration 33

(3.12) :Wide Constant Iteration 34

(2.13) :Narrow Ordinate Error 35

(3.14) :Narrow Ordinate Error 36

(3.15) :Narrow Constant Error 37

(3.16) :Narrow Constant Error 38

(3.17) :Wide Ordinate Error 39

(3.18) :Wide Ordinate Error 40

(3.19) :Wide Constant Error 41

(3.20) :Wide Constant Error 42

(4.1) :Narrow Ordinate SNR 80

(4.2) :Narrow Constant SNR 81

(4.3) :Wide Ordinate SNR 82

(4.4) :Wide Constant SNR 83

(4.5) :Narrow Ordinate Iteration 84

(4.6) :Narrow Ordinate Iteration 85

(4.7) :Narrow Constant Iteration 56

(4.8) :Narrow Constant Iteration 87

(4.9) :Wide Ordinate Iteration 88

(4.10) :Wide Ordinate Iteration 89

(4.11) :Wide Constant Iteration 90

(4.12) :Wide constant Iteration 91

(4.13) :Narrow Ordinate Error 92

(4.14) :Narrow Ordinate Error 93

(4.15) :Narrow Constant Error 94

(4.16) :Narrow Constant Error 95

(4.17) :Wide Ordinate Error 96

(4.18) :Wide Ordinate Error 97

(4.19) :Wide Constant Error 98

(4.20) :Wide Constant Error 99

(5.1) :Scaled Narrow Ordinate SNR 138

(5.2) :Scaled Narrow Constant SNR 139

(5.3) :Scaled Wide Ordinate SNR 140

(5.4) :Scaled Wide Constant SNR 141

(5.5) :Scaled Narrow Ordinate Iteration 142

(5.6) :Scaled Narrow Ordinate Iteration 143

(5.7) :Scaled Narrow Constant Iteration 144

(5.8) :Scaled Narrow Constant Iteration 145

(5.9) :Scaled Wide Ordinate Iteration 146

(5.10) :Scaled Wide Ordinate Iteration 147
(5.11) :Scaled Wide Constant Iteration 148
(5.12) :Scaled Wide Constant Iteration 149
(5.13) :Scaled Narrow Ordinate Error 150
(5.14) :Scaled Narrow Ordinate Error 151
(5.15) :Scaled Narrow Constant Error 152
(5.16) :Scaled Narrow Constant Error 153
(5.17) :Scaled Wide Ordinate Error 154
(5.18) :Scaled Wide Ordinate Error 155
(5.19) :Scaled Wide Constant Error 156
(5.20) :Scaled Wide Constant Error 157
(5.21) :Scaled Narrow Ordinate SNR Prior To Deco. 158
(5.22) :Scaled Narrow Constant SNR Prior To Deco. 159
(5.23) :Scaled Wide Ordinate SNR Prior To Deco. 160
(5.24) :Scaled Wide Constant SNR Prior To Deco. 161
(5.25) :Scaled Narrow Ordinate Iteration Prior To Deco. 162
(5.26) :Scaled Narrow Ordinate Iteration Prior To Deco. 163
(5.27) :Scaled Narrow Constant Iteration Prior To Deco. 164
(5.28) :Scaled Narrow Constant Iteration Prior To Deco. 165
(5.29) :Scaled Wide Ordinate Iteration Prior To Deco. 166
(5.30) :Scaled Wide Ordinate Iteration Prior To Deco. 167
(5.31) :Scaled Wide Constant Iteration Prior To Deco. 168
(5.32) :Scaled Wide constant Iteration Prior To Deco. 169
(5.33) :Scaled Narrow Ordinate Error Prior To Deco. 170
(5.34) :Scaled Narrow Ordinate Error Prior To Deco. 171
(5.35) :Scaled Narrow Constant Error Prior To Deco. 172

(5.36) :Scaled Narrow Constant Error Prior To Deco. 173

(5.37) :Scaled Wide Ordinate Error Prior To Deco. 174

(5.38) :Scaled Wide Ordinate Error Prior To Deco. 175

(5.39) :Scaled Wide Constant Error Prior To Deco. 176

(5.40) :Scaled Wide Constant Error Prior To Deco. 177

(5.41) :Scaled Narrow Constant SNR For Zero Conv. 178

(5.42) :Scaled Narrow Constant Iteration For Zero Conv 179

(5.43) :Scaled Narrow Constant Iteration For Zero Conv. 180

(5.44) :Scaled Narrow Constant Error For Zero Conv. 181

(5.45) :Scaled Narrow Constant Error For Zero Conv. 182

List Of Figures

Figure . . . . Page

(2.1) :Convolution Process 3

(2.2) :Input 7

(2.3) :Narrow Gaussian Response 8

(2.4) :Wide Gaussian Response 9

(2.5) :Narrow Output 10

(2.6) :Wide Output 11

(2.7) :Deconvolution Process 4

(3.1) :Narrow Ordinate Iteration For L1 Norm 43

(3.2) :Narrow Ordinate Iteration For L1 Norm 44

(3.3) :Narrow Ordinate Iteration For L2 Norm 45

(3.4) :Narrow Ordinate Iteration For L2 Norm 46

(3.5) :Narrow Constant Iteration For L1 Norm 47

(3.6) :Narrow Constant Iteration For L1 Norm 48

(3.7) :Narrow Constant Iteration For L2 Norm 49

(3.8) :Narrow Constant Iteration For L2 Norm 50

(3.9) :Wide Ordinate Iteration For L1 Norm 51

(3.10) :Wide Ordinate Iteration For L1 Norm 52

(3.11) :Wide Ordinate Iteration For L2 Norm 53

(3.12) :Wide Ordinate Iteration For L2 Norm 54

(3.13) :Wide Constant Iteration For L1 Norm 55

(3.14) :Wide Constant Iteration For L1 Norm 56

(3.15) :Wide Constant Iteration For L2 Norm 57

(3.16) :Wide Constant Iteration For L2 Norm 58

(3.17) :Narrow Ordinate Error For L1 Norm 59

(3.18) :Narrow Ordinate Error For L1 Norm 60

(3.19) :Narrow Ordinate Error For L2 Norm 61

(3.20) :Narrow Ordinate Error For L2 Norm 62

(3.21) :Narrow Constant Error For L1 Norm 63

(3.22) :Narrow Constant Error For L1 Norm 64

(3.23) :Narrow Constant Error For L2 Norm 65

(3.24) :Narrow Constant Error For L2 Norm 66

(3.25) :Wide Ordinate Error For L1 Norm 67

(3.26) :Wide Ordinate Error For L1 Norm 68

(3.27) :Wide Ordinate Error For L2 Norm 69

(3.28) :Wide Ordinate Error For L2 Norm 70

(3.29) :Wide Constant Error For L1 Norm 71

(3.30) :Wide Constant Error For L1 Norm 72

(3.31) :Wide Constant Error For L2 Norm 73

(3.32) :Wide Constant Error For L2 Norm 74

(4.1) :Narrow Ordinate Iteration L1 Norm 100

(4.2) :Narrow Ordinate Iteration L1 Norm 101

(4.3) :Narrow Ordinate Iteration L2 Norm 102

(4.4) :Narrow Ordinate Iteration L2 Norm 103

(4.5) :Narrow Constant Iteration L1 Norm 104

(4.6) :Narrow Constant Iteration L1 Norm 105

(4.7) :Narrow Constant Iteration L2 Norm 106

(4.8) :Narrow Constant Iteration L2 Norm 107

(4.9) :Wide Ordinate Iteration L1 Norm 108

(4.10) :Wide Ordinate Iteration L1 Norm 109

(4.11) :Wide Ordinate Iteration L2 Norm 110
(4.12) :Wide Ordinate Iteration L2 Norm 111
(4.13) :Wide Constant Iteration L1 Norm 112
(4.14) :Wide Constant Iteration L1 Norm 113
(4.15) :Wide Constant Iteration L2 Norm 114
(4.16) :Wide Constant Iteration L2 Norm 115
(4.17) :Narrow Ordinate Error L1 Norm 116
(4.18) :Narrow Ordinate Error L1 Norm 117
(4.19) :Narrow Ordinate Error L2 Norm 118
(4.20) :Narrow Ordinate Error L2 Norm 119
(4.21) :Narrow Constant Error L1 Norm 120
(4.22) :Narrow Constant Error L1 Norm 121
(4.23) :Narrow Constant Error L2 Norm 122
(4.24) :Narrow Constant Error L2 Norm 123
(4.25) :Wide Ordinate Error L1 Norm 124
(4.26) :Wide Ordinate Error L1 Norm 125
(4.27) :Wide Ordinate Error L2 Norm 126
(4.28) :Wide Ordinate Error L2 Norm 127
(4.29) :Wide Constant Error L1 Norm 128
(4.30) :Wide Constant Error L1 Norm 129
(4.31) :Wide Constant Error L2 Norm 130
(4.32) :Wide Constant Error L2 Norm 131
(5.1) :Scaled Input 133
(6.1) :Narrow Constant Iteration Of L2 Norm 186
(6.2) :Narrow Constant Error Of L2 Norm 187
(6.3) :Wide Constant Iteration Of L2 Norm 188

(6.4) :Wide Constant Error L2 Norm 189
(6.5) :Wide Constant Iteration L2 Norm Prior To Deco. 190
(6.7) :Wide Constant Iteration L2 Norm Prior To Deco. 191
(6.8) :Wide Constant Error L2 Norm Prior To Deco. 192

Abstract

Morrison's iterative method of noise removal can be applied for both noise removal alone and noise removal prior to deconvolution. This method is applied to noise of various noise levels added to data to determine the optimum use of the method.

The inverse filter is calculated by taking the inverse discrete Fourier transform of the reciprocal of the transform of the response of the system. The method of deconvolution used consists of convolving the data with the inverse filter. Deconvolution of non-noisy data is performed and the error is calculated by comparing the deconvolved results to the original input f.

A triangular and rectangular type input is selected and convolved with narrow and wide response Gaussian functions to produce the data sets to be analyzed. The types of noise added to the data are constant and ordinate-dependent Gaussian distributed noise. The noise levels of the data are characterized by their signal-to-noise ratios. L1 and L2 norms for errors are employed in the optimization.

Tables of results and figures are both included to show the results of optimization for both Gaussians, for both noise types, and for both norms.

The input is selected to contrast with the input of Leclere which consists of narrow Gaussians. The results of the two optimizations are compared. The current input is also scaled by multiplication by a constant to illustrate

the effect of scaling.

Chapter I

Introduction

This work concerns the optimum use of Morrison's method for both noise removal alone and noise removal prior to deconvolution.

Morrison's noise removal is an iterative technique in which which the first iteration smoothes the data to which it is applied, and each subsequent iteration restores the data back toward the original, except for the incompatable noise, upon the convergence of the method.

Some work has been done by Ioup(1968), Wright (1980). and Leclere(1984) to show that the iterations may be terminated before convergence of the method and a reasonable approximation to the noise free data obtained.

In Chapter II the method of determining the optimum length filter used for the deconvolution and the factors that affect its accuracy are briefly studied.

Chapter III contains the study of Morrison's noise removal method for noise removal alone and also a discussion of the ordinate-dependent and constant noise that is added to the data. Tables and plots are provided to show the optimum iteration number versus noise level as well as error improvements at the iteration numbers. Comparisons between narrow and wide Gaussians are also provided.

Chapter IV contains the study of Morrison's method for noise removal prior to deconvolution. As Morrison's smoothing is applied to the noisy data, the deconvolution is performed after each iteration by applying the optimum filter calculated in Chapter II. Tables and plots corresponding to those in Chapter III are also included in this chapter.

Chapter V contains the same study done in Chapter III and IV for the same input but of a different size. The size of the new input is reduced to one fourth and the study is done to see how the convergence value, the iteration number, and the error improvement is affected. Complete tables of results are included for convenience.

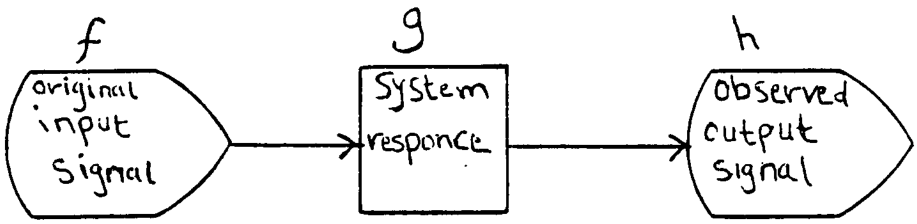
Chapter VI contains a comparison between two types of input. The first type of input is the one used by Wright(1980) and Leclere(1984)and the second is the one used in this study. The purpose is to have a better understanding of what effect a different input has on the convergence criteria, the iteration numbers, and the error improvements. Plots are given which show the average iteration numbers and average error improvements for both inputs. A brief discussion is also included.

Chapter VII is a conclusion section which contains a comparison of the use of Morrison's technique for noise removal alone and for noise removal prior to deconvolution. Suggestions for further study are given. A listing of the FORTRAN computer program used in this study is in the appendix.

Chapter II

Convolution and Inverse Filter

When input data are measured by a system, the system subjects those data to some distortion. The effect on the data is determined by the impulse response of the system. The effect of the impulse response on the data can be described by convolution if the system is linear and shift invariant. The relationship between the input and the output can be represented as shown in Figure (2.1). In Figure (2.1) the input data are denoted by f, the system response by g, and the output by h.



Figure(2.1) : $h = f * g$

where the asterisk * represents the convolution. The convolution integral in the function domain is:

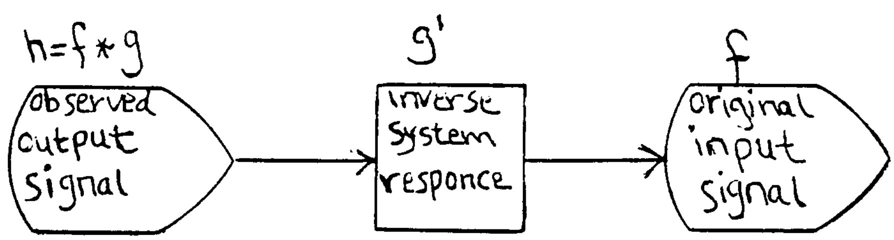
$$h(x) = \int_{-\infty}^{+\infty} f(u)\, g(x-u)\, du$$

If N denotes the number of points for either the narrow or wide responses and L the number for the input data, then the length of the output is (N+L-

1) points (Bracewell, 1978). For example, the number of points in the narrow Gaussian response used here is 9 and in the wide Gaussian response 21, so the number of points of the output is 32 in the narrow case and 44 in the wide case.

Figure (2.2) represents the input f to the system and Figures (2.3) and (2.4) show the narrow and the wide Gaussian responses respectively. Figures (2.5) and (2.6) represent the outputs, h, for the narrow and the wide cases respectively.

To remove the effect of the response, the output is deconvolved. The process of deconvolution (or inverse filtering) is extremely useful in radar, seismic, and other areas for removing the effect of some previous convolution on the signal. As in Figure (2.1), if the observed output signal is h, the general problem of deconvolution is one finding a box through which one can pass the observed signal h so as to recover the original signal f (Robinson, 1980). The process of deconvolution is depicted by the diagram shown below:



Figure(2.7) : Deconvolution process

The technique used in this work is to take the inverse transform of the reciprocal of the discrete Fourier transform (DFT) of the impulse response. The convolution

$$h(x) = f(x) * g(x)$$

in the Fourier transform domain corresponds to multiplication of the transforms of f and g (Bracewell,1978),

$$H(s) = F(s)G(s),$$

and

$$F(s) = \frac{H(s)}{G(s)},$$

which corresponds to

$$f(x) = h(x) * inverse\ of\ g(x).$$

The inverse filter is defined by

$$g'(x) = \frac{1}{NT} \sum_{s=1}^{NT} \left(\frac{1}{G(s)}\right) exp^{\frac{i2\pi xs}{N}}$$

where $F(s)$, $H(s)$, and $G(s)$ represent the Fourier transforms of $f(x)$, $h(x)$, and $g(x)$, respectively. NT is the number of discrete frequency components contained in 1/G(s).

It was shown by Leclere (1984) that the accuracy of the filter depends very much on the length of the filter. The following is a brief discussion of the factors that affect the accuracy of the inverse filter and the choice of the optimum filter length.

Bracewell (1978) points out that that if the system considered is entirely discrete there is no error due to sampling. The significant effects on the accuracy of the inverse filter are the wraparound error in the function domain (Oppenheim and Schafer, 1975) and the round- off error.

The procedure used to reduce the wraparound effect is to reduce the sampling interval in the transform domain, or correspondingly, to add zeros in the function domain. This results in widening the function domain window of the filter and thus reducing the error introduced by wraparound. This is significant because the filter is calculated from a sampled transform domain function with frequency components of large magnitude at the edges of the window.

In his work Leclere(1984) shows how too coarse a sampling interval in the transform domain causes a significant wraparound error in the calculation of the filter, and how sampling at a finer rate can reduce this effect greatly. Leclere also shows that the filter calculated from the narrow Gaussian has less wraparound error than a wide Gaussian of the same sampling interval and that the transform of the narrow Gaussian is wider and has larger values at the edges of its window.

For the determination of the inverse filter, the fast Fourier transform (FFT) subroutine (Higgins, 1976) is used for the calculation of the forward and inverse transforms. In his work, Leclere (1984) tests different inverse filter lengths to determine the optimum one. Because the wide Gaussian inverse has more round-off error than the narrow, its optimum length is less. As a result of his study, a 257 point filter is chosen for the narrow case, and a 129 point filter is chosen as the most accurate one for the wide case.

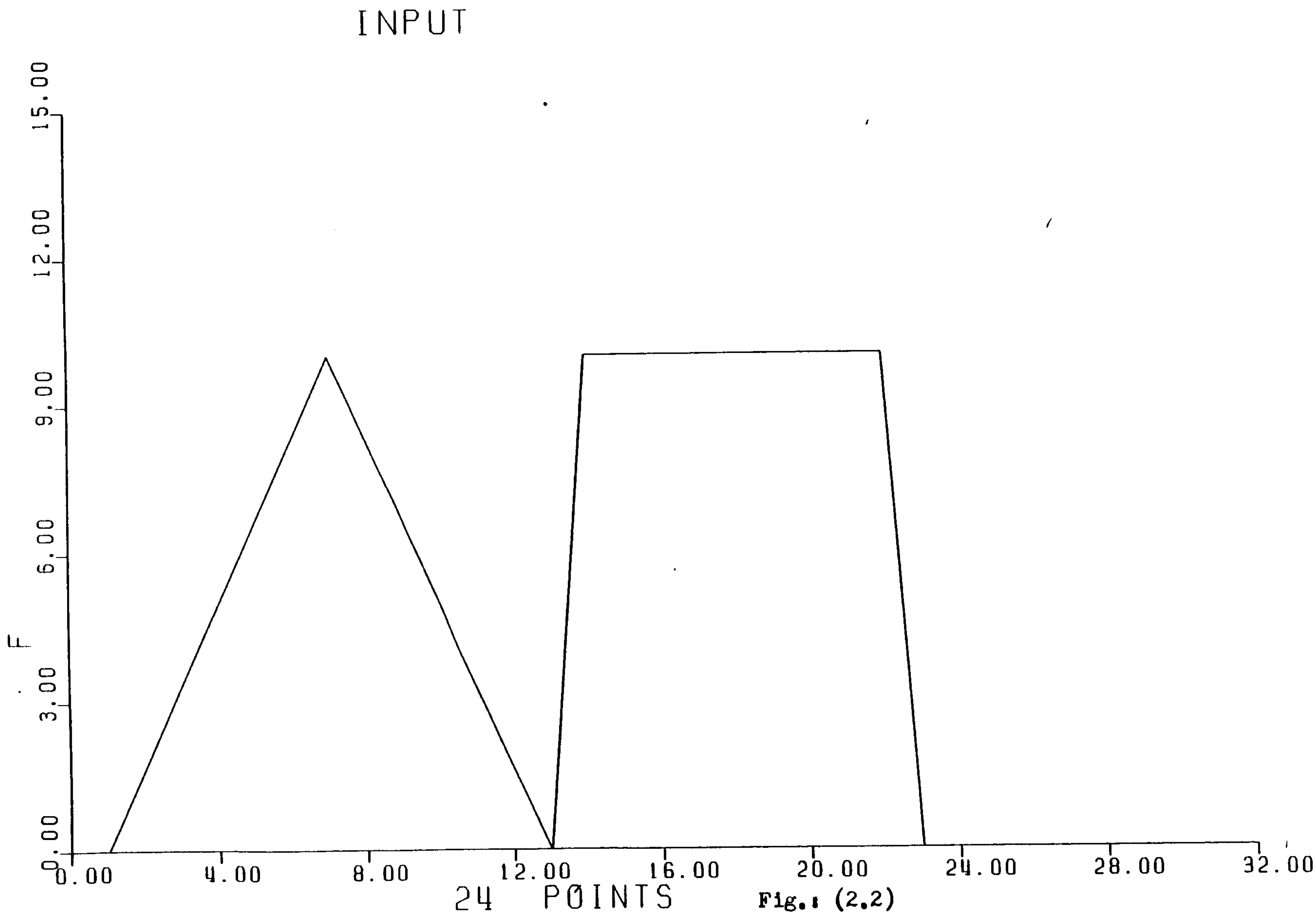

INPUT
F
0.00
3.00
6.00
9.00
12.00
15.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
24 PØINTS

Fig.: (2.2)

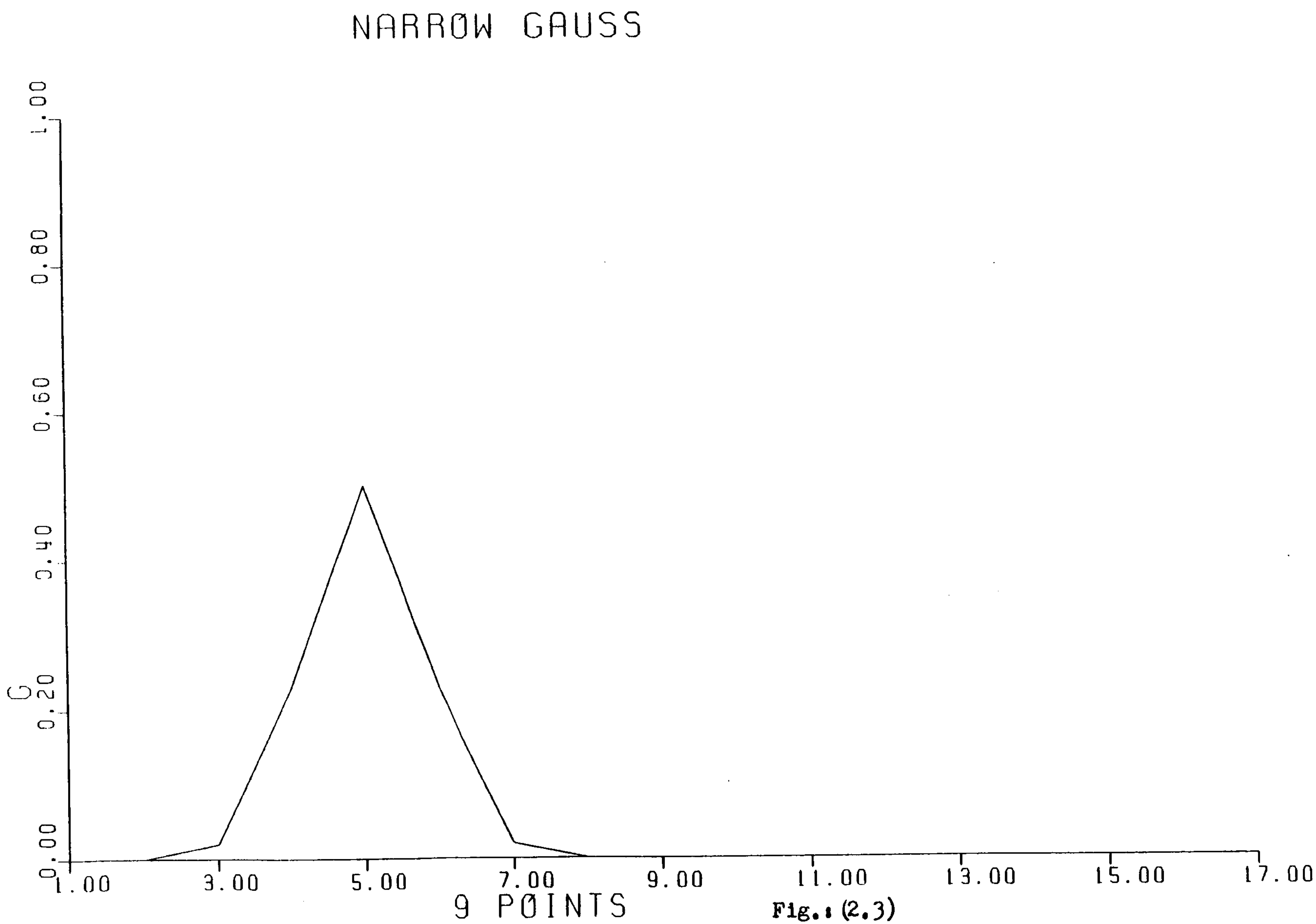

NARROW GAUSS
1.00
0.80
0.60
0.40
0.20
0.00
G
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
9 PØINTS

Fig.: (2.3)

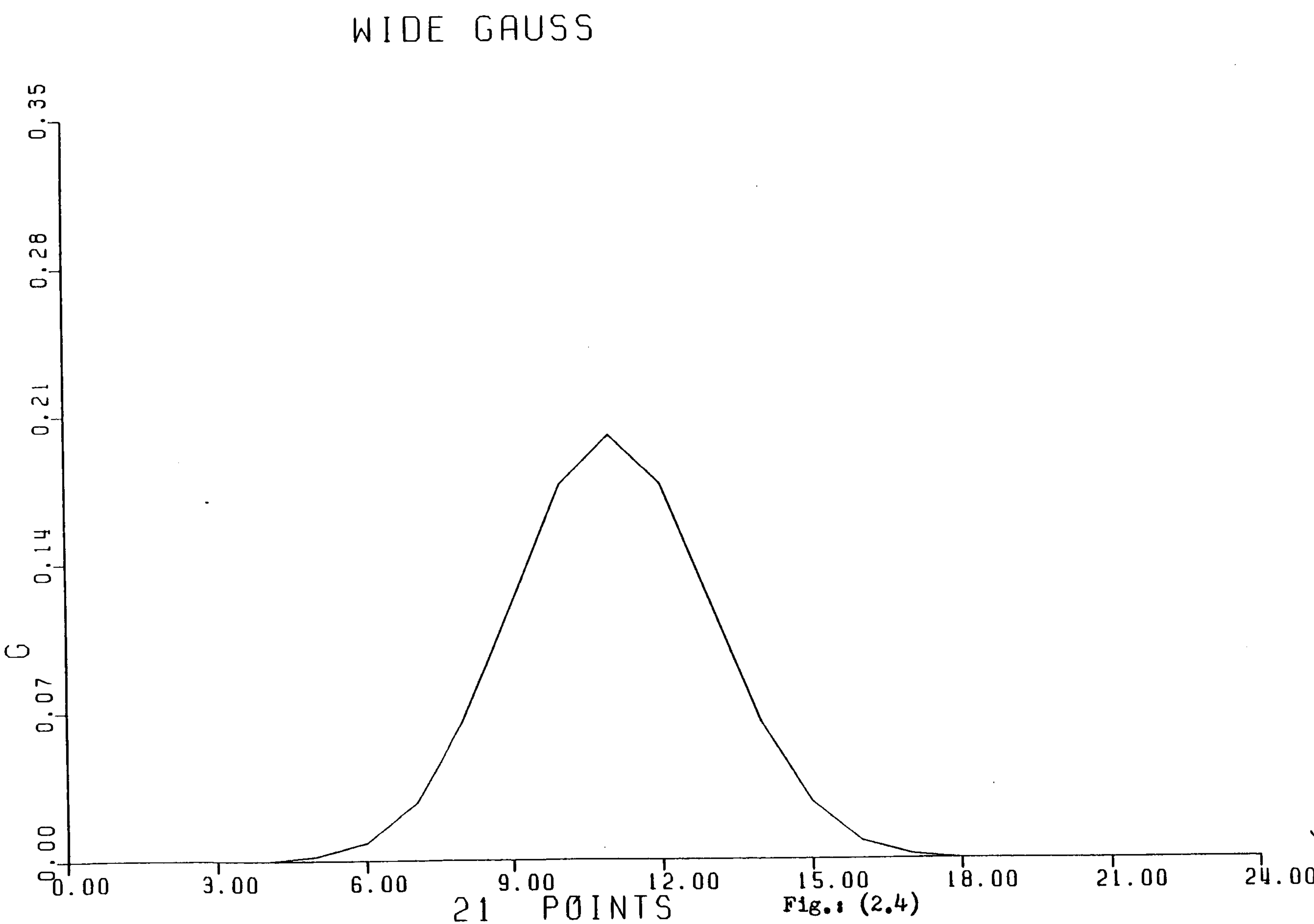

WIDE GAUSS
G
0.35
0.28
0.21
0.14
0.07
0.00
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
21 PØINTS

Fig.: (2.4)

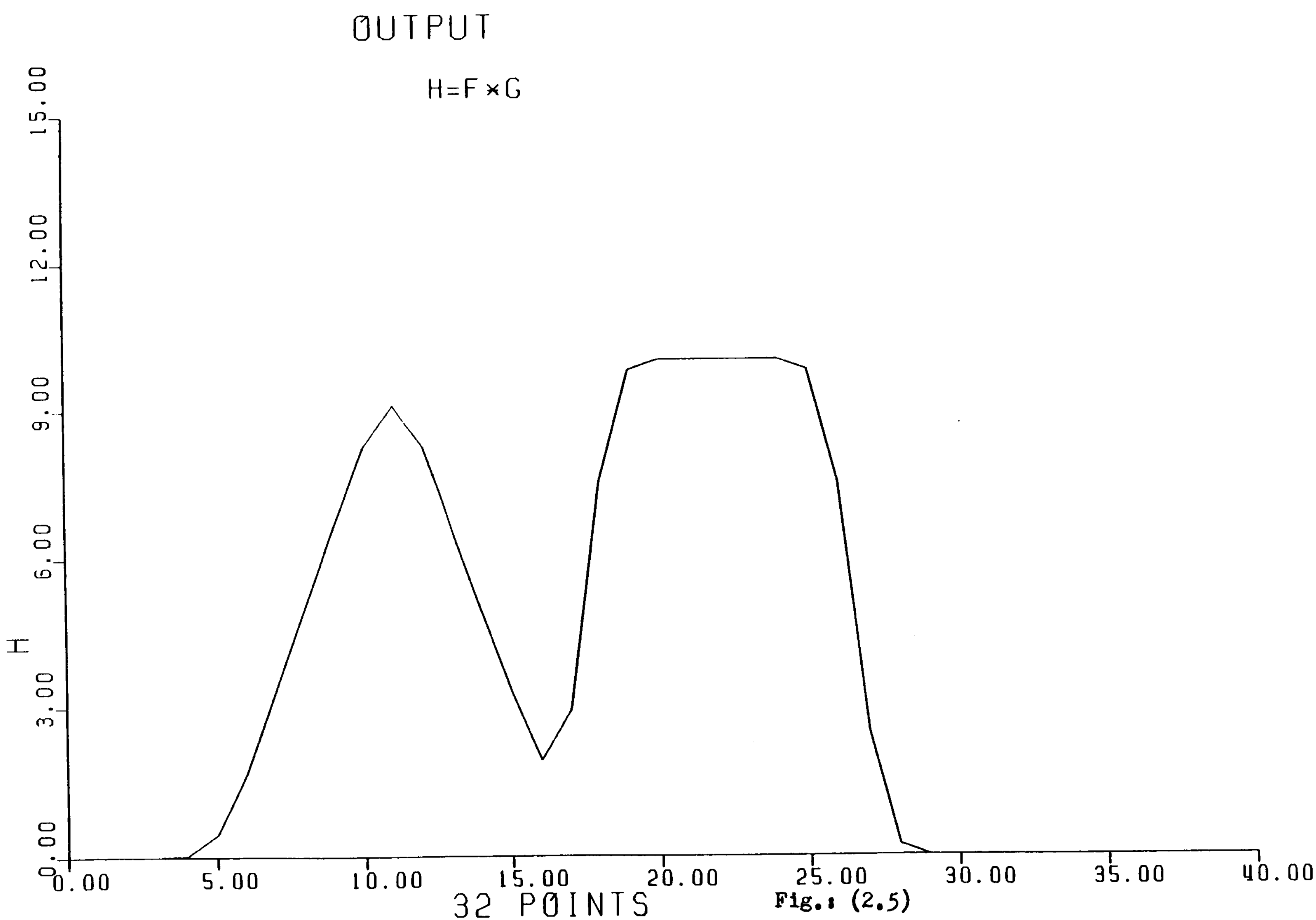

ØUTPUT
H=F×G
H
0.00
3.00
6.00
9.00
12.00
15.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
32 PØINTS

Fig.: (2.5)

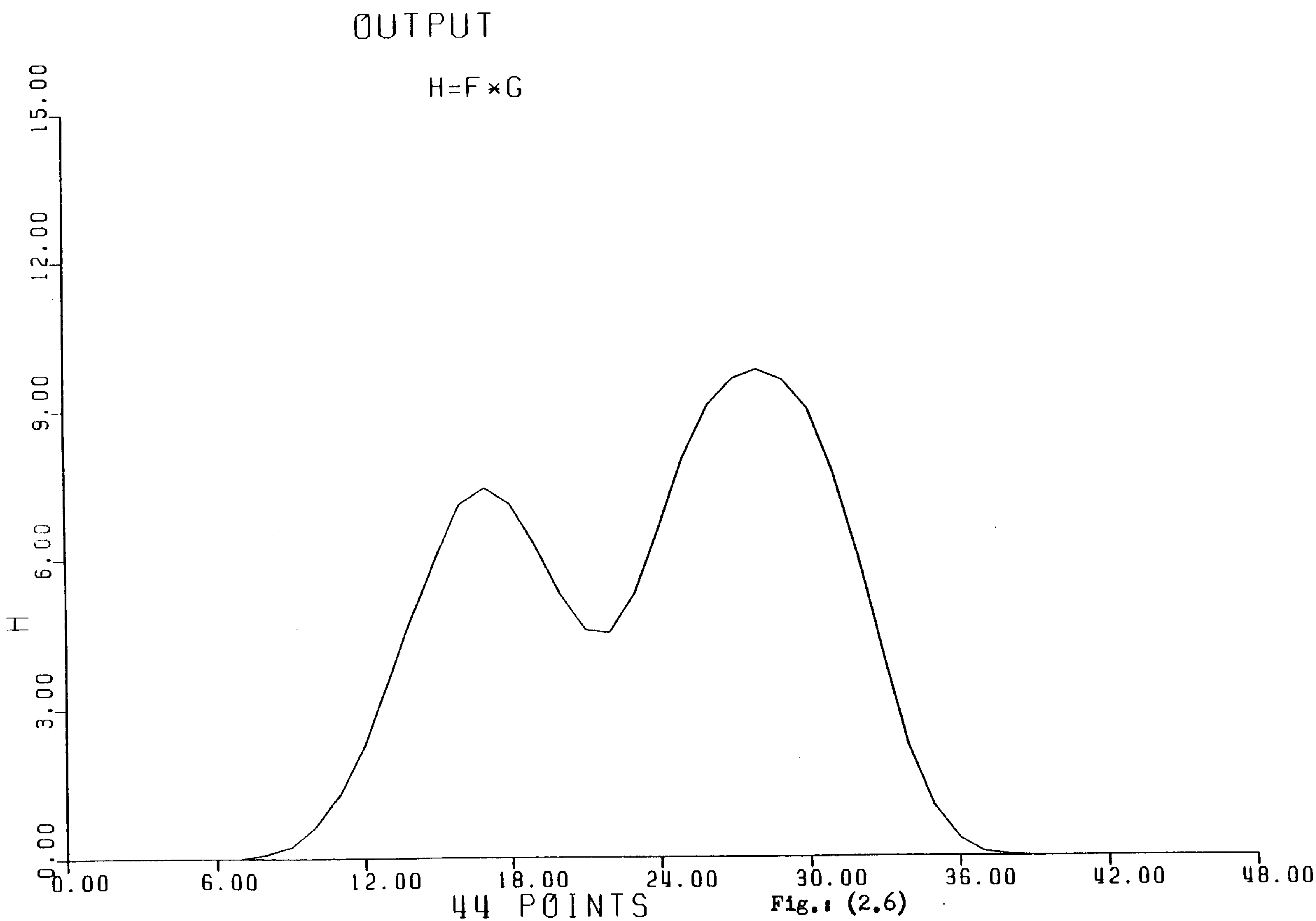

OUTPUT
H=F*G
H
15.00
12.00
9.00
6.00
3.00
0.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
44 POINTS

Fig.: (2.6)

Chapter III

Morrison's Method For Noise Removal

Morrison's iterative method of noise removal is a technique in which the first iteration smoothes the data by convolving h with g, and each subsequent iteration restores the data to the original except for the removal of incompatable noise, upon convergence of the method (Morrison, 1963:Ioup, 1968). The first iteration wherein h is convolved with g results in a function h_1 that has no frequency component higher than those found in g, the system response function.

Morrison's smoothing can be represented as follows (Ioup, 1968; Ioup and Ioup, 1983). In the function domain:

$$h_1(x) = h(x) * g(x)$$

$$h_n(x) = h_{n-1}(x) + [h(x) - h_{n-1}(x)] * g(x) \qquad n > 1$$

In the transform domain:

$$H_1(s) = H(s)G(s)$$

$$H_n(s) = H_{n-1}(s) + [H(s) - H_{n-1}(s)]G(s) \qquad n > 1$$

or

$$H_n(s) = [1 - (1 - G(s)^n]H(s)$$

In previous work Ioup(1968) discusses the convergence conditions. Convergence is assured if $ABS(1 - G(s)) < 1$ or if $G(s) = 0$. Morrison's noise removal converges faster in the case of the narrow response because, as stated earlier, the narrow response has a wider frequency spectrum than does the wide Gaussian and for any value of s, $|1-(1-G(s))^n|$ is a number closer to one, for any n.

Morrison's Method for Noise Removal Alone

Morrison's method applied to noise added data, h_r, restores both signal and noise with each iteration. It was shown by Wright (1980) and Leclere (1984) that the best approximation of the data, h, is obtainable by termination of the iterations before convergence of the method.

It was shown by Wright and Ioup (1980), Ioup and Ioup (1981), and Leclere (1984) that the optimum use of Morrison's method can be studied by adding ordinate-dependent and constant Gaussian distributed noise to the data h. The definition of the signal to noise ratio (SNR) used here is the ratio of the maximum value of h to the root-mean-square (RMS) value, or standard deviation, of the noise. The SNR is used to characterize the level of the noise added to the data. The procedure for noise addition used in this study is the same as that used by Leclere (1984). The procedure will be summarized in the following sections.

Constant Gaussian Noise Addition Procedure

Constant Gaussian noise is that which has a constant standard deviation at each point. It can be generated as follows (Leclere, 1984, Hamming, 1973):

$$h_p(I) = (\sum_{j=1}^{12} A_j - 6) * (NSF)^{0.5} + h(I)$$

where NSF is the noise scale factor chosen to vary the magnitude of the noise and thus the SNR. A is a random number uniformly distributed between zero and one, generated by a computer subroutine. The index I denotes each discrete data element.

Ordinate-Dependent Gaussian Noise Addition Procedure

Ordinate-dependent Gaussian noise is that which has an ordinate dependent standard deviation. The noise addition procedure is as follows:

$$h_p(I) = (\sum_{j=1}^{12} A_j - 6) * (NSF * h(I))^{0.5}) + h(I)$$

Signal To Noise Ratio

The SNR is used to measure the noisiness of the data sets and, as is evident from the noise addition procedure, the mean SNR is inversely proportional to the square root of the NSF:

$$SNR = constant/(NSF)^{0.5},$$

in both the constant and the ordinate-dependent noise cases. A single NSF produces a statiscally distributed range of SNR values upon repeated application of the above formulas. To limit the SNR values to a small neighborhood about the mean SNR for a given NSF, one approach is to add noise 100 times to h and calculate an average SNR, AVSNR, and standard deviation, SDSNR, for the 100 cases. Then the SNR of the data sets to be optimized is confined to a range about AVSNR of plus and minus one half SDSNR.

As will be shown later in this chapter, the rate of change of the optimum iteration number and the error improvement with SNR are much greater for relatively low SNR's. The two error measurements employed in the optimization were based on the minimization of the absolute error per point and the mean-square errors,or the RMS, between h andh_n. These measures are referred to as the L1 and L2 norms, respectively.

Convergence Criteria

In his previous work, Leclere(1984) uses a procedure for convergence which terminates the iterations for the narrow Gaussian case, constant noise and ordinate-dependent noise, when the fractional difference, DF1, or an absolute difference, DF2, between the errors at successive iteration are less than 0.0001 or 0.00002 respectively. For the wide Gaussian case the iterations are terminated, for the constant and the ordinate-dependent noise, when DF1 or DF2 are less than 0.0005 or 0.00005 respectively. The fractional difference is defined as:

$$DF1 = |e(i-1) - e(i)|/e(i-1),$$

and the absolute difference is obtained from:

$$DF2 = |e(i-1) - e(i)|,$$

where i denotes the iteration number of the current test.

Choosing a suitable convergence criterion is somewhat subjective as a preference for reduction in noise or resolution of signal comes into play. Other factors are the smoothness of the iteration vs SNR curve and the standard deviations of the iteration numbers. A convergence criterion is chosen which allows optimum error improvement in combination with results consistent with expected behavior. The convergence value for each case in this study determined experimentally. Convergence values of DF1=0.0001 and DF2=0.00002 are chosen for the narrow case for both constant and ordinate-dependent noise types. Convergence values of DF1=0.0005 and DF2=0.00002 are chosen for the wide case for both the constant and ordinate-dependent cases.

Optimization Procedure

The method for determining the optimum average iteration number is to calculate AVESNR and SDSNR as mentioned earlier and to continue adding noise for each SNR until 100 data sets having SNR's that fall within plus and minus one-half SDSNR for each AVSNR are generated and stored. From these sets new averages, AVSNR2, standard deviations, SDSNR2, and maximum and minimum SNR's, MXSNR and MNSNR, that fall within the one-half SDSNR range are calculated. These values are listed in Tables (3.1)-(3.4) for both Gaussians and both noise types.

Morrison's noise removal is applied to the data sets and the error is tested after each iteration by comparing the restored result to the noise-free h defined in Chapter II. The 100 optimum iteration numbers for each AVSNR2 are stored, and averages of iteration numbers,AVITER, are calculated along with their standard deviations, ITSD, and maximum and minimum iteration numbers, MAXITER and MINITER.

Figures (3.1)-(3.16) show AVITER versus AVSNR2 and AVITER versus the natural log of AVSNR2 for both the narrow and wide Gaussians, for both L1 and L2 norms, and for both constant and ordinate-dependent noise types. Standard deviations of iteration numbers are given on the semilog plots.

In the calculation of the average error improvement at each AVSNR2 the ratio of the error after noise removal to the error before applying Morrison's method is determined for each of the 100 data sets. The averages of each of the 100 ratios are calculated, ERROR, along with their standard deviation, SDERR, and their maxima and minima, MAXERR and MINERR.

Tables (3.13)-(3.20) list these values. Plots of average error versus AVSNR2 and average error versus the natural log of the AVSNR2 are shown in Figures (3.17)-(3.32). Standard deviations of error improvements are included on the semilog figures.

Results of Narrow Gaussian Iterations

Examining Tables (3.5)-(3.8) one can see the monotonic increase in average iteration number as the SNR increases. For the ordinate-dependent noise case the average iteration number for the L1 norm is higher than that of the L2 norm at the same AVSNR2. However, for the constant case the average iteration number for L2 norm is higher than that of the L1 norm for the same AVSNR2. For the L1 norm the average number of iterations for the ordinate-dependent noise is higher than that of the constant noise. For the L2 norm the average iteration number for the ordinate-dependent case is less than that of the constant case. For both norms and both noise types, there is a rapid increase in average iteration in the low and middle range of AVSNR2.

The data also show that for both L1 and L2 norms, and for both constant and ordinate-dependent noise types, there is no fluctuation in the average of the iteration number as the AVSNR2 increases over the total range.

Results For Wide Gaussian Iteration

Examining Tables (3.9)-(3.12) or Figures (3.9)-(3.16), one can see clearly the monotonic increase in the average iteration number as the average SNR increases. For the ordinate-dependent noise the average iteration number for the L1 norm is higher than that of the L2 norm in the region AVSNR2 5 to 200, and the L2 norm is slightly higher in the rest of the range. For constant noise the average iteration number for the L1 norm is higher than that of L2 in the range AVSNR2 7.8 to 100, and there is no significant difference over the rest of the range. For the L1 norm the average iteration number of the ordinate-dependent noise is higher than that of the constant noise. However for the L2 norm the average iteration number of the constant noise case is higher than that of the ordinate-dependent case.

As in the narrow Gaussian case for both L1 and L2 norms, and for both the ordinate-dependent and constant noise, there is a monotonic increase in average iteration number as the AVSNR2 increases. The data show no fluctuation in the average iteration number as AVSNR2 increases over the total range.

Comparison of Narrow to Wide Iteration Results

From the investigation of Tables (3.5)-(3.9) and (3.12), the monotonic increase in average iteration number as AVSNR2 increases is very clear. For both constant and ordinate-dependent noise and for both L1 and L2 norms, the average iteration number of the wide Gaussian is larger than those of the narrow Gaussian over the full range.

Error Results For Narrow Gaussian

Tables (3.13)-(3.16) and Figures (3.17)-(3.24) show the average error ratios versus AVSNR2. It should be noted that a smaller value in the table corresponds to a larger improvement in error with the application of Morrison's noise removal methods. It is also should be noted that an average error ratio greater than one implies no error improvement in the restored results.

For the L1 and L2 norms and for the constant and ordinate-dependent cases the larger error improvements take place in the low SNR's. For both noises and both norms there is a monotonic decrease in error improvement and no fluctuations noticed over the full range.

For ordinate-dependent noise there is no error improvement in the range of AVSNR2 from 755 to 1000, and the significant error improvement takes place in the AVSNR2 2.3 to 75 range. For the ordinate-dependent noise the L2 norm has a significantly greater error improvement than the L1 in the low SNR range but this difference is slight over the rest of the range. For the L1 norm the error improvement for the ordinate-dependent noise is greater than that of the constant case in the AVSNR2 2.2 to 100 range. However, the error improvement for the constant noise is slightly greater for the rest of the range. For the L2 norm the error improvement for the ordinate-dependent noise is larger than that of the constant noise over the full range.

Error Results for Wide Gaussian

Tables (3.17)-(3.20) and Figures (3.25)-(3.32) show the average error improvement versus AVSNR2 for the wide Gaussian. For both constant and ordinate-dependent noise the average error improvements for the L2 norm are greater than that of the L1 norm over the full range of AVSNR2. It is also noticed that the average error improvement is greater at low SNR for both L1 and L2 norms and both ordinate-dependent and constant noise. The ordinate-dependent noise has a greater error improvement than the constant noise over the full AVSNR2 range for both L1 and L2 norms.

In general both constant and ordinate-dependent and both L1 and L2 norms seem to have no fluctuation of error improvement with a monotonic decrease over the full range.

Comparison of The Narrow Gaussian to The Wide Gaussian Error Results

Comparison of Tables (3.13)-(3.16) and (3.17)-(3.20) shows that the error improvements in the wide case are greater than those of the narrow case for both constant and ordinate-dependent noise, and for both the L1 and L2 norms. In the constant case the error improvements for the L1 and L2 norm of the wide case are better than those of the narrow case especially at higher SNR. The same thing can be said about the L1 norm for the ordinate-dependent noise. For the ordinate-dependent noise and for the L2 norm, the error improvement of the wide Gaussian is much greater than that of the narrow Gaussian over the full range of SNR.

TABLE(3.1)

NARROW ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36258352E+00	2.56703777E+00	2.18037985E+00	3.99000000E+02
3.00000000E+00	3.14358198E+00	3.36858924E+00	2.91042395E+00	3.49000000E+02
4.00000000E+00	3.94490353E+00	4.23985292E+00	3.62263869E+00	3.57000000E+02
5.00000000E+00	4.82867728E+00	5.27650276E+00	4.46220520E+00	3.53000000E+02
7.50000000E+00	7.42870856E+00	8.11945281E+00	6.88343422E+00	3.58000000E+02
1.00000000E+01	9.86766080E+00	1.05756123E+01	9.17682847E+00	3.62000000E+02
1.50000000E+01	1.51777312E+01	1.67703053E+01	1.38689684E+01	3.27000000E+02
2.00000000E+01	1.93612024E+01	2.10230429E+01	1.77395950E+01	3.75000000E+02
2.50000000E+01	2.54713674E+01	2.78008266E+01	2.37453813E+01	3.72000000E+02
3.50000000E+01	3.49397879E+01	3.76998750E+01	3.22674728E+01	3.22000000E+02
5.00000000E+01	5.03170518E+01	5.40962651E+01	4.68674192E+01	4.12000000E+02
7.50000000E+01	7.50853183E+01	8.24997099E+01	6.87960515E+01	3.36000000E+02
1.00000000E+02	1.00476079E+02	1.08352560E+02	9.23643043E+01	3.98000000E+02
1.50000000E+02	1.45435096E+02	1.57608790E+02	1.34013516E+02	3.74000000E+02
2.00000000E+02	2.02956372E+02	2.21950430E+02	1.81066609E+02	3.17000000E+02
3.00000000E+02	2.96842156E+02	3.22487836E+02	2.73420205E+02	3.31000000E+02
4.00000000E+02	4.05393680E+02	4.43115165E+02	3.74198257E+02	3.60000000E+02
5.00000000E+02	4.91303172E+02	5.35148536E+02	4.50731963E+02	3.68000000E+02
7.50000000E+02	7.55217438E+02	8.12373375E+02	6.97853016E+02	3.80000000E+02
1.00000000E+03	1.00013445E+03	1.08080588E+03	9.30717090E+02	3.59000000E+02

TABLE (3.2)

NARROW CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.23024578E+00	2.38621271E+00	2.09679916E+00	3.86000000E+02
3.00000000E+00	3.14335956E+00	3.35897408E+00	2.91977810E+00	3.34000000E+02
4.00000000E+00	4.11323181E+00	4.33639361E+00	3.86745066E+00	3.50000000E+02
5.00000000E+00	5.03484074E+00	5.40346852E+00	4.77243965E+00	3.43000000E+02
7.50000000E+00	7.71418083E+00	8.26683028E+00	7.26938047E+00	3.48000000E+02
1.00000000E+01	1.01754591E+01	1.08254892E+01	9.60509325E+00	3.63000000E+02
1.50000000E+01	1.54093560E+01	1.63997432E+01	1.44417537E+01	3.78000000E+02
2.00000000E+01	2.01180204E+01	2.13376084E+01	1.87386813E+01	3.34000000E+02
2.50000000E+01	2.59659051E+01	2.74694257E+01	2.43412880E+01	3.76000000E+02
3.50000000E+01	3.50728506E+01	3.74770562E+01	3.30452773E+01	3.38000000E+02
5.00000000E+01	5.13631005E+01	5.45799338E+01	4.84832118E+01	3.65000000E+02
7.50000000E+01	7.39518697E+01	7.93018385E+01	6.94914662E+01	3.52000000E+02
1.00000000E+02	9.95079963E+01	1.06203812E+02	9.34674079E+01	3.65000000E+02
1.50000000E+02	1.50376137E+02	1.59570265E+02	1.40763020E+02	3.37000000E+02
2.00000000E+02	2.01464171E+02	2.12634123E+02	1.90081278E+02	3.80000000E+02
3.00000000E+02	3.04656202E+02	3.23046258E+02	2.86549482E+02	3.60000000E+02
4.00000000E+02	4.02653155E+02	4.29266904E+02	3.76326096E+02	3.58000000E+02
5.00000000E+02	5.09645109E+02	5.46508814E+02	4.74512065E+02	3.42000000E+02
7.50000000E+02	7.67146618E+02	8.15225229E+02	7.25147741E+02	3.68000000E+02
1.00000000E+03	1.02475298E+03	1.09361346E+03	9.62524660E+02	3.65000000E+02

TABLE(3.3)

WIDE ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36816213E+00	2.55548238E+00	2.17664384E+00	3.59000000E+02
3.00000000E+00	3.40120514E+00	3.65578801E+00	3.12070731E+00	3.65000000E+02
4.00000000E+00	4.20129687E+00	4.57414188E+00	3.92109558E+00	3.57000000E+02
5.00000000E+00	4.99396974E+00	5.40408909E+00	4.61384601E+00	3.36000000E+02
7.50000000E+00	7.50600568E+00	8.12727819E+00	6.96049309E+00	4.02000000E+02
1.00000000E+01	1.00642902E+01	1.08717194E+01	9.36312878E+00	3.60000000E+02
1.50000000E+01	1.44404672E+01	1.55358730E+01	1.34116717E+01	3.62000000E+02
2.00000000E+01	1.99548474E+01	2.16461180E+01	1.84673161E+01	3.54000000E+02
2.50000000E+01	2.52146239E+01	2.70240758E+01	2.33507449E+01	3.99000000E+02
3.50000000E+01	3.45358207E+01	3.72069659E+01	3.22789633E+01	3.44000000E+02
5.00000000E+01	5.08967918E+01	5.47343210E+01	4.70868406E+01	3.52000000E+02
7.50000000E+01	7.50989245E+01	8.22860744E+01	6.98302756E+01	3.62000000E+02
1.00000000E+02	9.93161410E+01	1.06231713E+02	9.25023444E+01	3.89000000E+02
1.50000000E+02	1.47331352E+02	1.57088444E+02	1.36887599E+02	3.47000000E+02
2.00000000E+02	2.03204025E+02	2.19569968E+02	1.88050980E+02	3.74000000E+02
3.00000000E+02	3.02238575E+02	3.24358292E+02	2.82326354E+02	3.79000000E+02
4.00000000E+02	3.83989191E+02	4.11103262E+02	3.55186542E+02	3.37000000E+02
5.00000000E+02	4.98222025E+02	5.43019534E+02	4.62979844E+02	3.25000000E+02
7.50000000E+02	7.32878479E+02	8.01353251E+02	6.76216682E+02	3.21000000E+02
1.00000000E+03	9.92074911E+02	1.07606527E+03	9.25104804E+02	3.70000000E+02

TABLE(3.4)

WIDE CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.13206184E+00	2.23381740E+00	2.02987954E+00	3.86000000E+02
3.00000000E+00	3.18414895E+00	3.35848771E+00	2.99941027E+00	3.31000000E+02
4.00000000E+00	4.18061046E+00	4.41853821E+00	3.98675333E+00	3.79000000E+02
5.00000000E+00	5.19808474E+00	5.47874324E+00	4.93218893E+00	3.44000000E+02
7.50000000E+00	7.88891598E+00	8.33965056E+00	7.44772209E+00	3.82000000E+02
1.00000000E+01	1.04449311E+01	1.09752614E+01	9.90095044E+00	3.67000000E+02
1.50000000E+01	1.51252135E+01	1.59666237E+01	1.44384688E+01	3.86000000E+02
2.00000000E+01	2.04064658E+01	2.15495764E+01	1.92478999E+01	3.67000000E+02
2.50000000E+01	2.55213832E+01	2.69256677E+01	2.42946164E+01	3.84000000E+02
3.50000000E+01	3.55528490E+01	3.74934165E+01	3.37254828E+01	3.41000000E+02
5.00000000E+01	5.08628546E+01	5.45141160E+01	4.81127301E+01	3.30000000E+02
7.50000000E+01	7.87435472E+01	8.35115546E+01	7.40958021E+01	3.43000000E+02
1.00000000E+02	1.02412893E+02	1.07688571E+02	9.77445161E+01	3.83000000E+02
1.50000000E+02	1.51128607E+02	1.58877707E+02	1.44270204E+02	3.82000000E+02
2.00000000E+02	2.04487334E+02	2.16933268E+02	1.95123356E+02	3.31000000E+02
3.00000000E+02	3.04848153E+02	3.21204571E+02	2.89570787E+02	3.82000000E+02
4.00000000E+02	3.98841395E+02	4.16446142E+02	3.81000149E+02	4.18000000E+02
5.00000000E+02	5.08989534E+02	5.36431751E+02	4.82279616E+02	3.35000000E+02
7.50000000E+02	7.42167119E+02	7.80436774E+02	7.07169063E+02	3.51000000E+02
1.00000000E+03	9.97471429E+02	1.04177808E+03	9.50764663E+02	4.35000000E+02

TABLE(3.5)

NARROW ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36258352E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14358198E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.94490353E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.82867728E+00	1.04000000E+00	1.95959179E-01	1.00000000E+00	0.00000000E+00
7.42870856E+00	1.25000000E+00	4.33012702E-01	1.06000000E+00	2.37486842E-01
9.86766080E+00	1.56000000E+00	6.52993109E-01	1.27000000E+00	4.43959458E-01
1.51777312E+01	2.25000000E+00	8.87411967E-01	1.85000000E+00	4.55521679E-01
1.93612024E+01	2.68000000E+00	9.88736568E-01	2.21000000E+00	4.95883051E-01
2.54713674E+01	3.09000000E+00	1.12334322E+00	2.69000000E+00	6.88403951E-01
3.49397879E+01	4.87000000E+00	4.02654939E+00	3.77000000E+00	1.05692952E+00
5.03170518E+01	7.23000000E+00	4.85768463E+00	5.59000000E+00	1.87667259E+00
7.50853183E+01	1.01600000E+01	7.81245160E+00	8.27000000E+00	4.34477848E+00
1.00476079E+02	1.54100000E+01	9.78784450E+00	1.24700000E+01	6.39289449E+00
1.45435096E+02	1.92300000E+01	1.00208333E+01	1.60000000E+01	6.12698947E+00
2.02956372E+02	2.47100000E+01	1.01973477E+01	2.11900000E+01	7.85836497E+00
2.96842156E+02	2.95700000E+01	9.25662465E+00	2.62500000E+01	7.12372796E+00
4.05393680E+02	3.29000000E+01	8.91795941E+00	3.02700000E+01	7.41600297E+00
4.91303172E+02	3.35400000E+01	7.68169252E+00	3.13500000E+01	7.07442577E+00
7.55217438E+02	3.57800000E+01	7.30147930E+00	3.31000000E+01	6.72086304E+00
1.00013445E+03	3.62900000E+01	6.35813652E+00	3.48000000E+01	5.34415569E+00

TABLE(3.6)

NARROW ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.25000000E+00	1.00000000E+00	2.00000000E+00	1.06000000E+00	1.00000000E+00	2.00000000E+00
1.56000000E+00	1.00000000E+00	5.00000000E+00	1.27000000E+00	1.00000000E+00	2.00000000E+00
2.25000000E+00	1.00000000E+00	6.00000000E+00	1.85000000E+00	1.00000000E+00	3.00000000E+00
2.68000000E+00	1.00000000E+00	7.00000000E+00	2.21000000E+00	1.00000000E+00	4.00000000E+00
3.09000000E+00	2.00000000E+00	8.00000000E+00	2.69000000E+00	2.00000000E+00	4.00000000E+00
4.87000000E+00	2.00000000E+00	3.80000000E+01	3.77000000E+00	2.00000000E+00	7.00000000E+00
7.23000000E+00	3.00000000E+00	3.10000000E+01	5.59000000E+00	3.00000000E+00	1.50000000E+01
1.01600000E+01	3.00000000E+00	3.90000000E+01	8.27000000E+00	4.00000000E+00	3.20000000E+01
1.54100000E+01	4.00000000E+00	4.60000000E+01	1.24700000E+01	5.00000000E+00	3.30000000E+01
1.92300000E+01	5.00000000E+00	4.30000000E+01	1.60000000E+01	7.00000000E+00	3.20000000E+01
2.47100000E+01	9.00000000E+00	4.40000000E+01	2.11900000E+01	1.00000000E+01	4.10000000E+01
2.95700000E+01	1.30000000E+01	4.70000000E+01	2.62500000E+01	1.20000000E+01	4.10000000E+01
3.29000000E+01	1.60000000E+01	4.70000000E+01	3.02700000E+01	1.80000000E+01	4.50000000E+01
3.35400000E+01	1.80000000E+01	4.50000000E+01	3.13500000E+01	1.80000000E+01	4.50000000E+01
3.57800000E+01	2.10000000E+01	4.80000000E+01	3.31000000E+01	2.00000000E+01	4.80000000E+01
3.62900000E+01	2.20000000E+01	4.90000000E+01	3.48000000E+01	2.10000000E+01	4.70000000E+01

TABLE (3.7)

NARROW CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.23024578E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14335956E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.11323181E+00	1.04000000E+00	1.95959179E-01	1.00000000E+00	0.00000000E+00
5.03484074E+00	1.06000000E+00	2.37486842E-01	1.00000000E+00	0.00000000E+00
7.71418083E+00	1.35000000E+00	4.76969601E-01	1.30000000E+00	4.58257569E-01
1.01754591E+01	1.71000000E+00	6.97065277E-01	1.58000000E+00	4.93558507E-01
1.54093560E+01	2.26000000E+00	5.58927544E-01	2.12000000E+00	3.81575681E-01
2.01180204E+01	2.69000000E+00	9.13181253E-01	2.46000000E+00	5.37028863E-01
2.59659051E+01	3.08000000E+00	1.25443214E+00	2.93000000E+00	8.27707678E-01
3.50728506E+01	4.83000000E+00	4.50789308E+00	3.74000000E+00	1.05470375E+00
5.13631005E+01	6.46000000E+00	5.16414562E+00	5.79000000E+00	1.80163814E+00
7.39518697E+01	8.74000000E+00	6.23477345E+00	8.81000000E+00	4.04646760E+00
9.95079963E+01	1.24000000E+01	7.91833316E+00	1.25000000E+01	5.82837885E+00
1.50376137E+02	1.76400000E+01	8.46583723E+00	1.81700000E+01	7.01862522E+00
2.01464171E+02	2.30800000E+01	8.68525187E+00	2.29100000E+01	7.40553172E+00
3.04656202E+02	2.55900000E+01	8.18913304E+00	2.72100000E+01	6.67876486E+00
4.02653155E+02	3.04900000E+01	8.60638716E+00	3.12700000E+01	6.62095915E+00
5.09645109E+02	3.05600000E+01	6.86049561E+00	3.16700000E+01	6.40789357E+00
7.67146618E+02	3.29400000E+01	6.95675212E+00	3.36400000E+01	6.06715749E+00
1.02475298E+03	3.43400000E+01	5.82789842E+00	3.58200000E+01	5.10955967E+00

TABLE (3.8)

NARROW CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.06000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.35000000E+00	1.00000000E+00	2.00000000E+00	1.30000000E+00	1.00000000E+00	2.00000000E+00
1.71000000E+00	1.00000000E+00	5.00000000E+00	1.58000000E+00	1.00000000E+00	2.00000000E+00
2.26000000E+00	1.00000000E+00	5.00000000E+00	2.12000000E+00	1.00000000E+00	3.00000000E+00
2.69000000E+00	1.00000000E+00	6.00000000E+00	2.46000000E+00	2.00000000E+00	4.00000000E+00
3.08000000E+00	2.00000000E+00	9.00000000E+00	2.93000000E+00	2.00000000E+00	5.00000000E+00
4.83000000E+00	2.00000000E+00	3.50000000E+01	3.74000000E+00	2.00000000E+00	7.00000000E+00
6.46000000E+00	3.00000000E+00	3.50000000E+01	5.79000000E+00	3.00000000E+00	1.20000000E+01
8.74000000E+00	3.00000000E+00	3.90000000E+01	8.81000000E+00	4.00000000E+00	2.50000000E+01
1.24000000E+01	4.00000000E+00	4.00000000E+01	1.25000000E+01	5.00000000E+00	3.50000000E+01
1.76400000E+01	4.00000000E+00	3.90000000E+01	1.81700000E+01	7.00000000E+00	3.70000000E+01
2.30800000E+01	9.00000000E+00	4.30000000E+01	2.29100000E+01	1.30000000E+01	4.10000000E+01
2.55900000E+01	1.30000000E+01	4.50000000E+01	2.72100000E+01	1.50000000E+01	4.30000000E+01
3.04900000E+01	1.40000000E+01	4.60000000E+01	3.12700000E+01	1.50000000E+01	4.30000000E+01
3.05600000E+01	1.60000000E+01	4.50000000E+01	3.16700000E+01	1.90000000E+01	4.50000000E+01
3.29400000E+01	2.00000000E+01	4.80000000E+01	3.36400000E+01	2.10000000E+01	4.80000000E+01
3.43400000E+01	2.10000000E+01	4.80000000E+01	3.58200000E+01	2.30000000E+01	4.60000000E+01

TABLE(3.9)

WIDE ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36816213E+00	1.21000000E+00	6.37102817E-01	1.02000000E+00	1.40000000E-01
3.40120514E+00	1.53000000E+00	6.55057249E-01	1.31000000E+00	5.60267793E-01
4.20129687E+00	1.84000000E+00	8.56971411E-01	1.43000000E+00	6.20564259E-01
4.99396974E+00	2.15000000E+00	1.22780292E+00	1.77000000E+00	7.72722460E-01
7.50600568E+00	2.78000000E+00	1.17115328E+00	2.38000000E+00	8.34026378E-01
1.00642902E+01	3.06000000E+00	1.05659832E+00	2.87000000E+00	9.34398202E-01
1.44404672E+01	4.23000000E+00	2.24434846E+00	3.62000000E+00	1.38405202E+00
1.99548474E+01	4.51000000E+00	1.85199892E+00	4.15000000E+00	1.63324830E+00
2.52146239E+01	5.48000000E+00	2.71470072E+00	5.06000000E+00	2.17632718E+00
3.45358207E+01	8.64000000E+00	4.83015528E+00	7.57000000E+00	3.71552150E+00
5.08967918E+01	1.29200000E+01	6.62371497E+00	1.20900000E+01	5.42235189E+00
7.50989245E+01	1.72600000E+01	8.79502132E+00	1.57500000E+01	5.88960949E+00
9.93161410E+01	2.07400000E+01	9.50433585E+00	1.82000000E+01	6.08440630E+00
1.47331352E+02	2.64800000E+01	9.97845679E+00	2.42400000E+01	8.03756182E+00
2.03204025E+02	3.07300000E+01	1.07087394E+01	2.79200000E+01	9.01518719E+00
3.02238575E+02	3.74400000E+01	1.02032544E+01	3.47700000E+01	8.92396212E+00
3.83989191E+02	3.81900000E+01	9.57673744E+00	3.53900000E+01	8.78054099E+00
4.98222025E+02	4.33100000E+01	8.90134260E+00	4.11700000E+01	8.73390520E+00
7.32878479E+02	4.69000000E+01	8.52818855E+00	4.57600000E+01	8.45472649E+00
9.92074911E+02	4.84800000E+01	7.78136235E+00	4.80400000E+01	8.10298710E+00

TABLE(3.10)

WIDE ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.21000000E+00	1.00000000E+00	6.00000000E+00	1.02000000E+00	1.00000000E+00	2.00000000E+00
1.53000000E+00	1.00000000E+00	4.00000000E+00	1.31000000E+00	1.00000000E+00	3.00000000E+00
1.84000000E+00	1.00000000E+00	5.00000000E+00	1.43000000E+00	1.00000000E+00	3.00000000E+00
2.15000000E+00	1.00000000E+00	1.10000000E+01	1.77000000E+00	1.00000000E+00	5.00000000E+00
2.78000000E+00	1.00000000E+00	9.00000000E+00	2.38000000E+00	1.00000000E+00	5.00000000E+00
3.06000000E+00	2.00000000E+00	7.00000000E+00	2.87000000E+00	1.00000000E+00	6.00000000E+00
4.23000000E+00	2.00000000E+00	1.70000000E+01	3.62000000E+00	2.00000000E+00	9.00000000E+00
4.51000000E+00	2.00000000E+00	1.60000000E+01	4.15000000E+00	2.00000000E+00	1.30000000E+01
5.48000000E+00	2.00000000E+00	1.90000000E+01	5.06000000E+00	2.00000000E+00	1.40000000E+01
8.64000000E+00	3.00000000E+00	3.30000000E+01	7.57000000E+00	3.00000000E+00	1.90000000E+01
1.29200000E+01	4.00000000E+00	3.40000000E+01	1.20900000E+01	4.00000000E+00	2.70000000E+01
1.72600000E+01	5.00000000E+00	4.70000000E+01	1.57500000E+01	5.00000000E+00	3.10000000E+01
2.07400000E+01	6.00000000E+00	5.30000000E+01	1.82000000E+01	7.00000000E+00	3.10000000E+01
2.64800000E+01	1.00000000E+01	5.20000000E+01	2.42400000E+01	9.00000000E+00	4.50000000E+01
3.07300000E+01	1.30000000E+01	6.20000000E+01	2.79200000E+01	1.30000000E+01	4.60000000E+01
3.74400000E+01	1.50000000E+01	5.70000000E+01	3.47700000E+01	1.90000000E+01	5.50000000E+01
3.81900000E+01	1.60000000E+01	5.90000000E+01	3.53900000E+01	1.70000000E+01	5.50000000E+01
4.33100000E+01	2.20000000E+01	5.70000000E+01	4.11700000E+01	2.40000000E+01	5.60000000E+01
4.69000000E+01	2.80000000E+01	6.60000000E+01	4.57600000E+01	2.70000000E+01	6.40000000E+01
4.84800000E+01	2.90000000E+01	6.30000000E+01	4.80400000E+01	3.10000000E+01	6.80000000E+01

TABLE(3.11)

WIDE CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.13206184E+00	1.03000000E+00	2.21585198E-01	1.00000000E+00	0.00000000E+00
3.18414895E+00	1.63000000E+00	8.08146026E-01	1.22000000E+00	4.37721373E-01
4.18061046E+00	1.92000000E+00	8.68101377E-01	1.67000000E+00	5.30188646E-01
5.19808474E+00	2.41000000E+00	1.07791465E+00	2.04000000E+00	5.81721583E-01
7.88891598E+00	3.21000000E+00	1.91465402E+00	2.58000000E+00	6.66033032E-01
1.04449311E+01	3.51000000E+00	1.24494980E+00	2.99000000E+00	7.80960947E-01
1.51252135E+01	4.02000000E+00	2.28901726E+00	3.41000000E+00	1.12334322E+00
2.04064658E+01	5.27000000E+00	2.97272602E+00	4.28000000E+00	1.53674982E+00
2.55213832E+01	6.01000000E+00	3.70808576E+00	5.23000000E+00	2.18565780E+00
3.55528490E+01	8.33000000E+00	4.87248397E+00	7.59000000E+00	3.46726117E+00
5.08628546E+01	1.16100000E+01	5.79809451E+00	1.13900000E+01	4.23295405E+00
7.87435472E+01	1.57800000E+01	6.42585403E+00	1.53200000E+01	5.22088115E+00
1.02412893E+02	1.91400000E+01	6.56356610E+00	1.85500000E+01	4.85875498E+00
1.51128607E+02	2.57900000E+01	9.63980809E+00	2.48700000E+01	6.64477991E+00
2.04487334E+02	2.91500000E+01	8.30346313E+00	2.75000000E+01	6.40078120E+00
3.04848153E+02	3.46400000E+01	7.82370756E+00	3.49500000E+01	7.18383602E+00
3.98841395E+02	3.68900000E+01	8.33534042E+00	3.68100000E+01	7.51757275E+00
5.08989534E+02	4.14900000E+01	7.14212153E+00	4.19700000E+01	7.40871784E+00
7.42167119E+02	4.41900000E+01	8.04946582E+00	4.48900000E+01	6.84528305E+00
9.97471429E+02	4.78800000E+01	6.97463978E+00	4.87500000E+01	6.51363954E+00

TABLE(3.12)

WIDE CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.03000000E+00	1.00000000E+00	3.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.63000000E+00	1.00000000E+00	5.00000000E+00	1.22000000E+00	1.00000000E+00	3.00000000E+00
1.92000000E+00	1.00000000E+00	5.00000000E+00	1.67000000E+00	1.00000000E+00	3.00000000E+00
2.41000000E+00	1.00000000E+00	9.00000000E+00	2.04000000E+00	1.00000000E+00	4.00000000E+00
3.21000000E+00	2.00000000E+00	1.80000000E+01	2.58000000E+00	2.00000000E+00	5.00000000E+00
3.51000000E+00	2.00000000E+00	7.00000000E+00	2.99000000E+00	2.00000000E+00	5.00000000E+00
4.02000000E+00	2.00000000E+00	1.50000000E+01	3.41000000E+00	2.00000000E+00	9.00000000E+00
5.27000000E+00	2.00000000E+00	1.80000000E+01	4.28000000E+00	2.00000000E+00	1.10000000E+01
6.01000000E+00	3.00000000E+00	2.30000000E+01	5.23000000E+00	3.00000000E+00	1.30000000E+01
8.33000000E+00	3.00000000E+00	2.90000000E+01	7.59000000E+00	3.00000000E+00	1.80000000E+01
1.16100000E+01	4.00000000E+00	3.20000000E+01	1.13900000E+01	4.00000000E+00	2.20000000E+01
1.57800000E+01	4.00000000E+00	3.50000000E+01	1.53200000E+01	5.00000000E+00	2.80000000E+01
1.91400000E+01	7.00000000E+00	3.40000000E+01	1.85500000E+01	8.00000000E+00	3.10000000E+01
2.57900000E+01	1.20000000E+01	5.30000000E+01	2.48700000E+01	1.40000000E+01	4.20000000E+01
2.91500000E+01	1.30000000E+01	5.10000000E+01	2.75000000E+01	1.60000000E+01	4.40000000E+01
3.46400000E+01	1.70000000E+01	5.30000000E+01	3.49500000E+01	1.90000000E+01	5.00000000E+01
3.68900000E+01	2.00000000E+01	5.60000000E+01	3.68100000E+01	2.10000000E+01	5.10000000E+01
4.14900000E+01	2.70000000E+01	5.80000000E+01	4.19700000E+01	2.70000000E+01	5.50000000E+01
4.41900000E+01	2.50000000E+01	6.20000000E+01	4.48900000E+01	2.90000000E+01	6.20000000E+01
4.78800000E+01	3.30000000E+01	6.10000000E+01	4.87500000E+01	3.50000000E+01	6.20000000E+01

TABLE(3.13)

NARROW ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36258352E+00	6.48431428E-01	9.85604950E-02	6.17718987E-01	9.20716948E-02
3.14358198E+00	6.38055439E-01	9.97898310E-02	5.97672688E-01	9.03616975E-02
3.94490353E+00	6.56774790E-01	9.41808566E-02	6.23142476E-01	8.55357715E-02
4.82867728E+00	6.61453871E-01	9.31952699E-02	6.22862967E-01	8.50062707E-02
7.42870856E+00	6.93843885E-01	1.04839078E-01	6.55267416E-01	9.48784763E-02
9.86766080E+00	7.24736091E-01	1.11690310E-01	6.90656302E-01	1.01087675E-01
1.51777312E+01	7.80470332E-01	9.49110432E-02	7.49918414E-01	9.10927928E-02
1.93612024E+01	7.89507109E-01	1.01846370E-01	7.68066238E-01	9.20432738E-02
2.54713674E+01	8.15139555E-01	8.81207306E-02	7.95031205E-01	8.25555992E-02
3.49397879E+01	8.73067571E-01	8.57269214E-02	8.50846613E-01	7.98842158E-02
5.03170518E+01	9.00703472E-01	7.95063512E-02	8.87029283E-01	7.22714939E-02
7.50853183E+01	9.32011069E-01	6.81638649E-02	9.13451779E-01	6.95663164E-02
1.00476079E+02	9.58778532E-01	4.64932203E-02	9.48834448E-01	4.27363666E-02
1.45435096E+02	9.69811819E-01	4.26578934E-02	9.63850772E-01	3.93117880E-02
2.02956372E+02	9.83077162E-01	3.29580983E-02	9.75507461E-01	2.92396860E-02
2.96842156E+02	9.88844980E-01	3.06910825E-02	9.83908163E-01	3.37774854E-02
4.05393680E+02	9.97469940E-01	2.35720252E-02	9.89444592E-01	2.59739329E-02
4.91303172E+02	9.98569493E-01	2.55018788E-02	9.89154049E-01	2.82048385E-02
7.55217438E+02	1.00299081E+00	2.57971627E-02	9.88534954E-01	2.93574365E-02
1.00013445E+03	1.00556009E+00	3.20541570E-02	9.93116480E-01	3.73358384E-02

TABLE(3.14)

NARROW ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
6.48431428E-01	4.01992749E-01	8.68978842E-01	6.17718987E-01	3.71611141E-01	8.24138405E-01
6.38055439E-01	4.44664657E-01	8.37645977E-01	5.97672688E-01	3.96790844E-01	7.99140304E-01
6.56774790E-01	4.56286419E-01	8.66902982E-01	6.23142476E-01	3.93212356E-01	7.98804217E-01
6.61453871E-01	4.40917238E-01	9.08353957E-01	6.22862967E-01	4.34216547E-01	8.30902210E-01
6.93843885E-01	4.58338798E-01	9.12662648E-01	6.55267416E-01	4.36256611E-01	8.42330185E-01
7.24736091E-01	5.05944366E-01	9.59926459E-01	6.90656302E-01	4.47705304E-01	9.09306858E-01
7.80470332E-01	5.80358310E-01	9.67943503E-01	7.49918414E-01	5.69085586E-01	9.60562481E-01
7.89507109E-01	4.86340000E-01	9.70856607E-01	7.68066238E-01	4.94425010E-01	9.45956207E-01
8.15139555E-01	6.04033529E-01	1.00017942E+00	7.95031205E-01	5.82367576E-01	9.50966506E-01
8.73067571E-01	5.49459739E-01	1.00111374E+00	8.50846613E-01	5.39663992E-01	9.69390025E-01
9.00703472E-01	6.33717881E-01	1.01723515E+00	8.87029283E-01	6.48110513E-01	9.95503365E-01
9.32011069E-01	6.46935347E-01	1.03210953E+00	9.13451779E-01	6.30773244E-01	1.00135772E+00
9.58778532E-01	8.17916601E-01	1.00744566E+00	9.48834448E-01	8.20890623E-01	1.00168584E+00
9.69811819E-01	8.42911980E-01	1.01723310E+00	9.63850772E-01	8.25953319E-01	1.00328828E+00
9.83077162E-01	8.34147683E-01	1.04292529E+00	9.75507461E-01	8.80146783E-01	1.00444999E+00
9.88844980E-01	8.31470838E-01	1.01695975E+00	9.83908163E-01	7.99057438E-01	1.00655763E+00
9.97469940E-01	8.55491038E-01	1.01722302E+00	9.89444592E-01	8.93897139E-01	1.01089143E+00
9.98569493E-01	8.55237681E-01	1.02474518E+00	9.89154049E-01	8.91840443E-01	1.01363290E+00
1.00299081E+00	9.14963941E-01	1.07456488E+00	9.88534954E-01	8.93728910E-01	1.01608802E+00
1.00556009E+00	8.32423908E-01	1.03756646E+00	9.93116480E-01	7.57607086E-01	1.02089100E+00

TABLE (3.15)

NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.23024578E+00	7.58474963E-01	6.44554686E-02	7.19748545E-01	5.69264648E-02
3.14335956E+00	7.37248215E-01	7.21155848E-02	7.07372568E-01	6.47200758E-02
4.11323181E+00	7.35409610E-01	7.35089494E-02	7.10248365E-01	6.64098950E-02
5.03484074E+00	7.46664917E-01	7.37153577E-02	7.16475567E-01	6.48706901E-02
7.71418083E+00	7.71740578E-01	8.76457547E-02	7.41321879E-01	7.98498020E-02
1.01754591E+01	7.93205125E-01	7.28851466E-02	7.68911818E-01	6.68154636E-02
1.54093560E+01	8.18258408E-01	7.17756463E-02	8.04213514E-01	7.10894129E-02
2.01180204E+01	8.27310357E-01	8.40750411E-02	8.20619237E-01	7.25058899E-02
2.59659051E+01	8.47303465E-01	7.11318514E-02	8.41025418E-01	6.26681535E-02
3.50728506E+01	8.79990364E-01	7.35795704E-02	8.77708174E-01	5.98826873E-02
5.13631005E+01	9.13908796E-01	6.20901624E-02	9.12799101E-01	5.27091872E-02
7.39518697E+01	9.31531373E-01	6.00836907E-02	9.35902406E-01	5.41321155E-02
9.95079963E+01	9.61820786E-01	4.78701801E-02	9.62675989E-01	3.60892614E-02
1.50376137E+02	9.73076603E-01	3.69702215E-02	9.76273401E-01	2.84190281E-02
2.01464171E+02	9.83879346E-01	2.72351151E-02	9.87011492E-01	1.91236392E-02
3.04656202E+02	9.83222848E-01	3.24984469E-02	9.90622659E-01	2.00654810E-02
4.02653155E+02	9.92757127E-01	2.51113118E-02	9.95320119E-01	1.85364410E-02
5.09645109E+02	9.92913735E-01	2.60808310E-02	9.92514374E-01	2.20456879E-02
7.67146618E+02	9.88358199E-01	3.62381541E-02	9.91690382E-01	2.80043571E-02
1.02475298E+03	9.93692755E-01	3.26732101E-02	9.97884463E-01	2.76726985E-02

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OF POOR QUALITY

TABLE (3.16)

NARROW CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2zex
7.58474963E-01	5.71290531E-01	8.84296248E-01	7.19748545E-01	5.64783730E-01	8.36933081E-01
7.37248215E-01	5.81248553E-01	8.86152712E-01	7.07372568E-01	5.52922395E-01	8.49538707E-01
7.35409610E-01	5.29466815E-01	9.10080005E-01	7.10248365E-01	5.22759177E-01	8.62443097E-01
7.46664917E-01	5.15873572E-01	8.97973880E-01	7.16475567E-01	5.28814620E-01	8.52532506E-01
7.71740578E-01	4.47791391E-01	9.34025737E-01	7.41321879E-01	4.66211060E-01	9.00545986E-01
7.93205125E-01	6.29472545E-01	9.55593127E-01	7.68911818E-01	6.22076666E-01	9.06547172E-01
8.18258408E-01	6.34494050E-01	9.40062167E-01	8.04213514E-01	6.19763724E-01	9.30234916E-01
8.27310357E-01	6.01083269E-01	9.81476462E-01	8.20619237E-01	5.78079462E-01	9.38355611E-01
8.47303465E-01	6.76362418E-01	9.83787207E-01	8.41025418E-01	6.70575476E-01	9.83467855E-01
8.79990364E-01	6.52325148E-01	1.00297622E+00	8.77708174E-01	7.13568460E-01	9.80870702E-01
9.13908796E-01	7.23472647E-01	1.00442934E+00	9.12799101E-01	7.77332811E-01	9.97431484E-01
9.31531373E-01	7.20637152E-01	1.02249630E+00	9.35902406E-01	6.92745242E-01	1.00917269E+00
9.61820786E-01	7.80134876E-01	1.12916139E+00	9.62675989E-01	8.33187818E-01	1.00161462E+00
9.73076603E-01	8.51406081E-01	1.07897484E+00	9.76273401E-01	8.73290848E-01	1.00365614E+00
9.83879346E-01	8.84565710E-01	1.01199338E+00	9.87011492E-01	9.20401007E-01	1.00519985E+00
9.83222848E-01	8.33928476E-01	1.01310052E+00	9.90622659E-01	9.03490986E-01	1.00655498E+00
9.92757127E-01	8.85490982E-01	1.01672544E+00	9.95320119E-01	8.99509102E-01	1.01072659E+00
9.92913735E-01	8.98236420E-01	1.02354407E+00	9.92514374E-01	9.00508761E-01	1.01138588E+00
9.88358199E-01	8.71885576E-01	1.04416142E+00	9.91690382E-01	8.75193826E-01	1.01568970E+00
9.93692755E-01	8.35501398E-01	1.03682992E+00	9.97884463E-01	8.09957283E-01	1.02009220E+00

TABLE(3.17)

WIDE ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36816213E+00	5.19821090E-01	1.22819339E-01	4.30905604E-01	9.70108443E-02
3.40120514E+00	4.55128022E-01	1.09651611E-01	4.03660978E-01	9.88310765E-02
4.20129687E+00	4.99806012E-01	1.19401779E-01	4.48713302E-01	1.09256801E-01
4.99396974E+00	4.65929130E-01	1.13339270E-01	4.23835130E-01	1.03895242E-01
7.50600568E+00	4.88475174E-01	1.23344192E-01	4.60558008E-01	1.11899382E-01
1.00642902E+01	5.10183922E-01	1.28627118E-01	4.77897232E-01	1.19326140E-01
1.44404672E+01	5.53274487E-01	1.34243228E-01	5.17988495E-01	1.24724237E-01
1.99548474E+01	5.49957985E-01	1.22262188E-01	5.15861560E-01	1.21137226E-01
2.52146239E+01	5.65936169E-01	1.25530108E-01	5.37169499E-01	1.14380870E-01
3.45358207E+01	5.63868812E-01	1.24725999E-01	5.36731180E-01	1.17603349E-01
5.08967918E+01	6.06027792E-01	1.21431599E-01	5.75644665E-01	1.15754892E-01
7.50989245E+01	6.41480592E-01	9.44181861E-02	6.08839005E-01	9.75475606E-02
9.93161410E+01	6.21530116E-01	1.21241616E-01	5.85390077E-01	1.11521693E-01
1.47331352E+02	6.56646659E-01	1.13445993E-01	6.20986956E-01	1.12768510E-01
2.03204025E+02	6.45826927E-01	1.20682347E-01	6.09438252E-01	1.21203491E-01
3.02238575E+02	6.97557815E-01	1.13451396E-01	6.55725494E-01	1.07717496E-01
3.83989191E+02	6.84490784E-01	1.25727475E-01	6.36587392E-01	1.19070158E-01
4.98222025E+02	7.15527186E-01	1.13442459E-01	6.71649213E-01	1.03343890E-01
7.32878479E+02	7.28377252E-01	1.05927751E-01	6.62869555E-01	9.59904194E-02
9.92074911E+02	7.71162297E-01	1.04925560E-01	7.05080298E-01	9.73037133E-02

TABLE(3.18)

WIDE ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
5.19821090E-01	2.60724081E-01	8.43817983E-01	4.30905604E-01	2.17935436E-01	7.09156018E-01
4.55128022E-01	2.33129555E-01	6.95300418E-01	4.03660978E-01	2.05570578E-01	6.40439528E-01
4.99806012E-01	1.93110334E-01	7.55195578E-01	4.48713302E-01	1.99902246E-01	6.99980016E-01
4.65929130E-01	2.31049749E-01	8.31421561E-01	4.23835130E-01	1.98441710E-01	7.54390688E-01
4.88475174E-01	2.52871472E-01	8.22235664E-01	4.60558008E-01	2.54945514E-01	7.43795414E-01
5.10183922E-01	2.15005539E-01	8.13631402E-01	4.77897232E-01	1.78788511E-01	7.92578467E-01
5.53274487E-01	2.51350011E-01	8.89546282E-01	5.17988495E-01	2.41160522E-01	8.31403258E-01
5.49957985E-01	3.01795708E-01	8.77880292E-01	5.15861560E-01	2.75461128E-01	8.66652893E-01
5.65936169E-01	2.88770452E-01	8.87043095E-01	5.37169499E-01	2.44358688E-01	7.76753727E-01
5.63868812E-01	2.81025589E-01	8.76694579E-01	5.36731180E-01	2.78510448E-01	8.40167829E-01
6.06027792E-01	2.90432758E-01	8.50554458E-01	5.75644665E-01	2.62394140E-01	8.51510677E-01
6.41480592E-01	4.02802593E-01	8.76327772E-01	6.08839005E-01	3.82687020E-01	8.71123736E-01
6.21530116E-01	3.37704568E-01	8.97940702E-01	5.85390077E-01	3.44602445E-01	9.08407918E-01
6.56646659E-01	3.52142825E-01	9.10550228E-01	6.20986956E-01	3.55381981E-01	8.53500319E-01
6.45826927E-01	3.87312159E-01	9.12792388E-01	6.09438252E-01	3.40932328E-01	8.30631427E-01
6.97557815E-01	3.99354309E-01	9.51796359E-01	6.55725494E-01	3.78966095E-01	9.25721084E-01
6.84490784E-01	3.69652951E-01	9.79730991E-01	6.36587392E-01	3.10461327E-01	8.78693556E-01
7.15527186E-01	3.27734075E-01	9.31350358E-01	6.71649213E-01	3.02761908E-01	9.03945831E-01
7.28377252E-01	4.83927810E-01	9.43129260E-01	6.62869555E-01	4.46413333E-01	8.48478957E-01
7.71162297E-01	5.46551811E-01	1.01461835E+00	7.05080298E-01	4.64254389E-01	9.13079331E-01

TABLE(3.19)

WIDE CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.13206184E+00	6.98751637E-01	5.99815580E-02	6.47762944E-01	5.44761710E-02
3.18414895E+00	6.79395871E-01	7.19145191E-02	6.34580955E-01	5.81105798E-02
4.18061046E+00	7.01493410E-01	7.15378879E-02	6.46360728E-01	6.11609091E-02
5.19808474E+00	6.70713256E-01	7.88165501E-02	6.26677262E-01	6.73282308E-02
7.88891598E+00	6.77408991E-01	7.92314955E-02	6.37512368E-01	6.85029659E-02
1.04449311E+01	6.83105540E-01	8.10673379E-02	6.43811518E-01	6.62272872E-02
1.51252135E+01	6.74160165E-01	9.04582642E-02	6.39940160E-01	8.38108146E-02
2.04064658E+01	6.78937359E-01	8.84491436E-02	6.42591779E-01	7.91543861E-02
2.55213832E+01	6.89491038E-01	8.19022419E-02	6.59234277E-01	7.27887240E-02
3.55528490E+01	6.85264984E-01	8.07276546E-02	6.60350692E-01	7.16255996E-02
5.08628546E+01	6.97616178E-01	7.97104636E-02	6.78644404E-01	7.28990701E-02
7.87435472E+01	7.15522128E-01	7.86212652E-02	6.87277369E-01	7.42604343E-02
1.02412893E+02	7.20929319E-01	8.01560418E-02	6.97729418E-01	6.96241589E-02
1.51128607E+02	7.23013458E-01	7.59111620E-02	6.97667280E-01	6.84176858E-02
2.04487334E+02	7.39749067E-01	7.78999826E-02	7.16999781E-01	6.83230180E-02
3.04848153E+02	7.49986505E-01	7.99724289E-02	7.22697712E-01	7.22387189E-02
3.98841395E+02	7.34403753E-01	7.59609120E-02	7.16420766E-01	6.69612725E-02
5.08989534E+02	7.43853651E-01	8.39828936E-02	7.25201136E-01	7.76289554E-02
7.42167119E+02	7.58998842E-01	7.64406835E-02	7.36913693E-01	6.75924825E-02
9.97471429E+02	7.85636009E-01	7.60800393E-02	7.61227365E-01	6.78416665E-02

TABLE(3.20)

WIDE CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
6.98751637E-01	5.34751980E-01	8.49845452E-01	6.47762944E-01	4.99990263E-01	7.82622786E-01
6.79395871E-01	4.80106270E-01	8.01658901E-01	6.34580955E-01	4.46477357E-01	7.48461999E-01
7.01493410E-01	5.10211082E-01	8.72518719E-01	6.46360728E-01	5.24927922E-01	7.87624346E-01
6.70713256E-01	5.07993153E-01	8.36501618E-01	6.26677262E-01	4.79732337E-01	7.77146934E-01
6.77408991E-01	4.42785337E-01	8.58246746E-01	6.37512368E-01	4.42975576E-01	8.05625955E-01
6.83105540E-01	4.55017957E-01	8.73897812E-01	6.43811518E-01	4.22917020E-01	7.58075372E-01
6.74160165E-01	4.64643109E-01	8.92393430E-01	6.39940160E-01	4.41951590E-01	8.31741026E-01
6.78937359E-01	4.85904558E-01	8.57240567E-01	6.42591779E-01	4.74718332E-01	8.07927767E-01
6.89491038E-01	5.05149022E-01	8.99530754E-01	6.59234277E-01	4.49815369E-01	8.09165249E-01
6.85264984E-01	4.79697267E-01	9.06559515E-01	6.60350692E-01	4.56348882E-01	8.41671157E-01
6.97616178E-01	5.15772598E-01	8.77530587E-01	6.78644404E-01	5.19798444E-01	8.37428066E-01
7.15522128E-01	5.12966459E-01	9.32040660E-01	6.87277369E-01	4.84708451E-01	8.67893149E-01
7.20929319E-01	4.52280215E-01	9.15957404E-01	6.97729418E-01	4.98810441E-01	8.99001957E-01
7.23013458E-01	5.47127532E-01	9.41739053E-01	6.97667280E-01	5.36946528E-01	8.78914358E-01
7.39749067E-01	5.59383390E-01	9.47621211E-01	7.16999781E-01	5.46193015E-01	8.91837968E-01
7.49986505E-01	5.60293589E-01	9.28030440E-01	7.22697712E-01	5.72974085E-01	8.76267867E-01
7.34403753E-01	5.49302915E-01	8.93610148E-01	7.16420766E-01	5.65100996E-01	8.53673544E-01
7.43853651E-01	4.89567159E-01	9.26492561E-01	7.25201136E-01	5.10101356E-01	8.79246567E-01
7.58998842E-01	5.98295554E-01	9.38681239E-01	7.36913693E-01	5.75203559E-01	9.17446344E-01
7.85636009E-01	5.47206352E-01	9.32483358E-01	7.61227365E-01	5.88389993E-01	9.17803745E-01

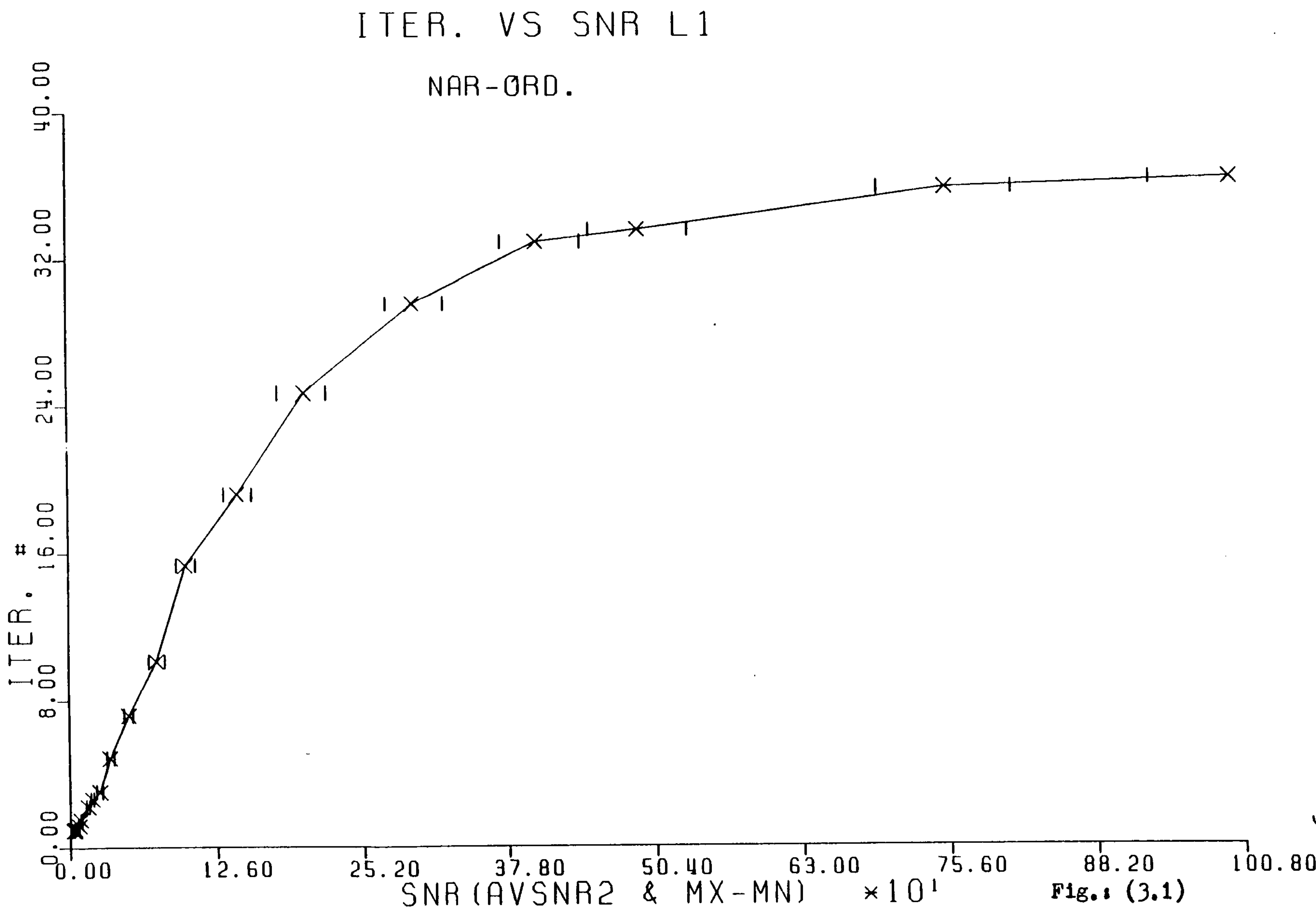
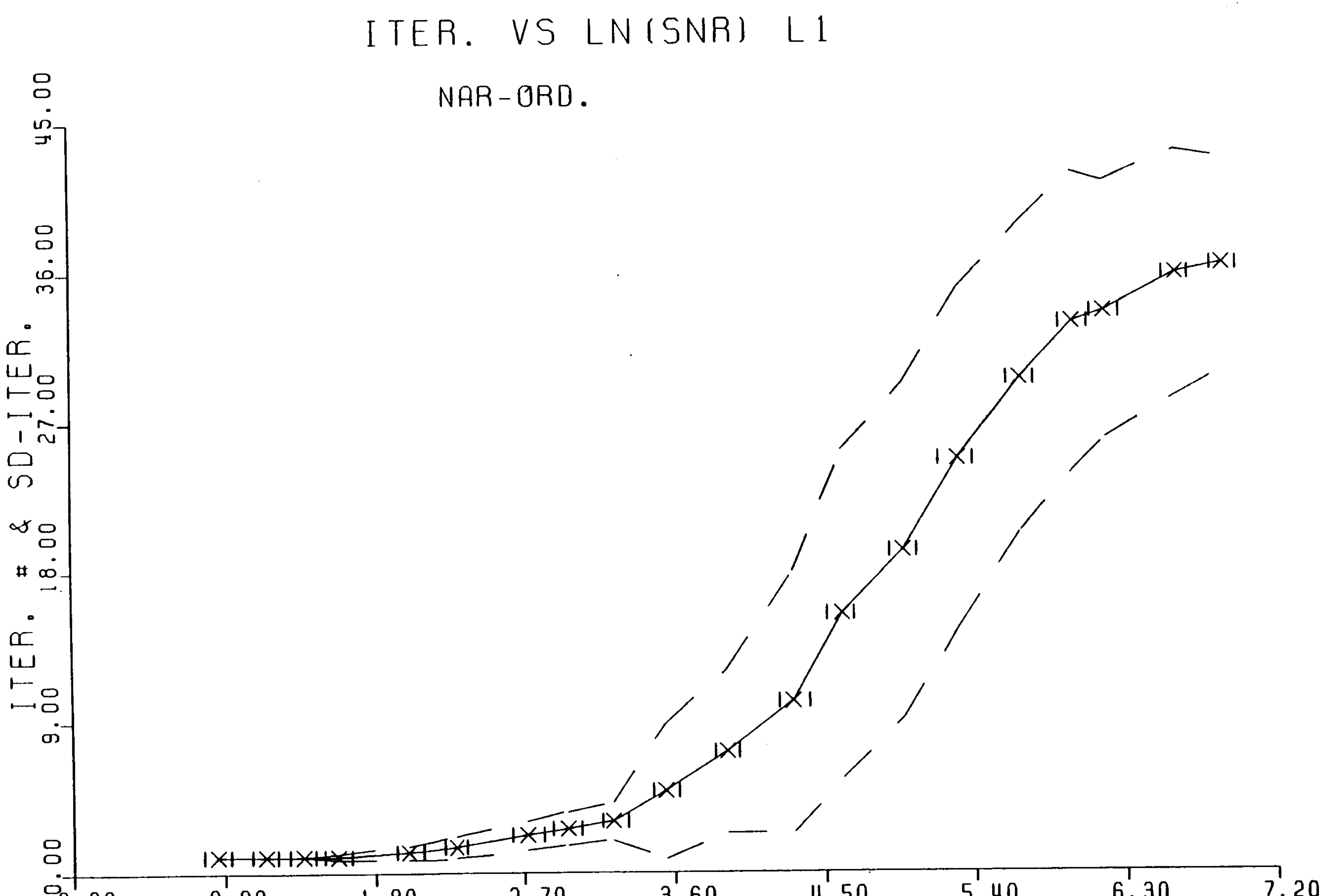

ITER. VS SNR L1
NAR-ØRD.
ITER. #
0.00
8.00
16.00
24.00
32.00
40.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (3.1)


ITER. VS LN(SNR) L1
NAR-ØRD.
ITER. # & SD-ITER.
0.00
9.00
18.00
27.00
36.00
45.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)
Fig.: (3.2)

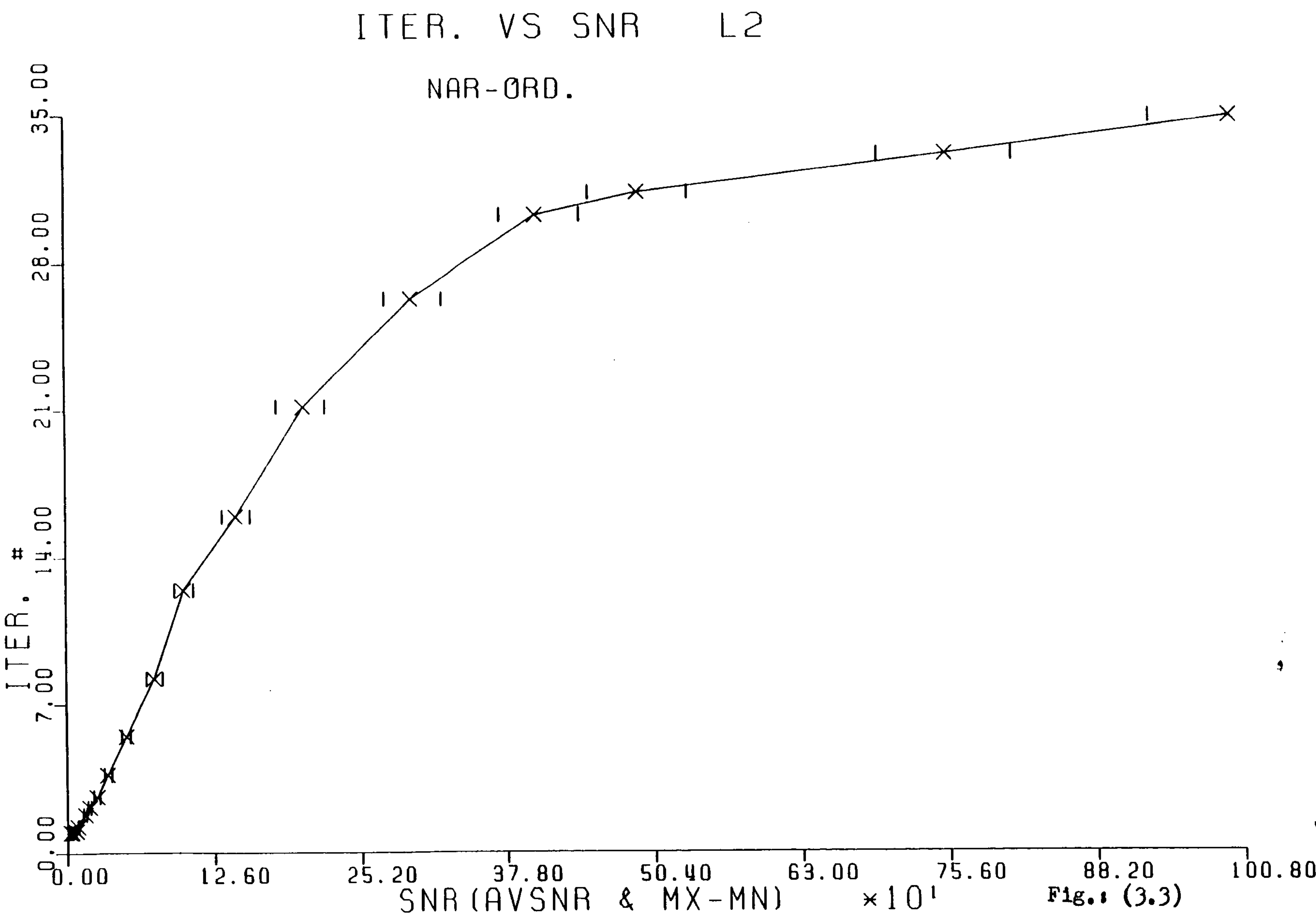

ITER. VS SNR L2
NAR-ØRD.
ITER. #
35.00
28.00
21.00
14.00
7.00
0.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR & MX-MN) $\times 10^1$

Fig.: (3.3)

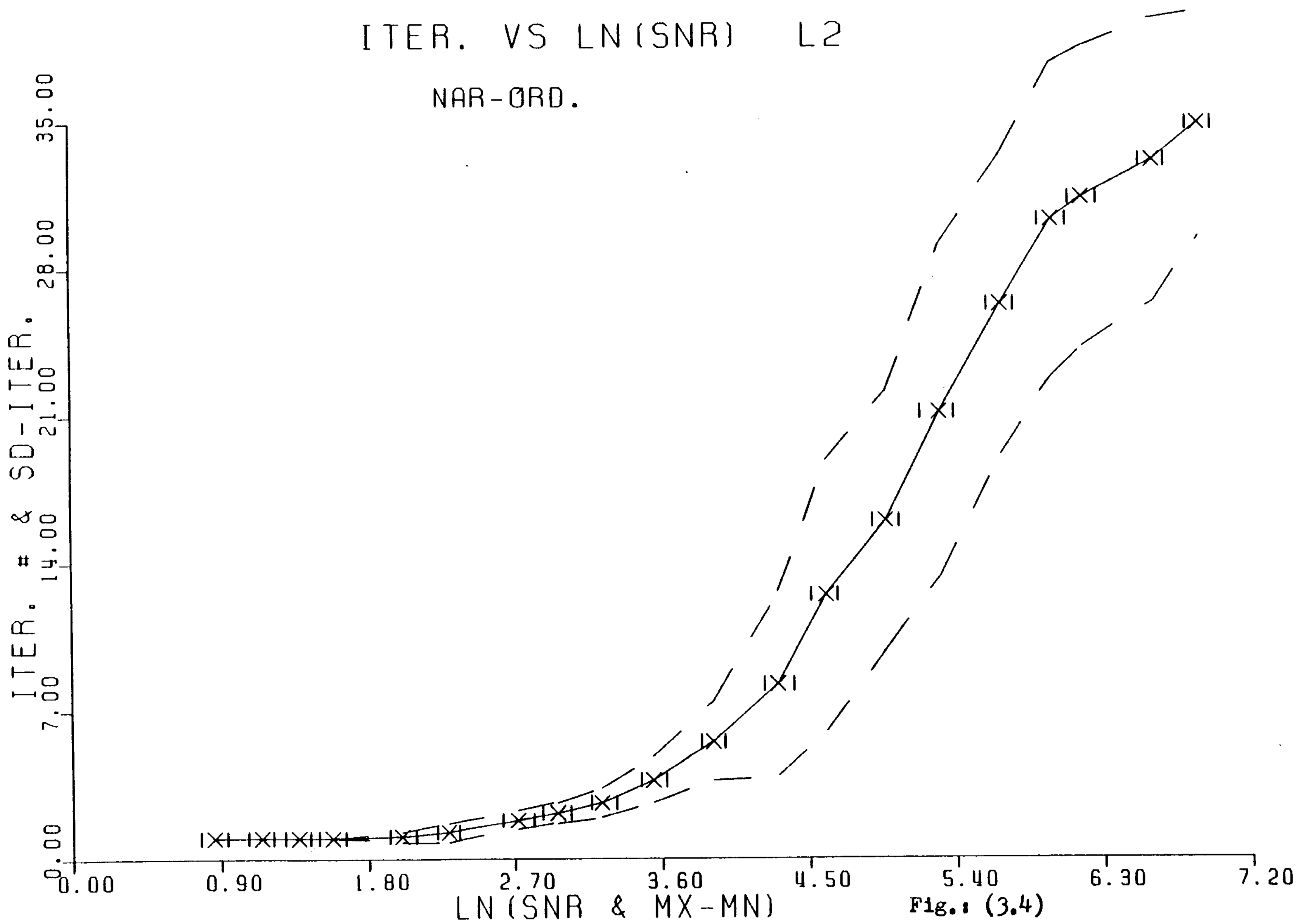

ITER. VS LN(SNR) L2
NAR-ØRD.
ITER. # & SD-ITER.
0.00
7.00
14.00
21.00
28.00
35.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.4)

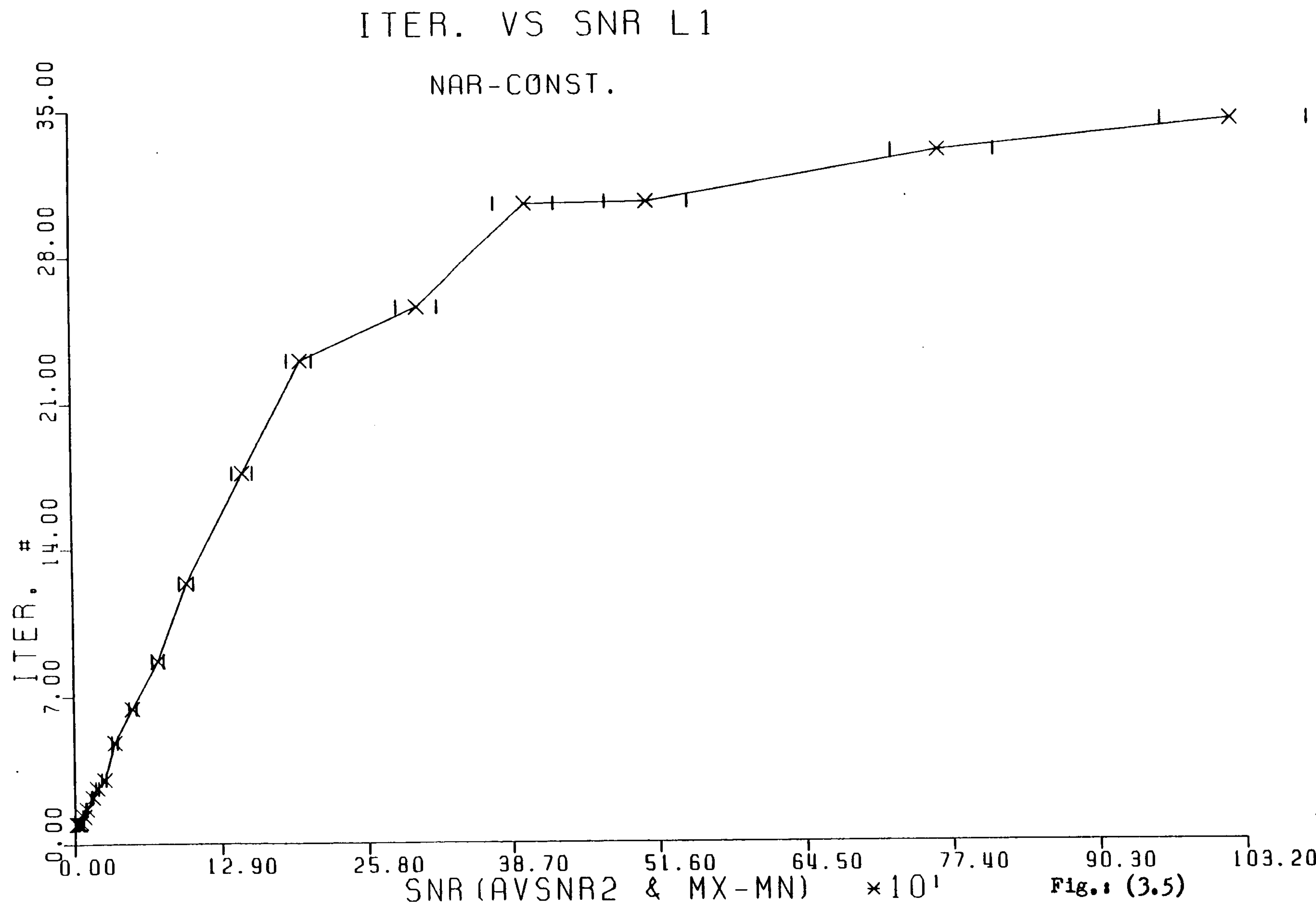

ITER. VS SNR L1
NAR-CONST.
ITER. #
35.00
28.00
21.00
14.00
7.00
0.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (3.5)

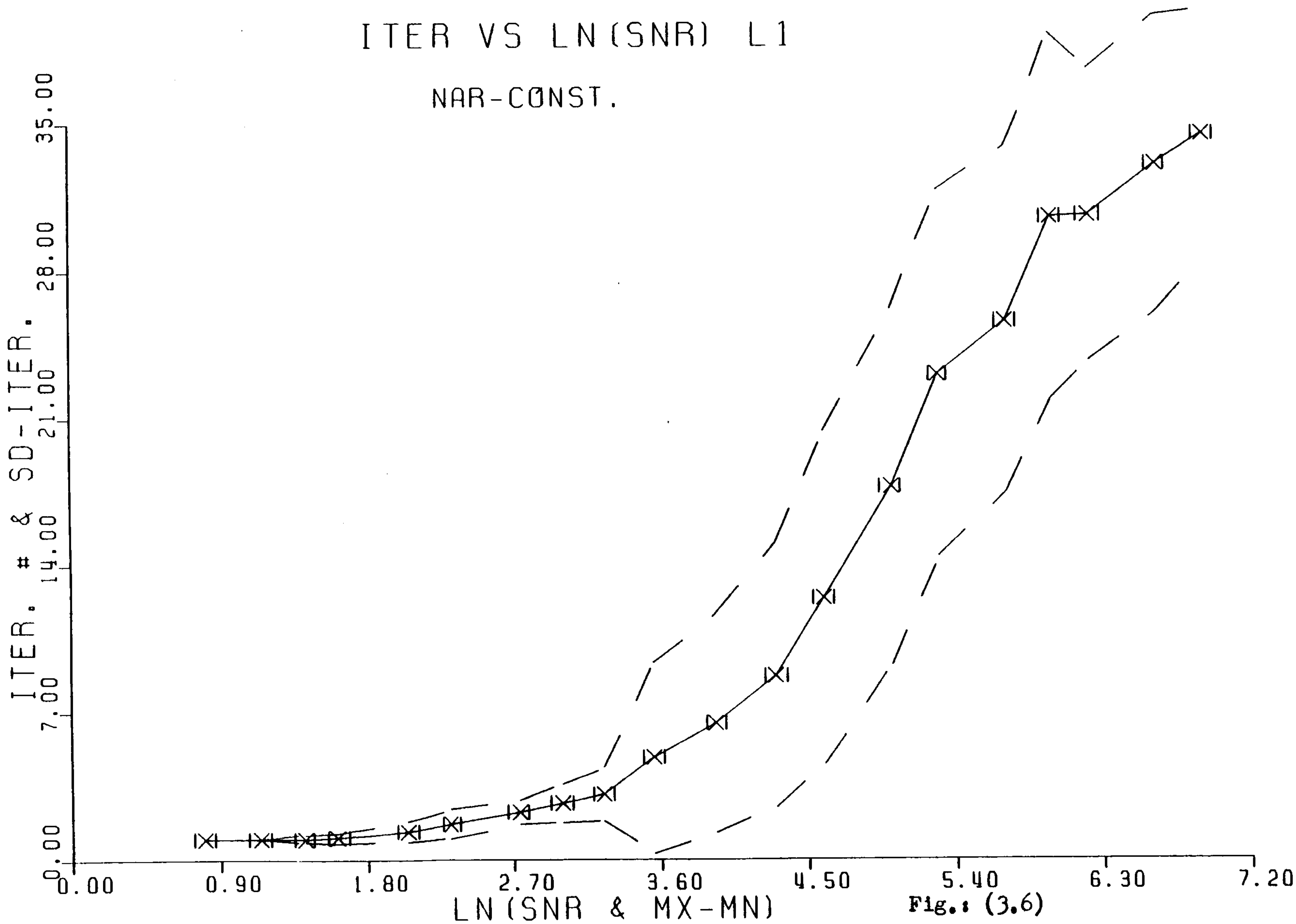

ITER VS LN(SNR) L1
NAR-CONST.
ITER. # & SD-ITER.
0.00
7.00
14.00
21.00
28.00
35.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.6)

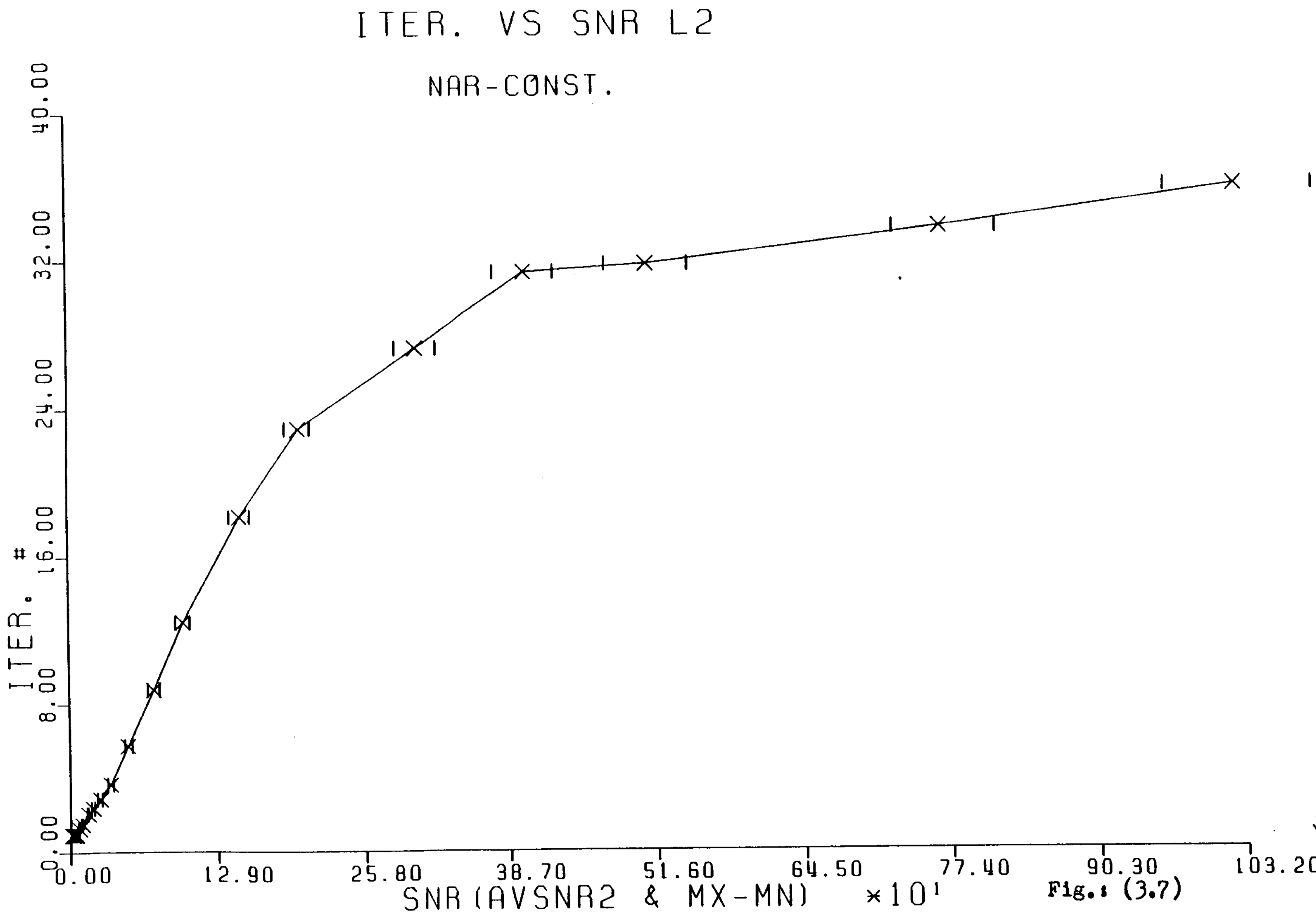

ITER. VS SNR L2
NAR-CONST.
ITER. #
0.00
8.00
16.00
24.00
32.00
40.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) $\times 10^1$

Fig.: (3.7)

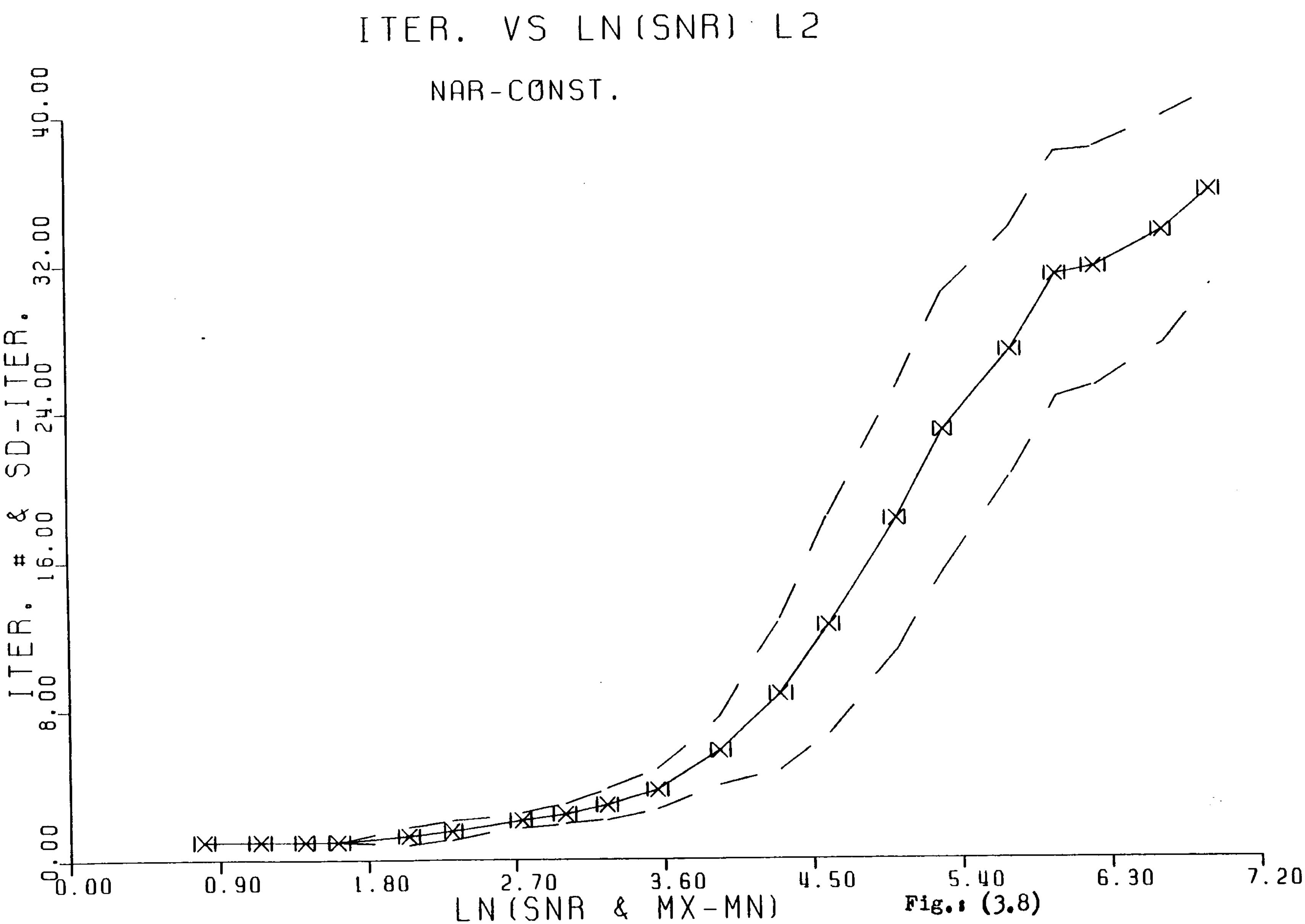
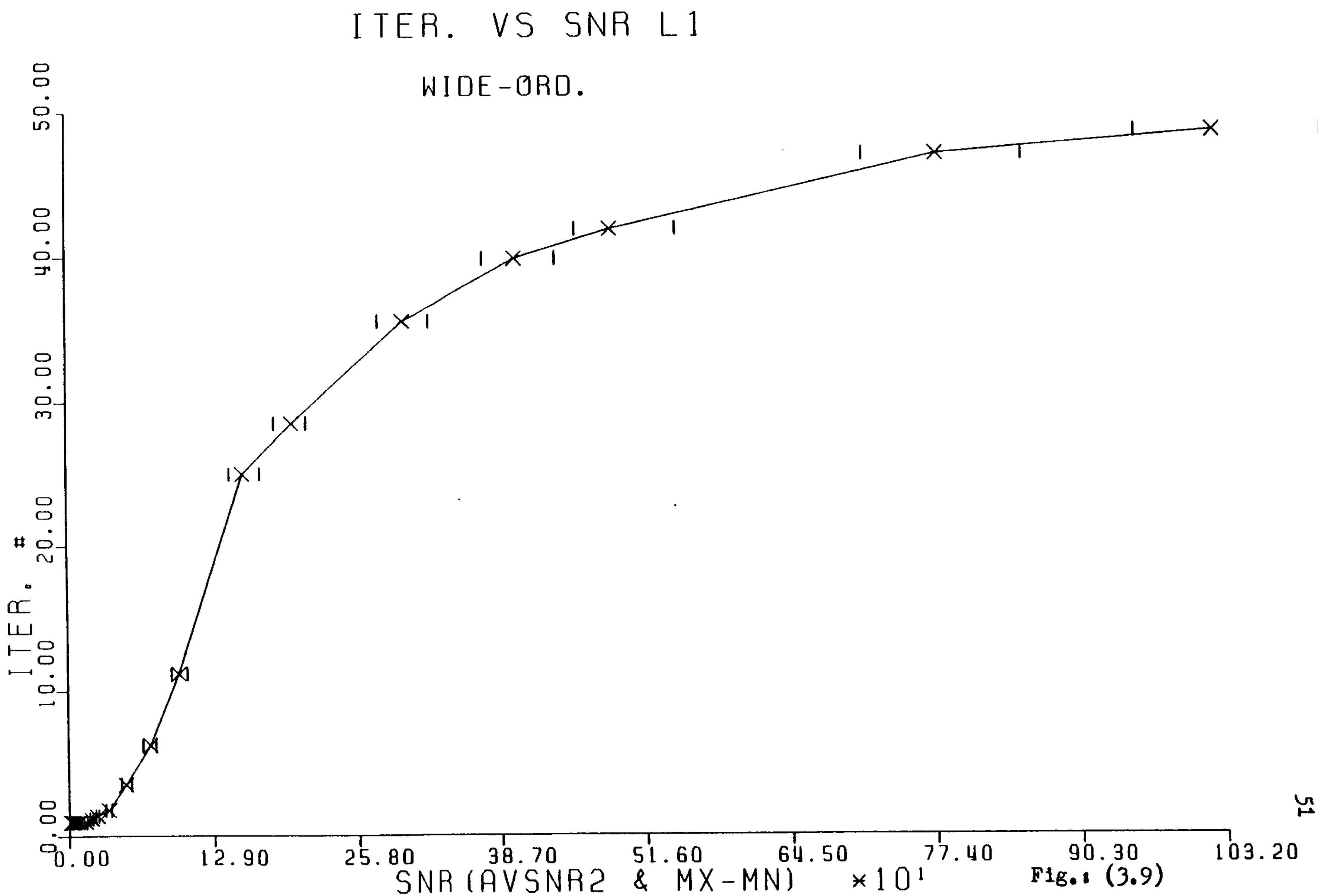

ITER. VS LN(SNR) L2
NAR-CØNST.
ITER. # & SD-ITER.
0.00
8.00
16.00
24.00
32.00
40.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.8)


ITER. VS SNR L1
WIDE-ØRD.
ITER. #
0.00
10.00
20.00
30.00
40.00
50.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) $\times 10^1$
Fig.: (3.9)

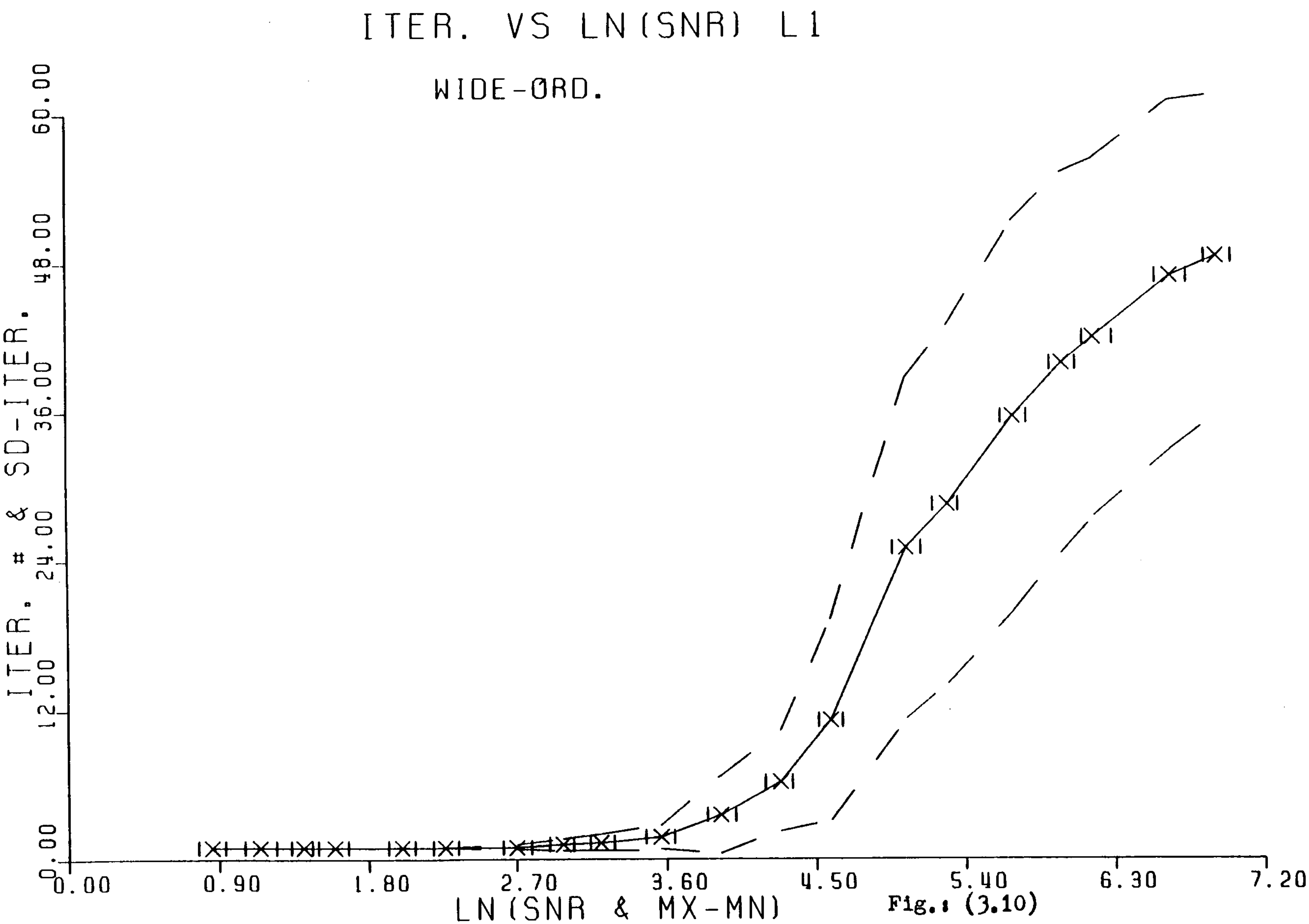

ITER. VS LN(SNR) L1
WIDE-ØRD.
ITER. # & SD-ITER.
60.00
48.00
36.00
24.00
12.00
0.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.10)

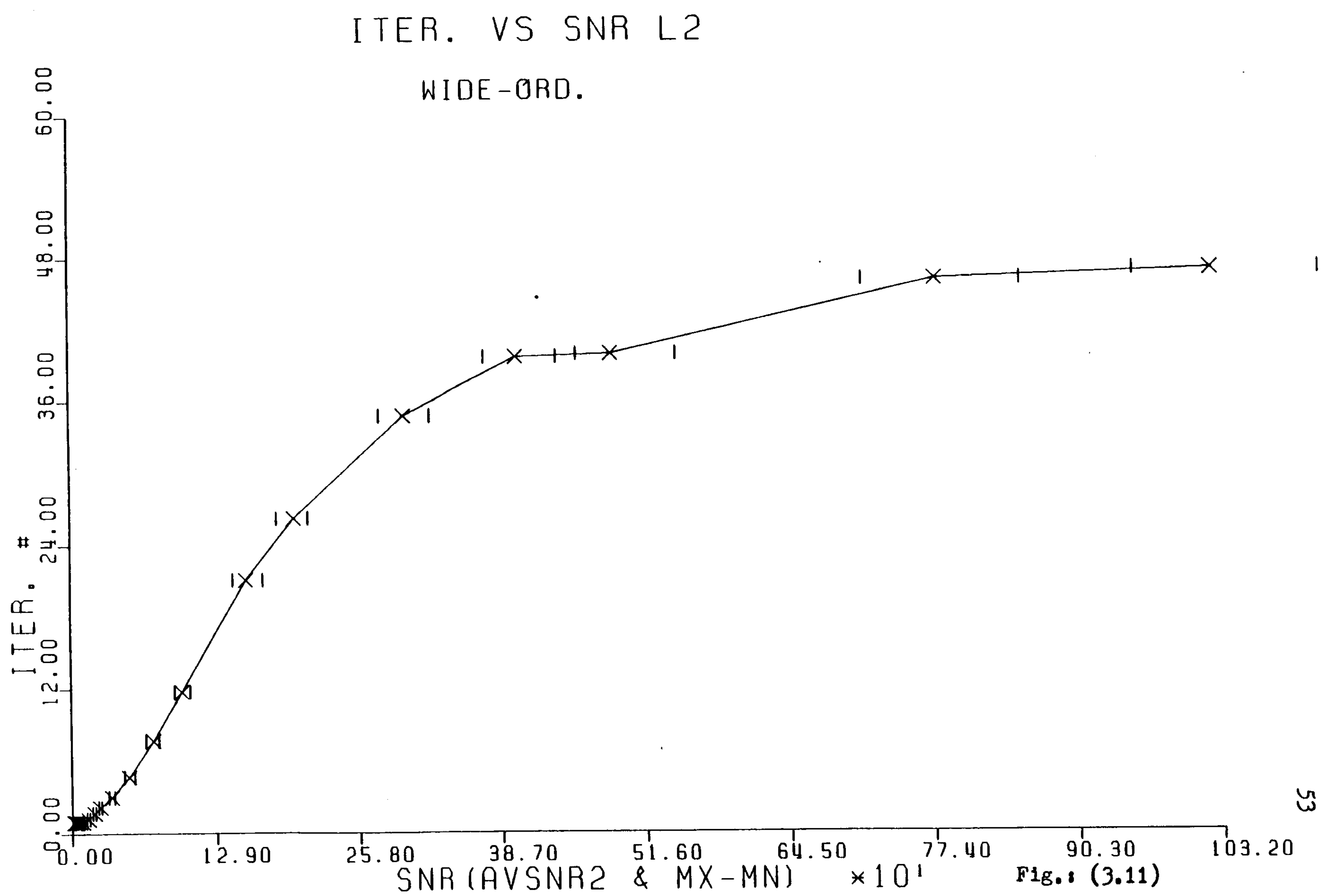

ITER. VS SNR L2
WIDE-ØRD.
ITER. #
0.00
12.00
24.00
36.00
48.00
60.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) $\times 10^1$

Fig.: (3.11)

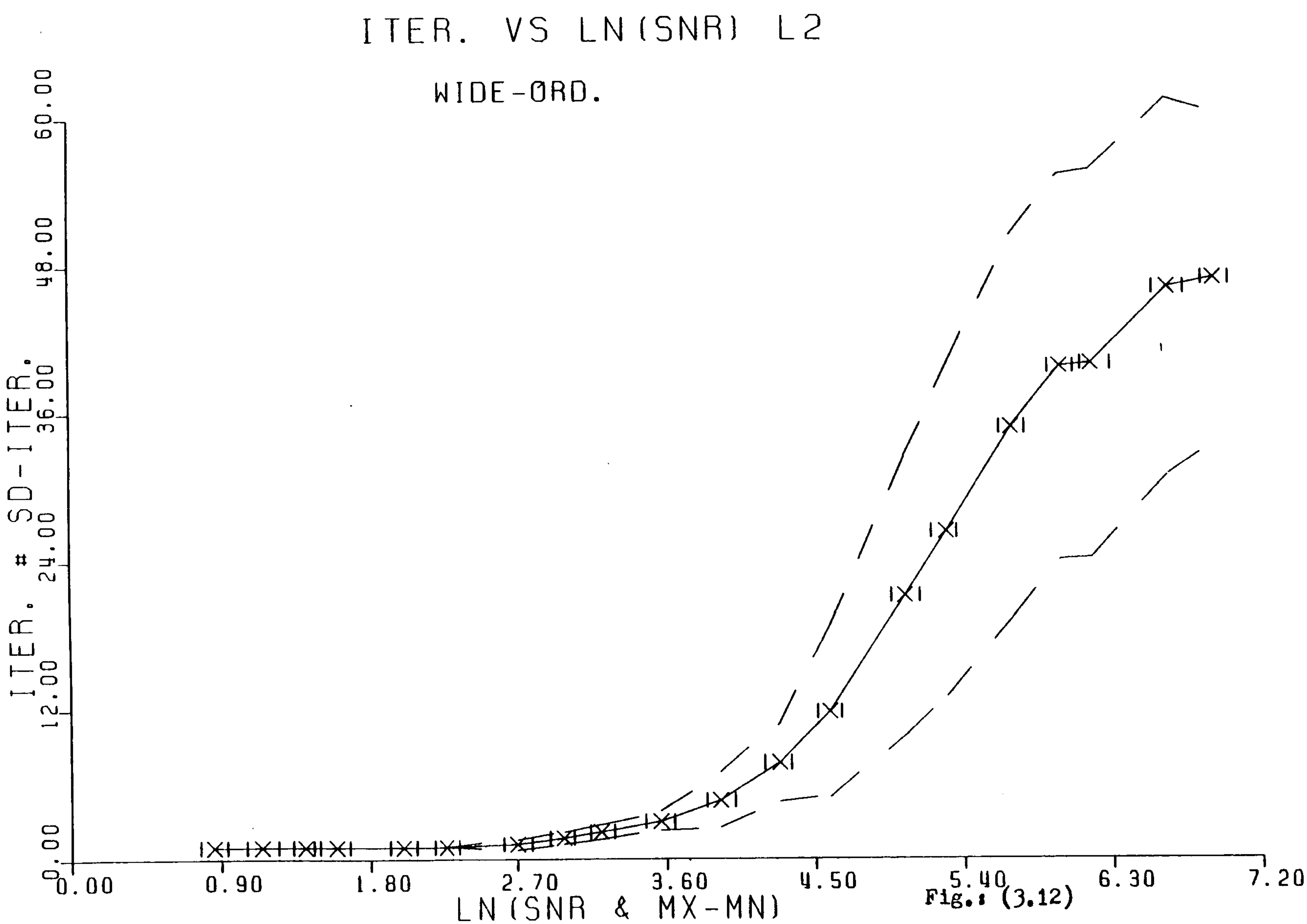

ITER. VS LN(SNR) L2
WIDE-ØRD.
ITER. # SD-ITER.
0.00
12.00
24.00
36.00
48.00
60.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.12)

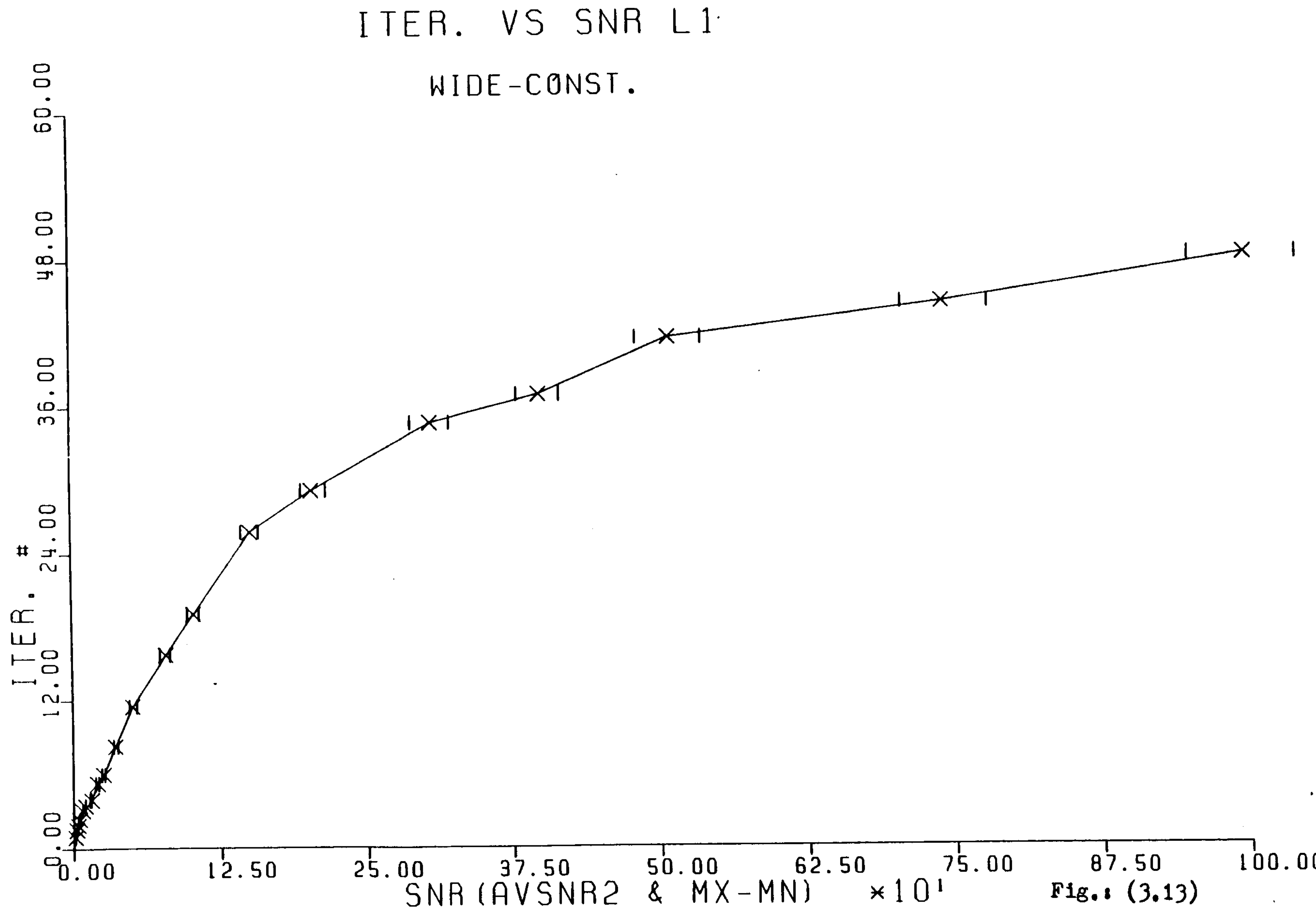

ITER. VS SNR L1
WIDE-CØNST.
ITER. #
0.00
12.00
24.00
36.00
48.00
60.00
0.00
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00
SNR (AVSNR2 & MX-MN) $\times 10^{1}$

Fig.: (3.13)

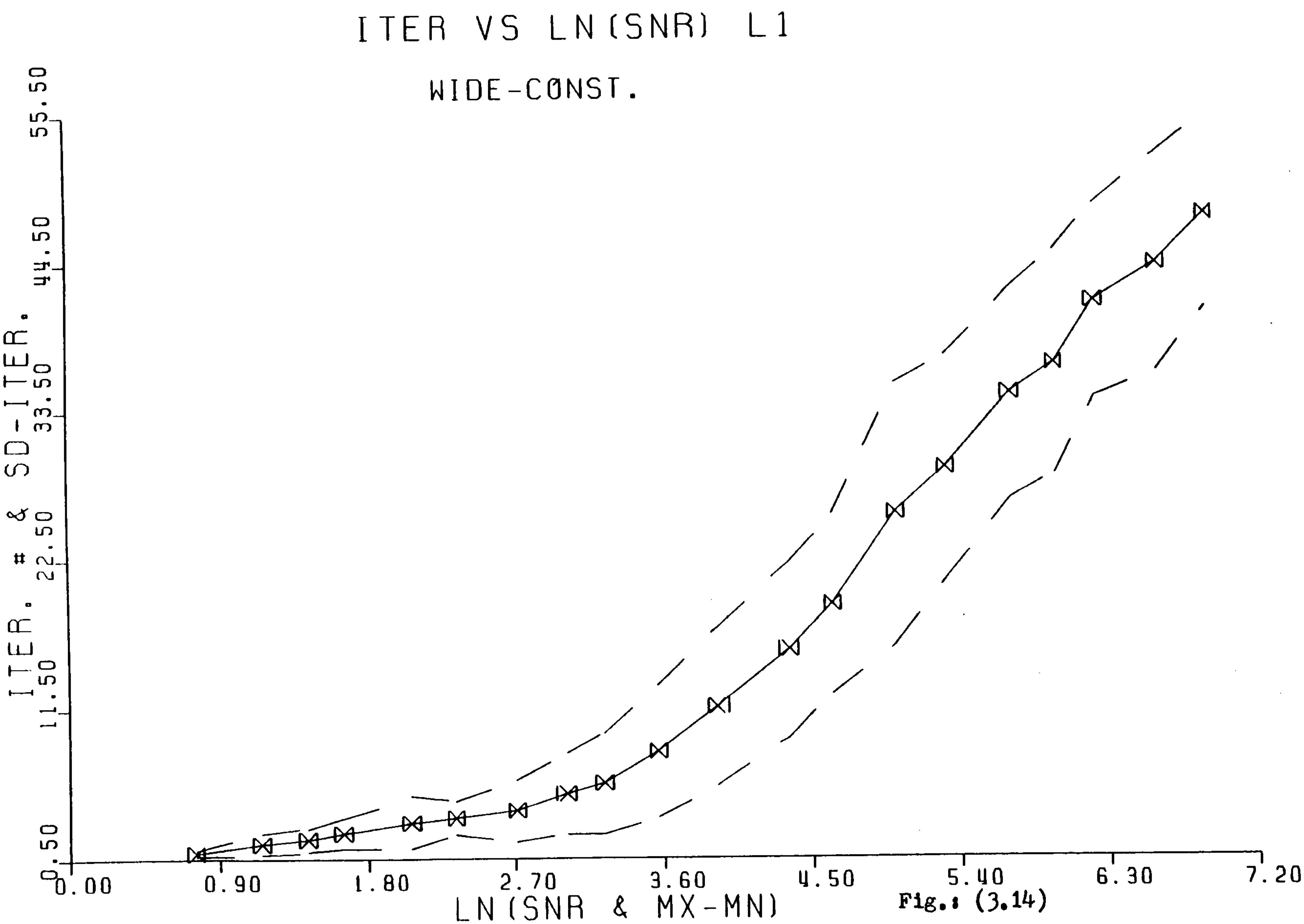

ITER VS LN(SNR) L1
WIDE-CØNST.
ITER. # & SD-ITER.
55.50
44.50
33.50
22.50
11.50
0.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.14)

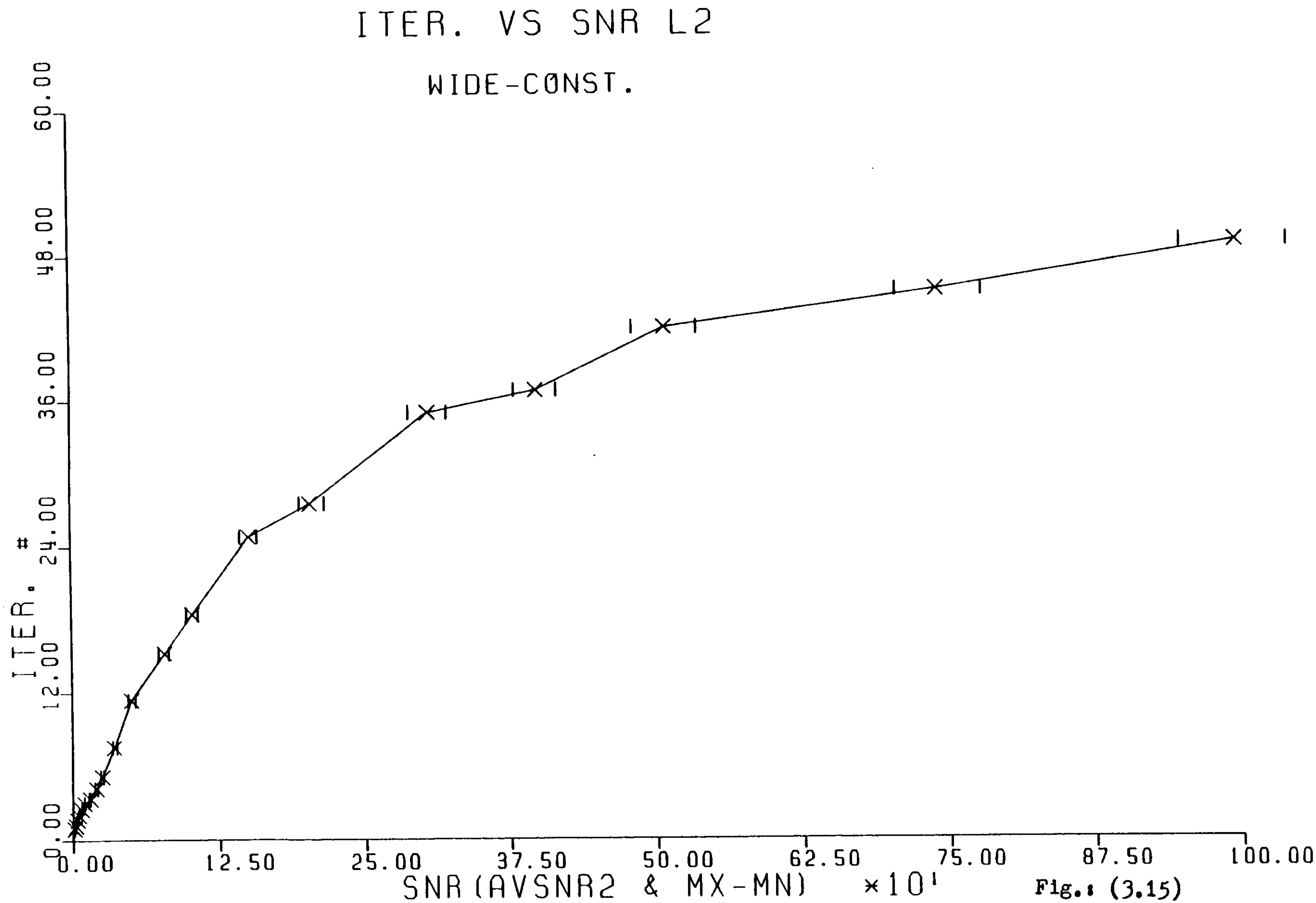

ITER. VS SNR L2
WIDE-CØNST.
ITER. #
0.00
12.00
24.00
36.00
48.00
60.00
0.00
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00
SNR(AVSNR2 & MX-MN) ×10¹

Fig.: (3.15)

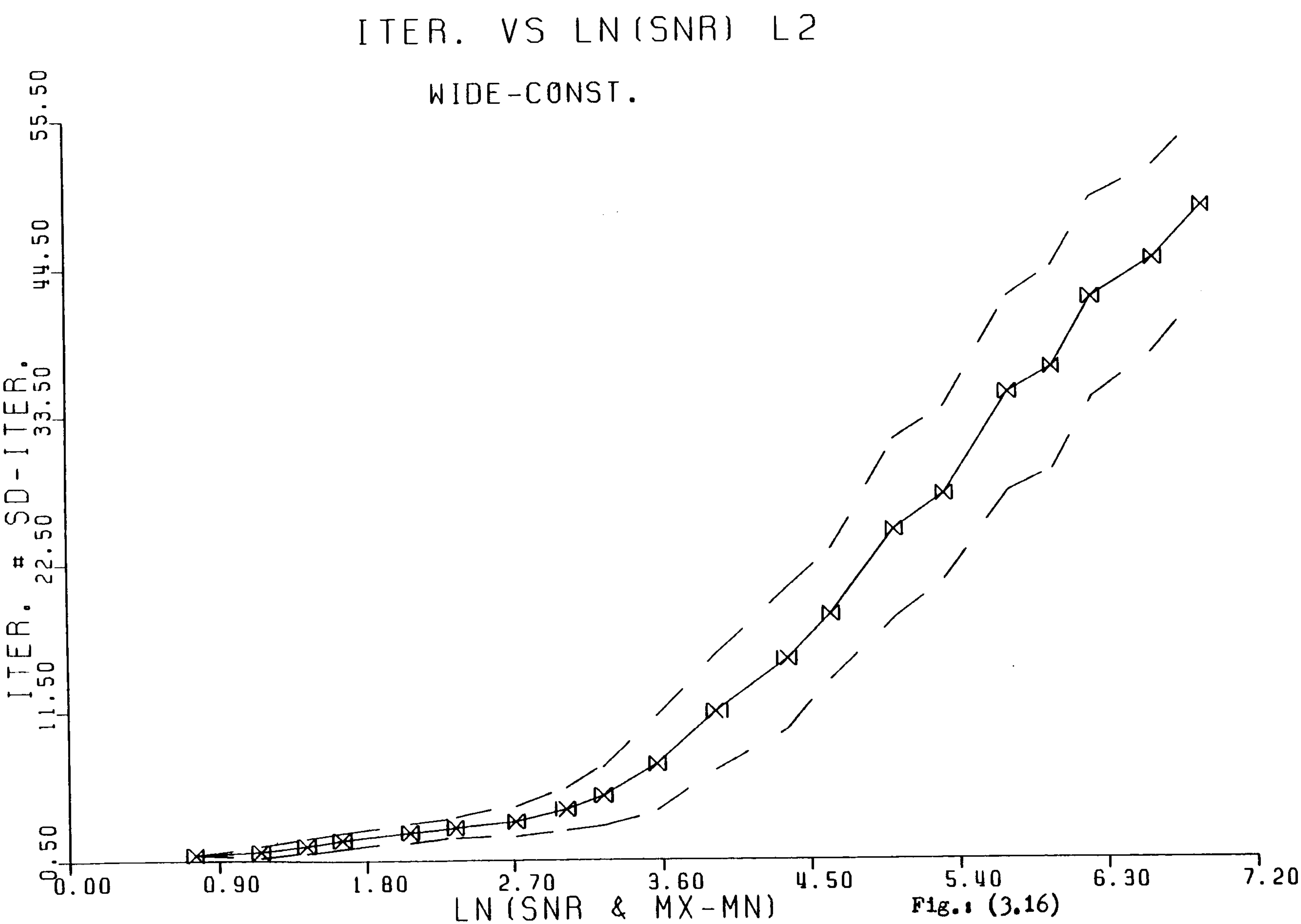
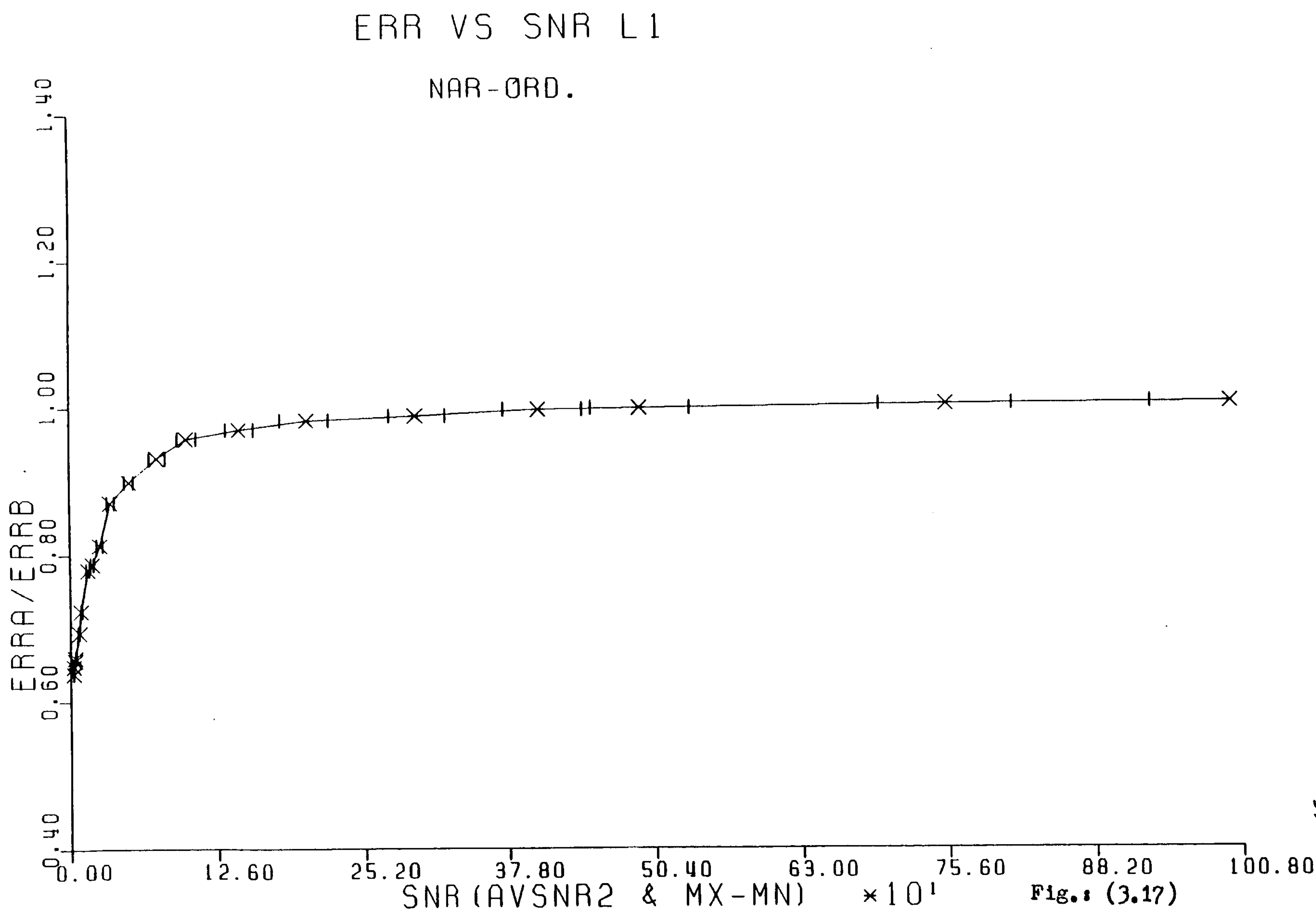

ITER. VS LN(SNR) L2
WIDE-CONST.
ITER. # SD-ITER.
0.50
11.50
22.50
33.50
44.50
55.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.16)



ERR VS SNR L1
NAR-ØRD.
ERRA/ERRB
0.40
0.60
0.80
1.00
1.20
1.40
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (3.17)

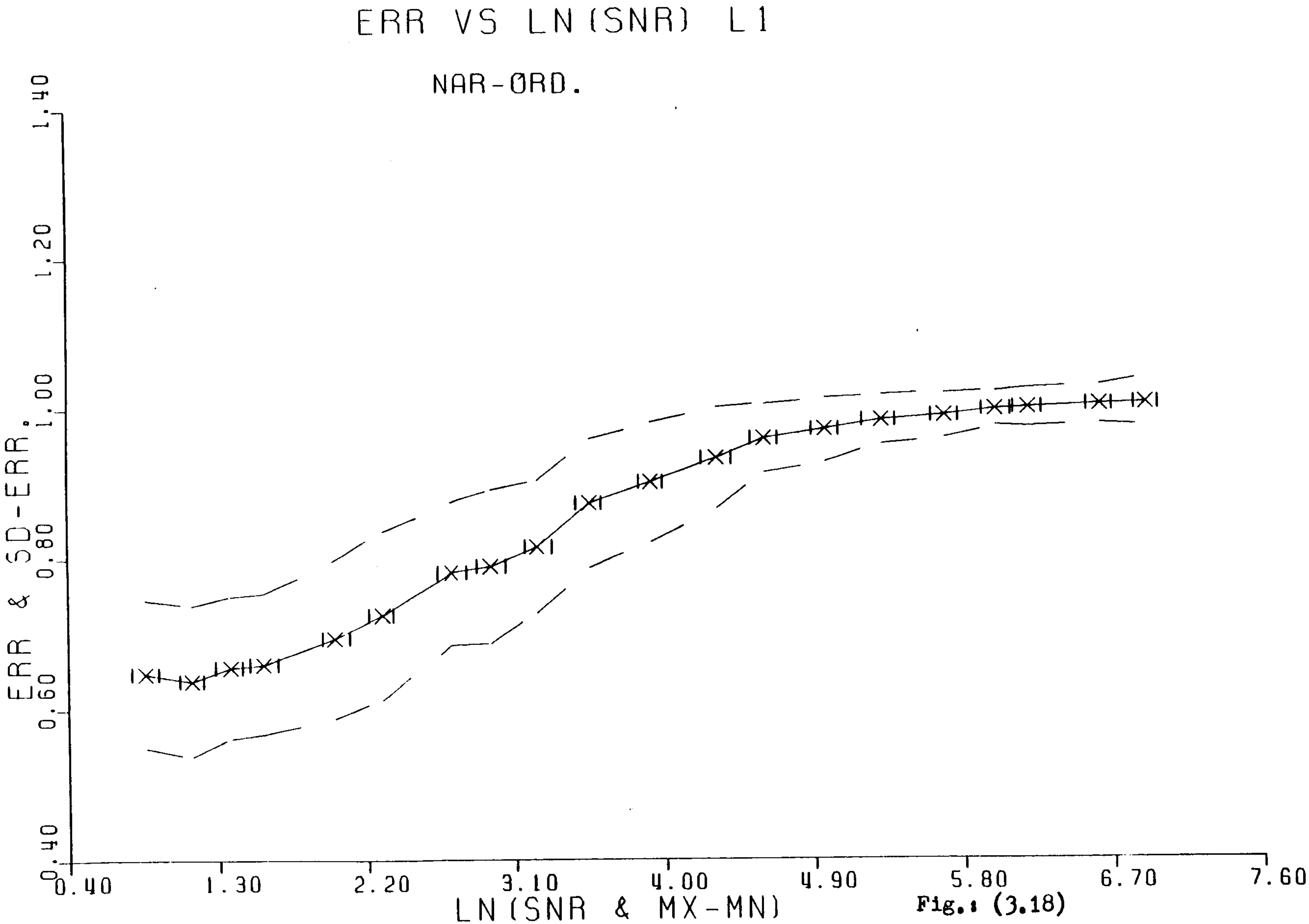
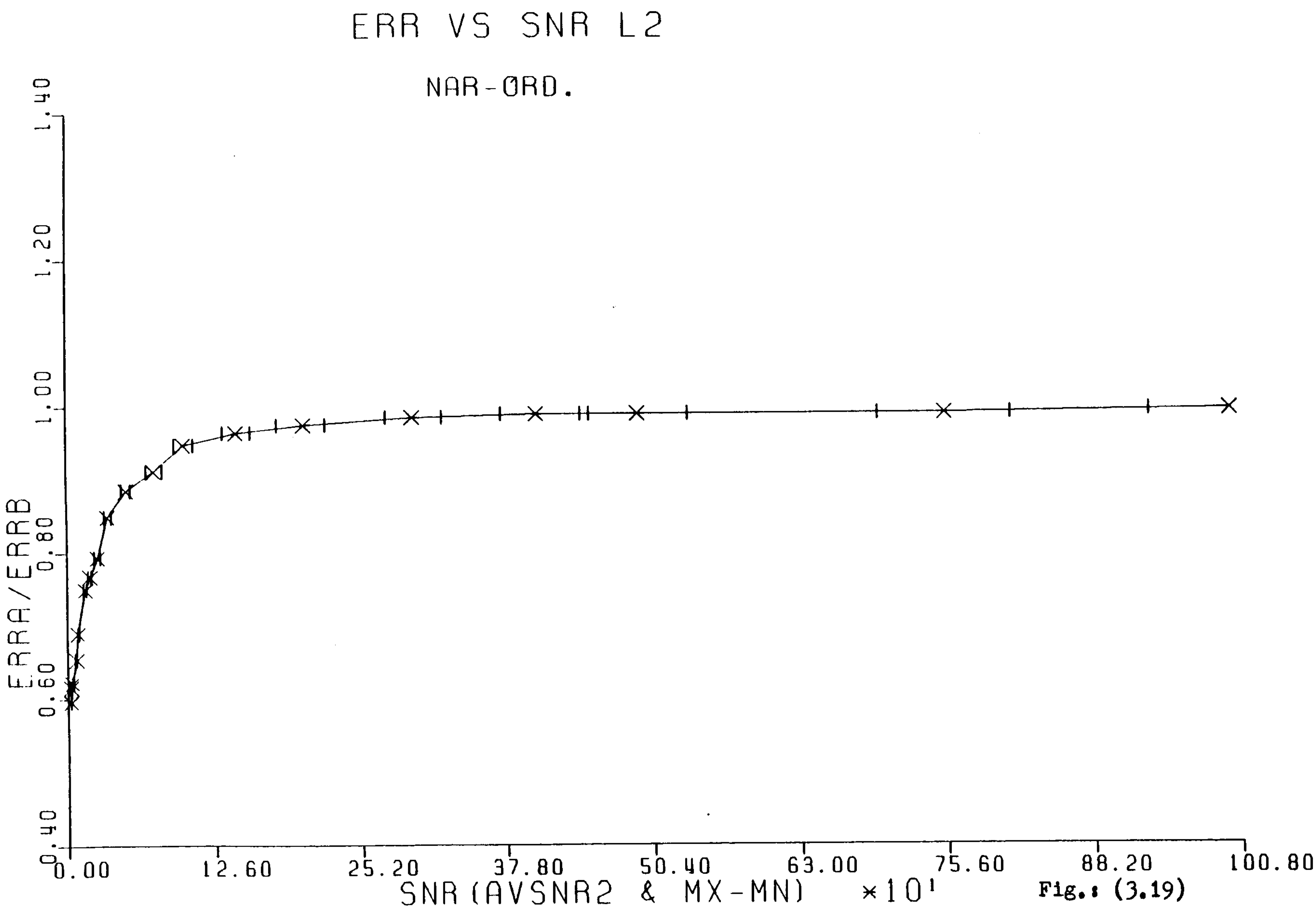

ERR VS LN(SNR) L1
NAR-ØRD.
ERR & SD-ERR.
0.40
0.60
0.80
1.00
1.20
1.40
0.40
1.30
2.20
3.10
4.00
4.90
5.80
6.70
7.60
LN(SNR & MX-MN)

Fig.: (3.18)



ERR VS SNR L2
NAR-ØRD.
ERRA/ERRB
1.40
1.20
1.00
0.80
0.60
0.40
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR(AVSNR2 & MX-MN) $\times 10^{1}$

Fig.: (3.19)

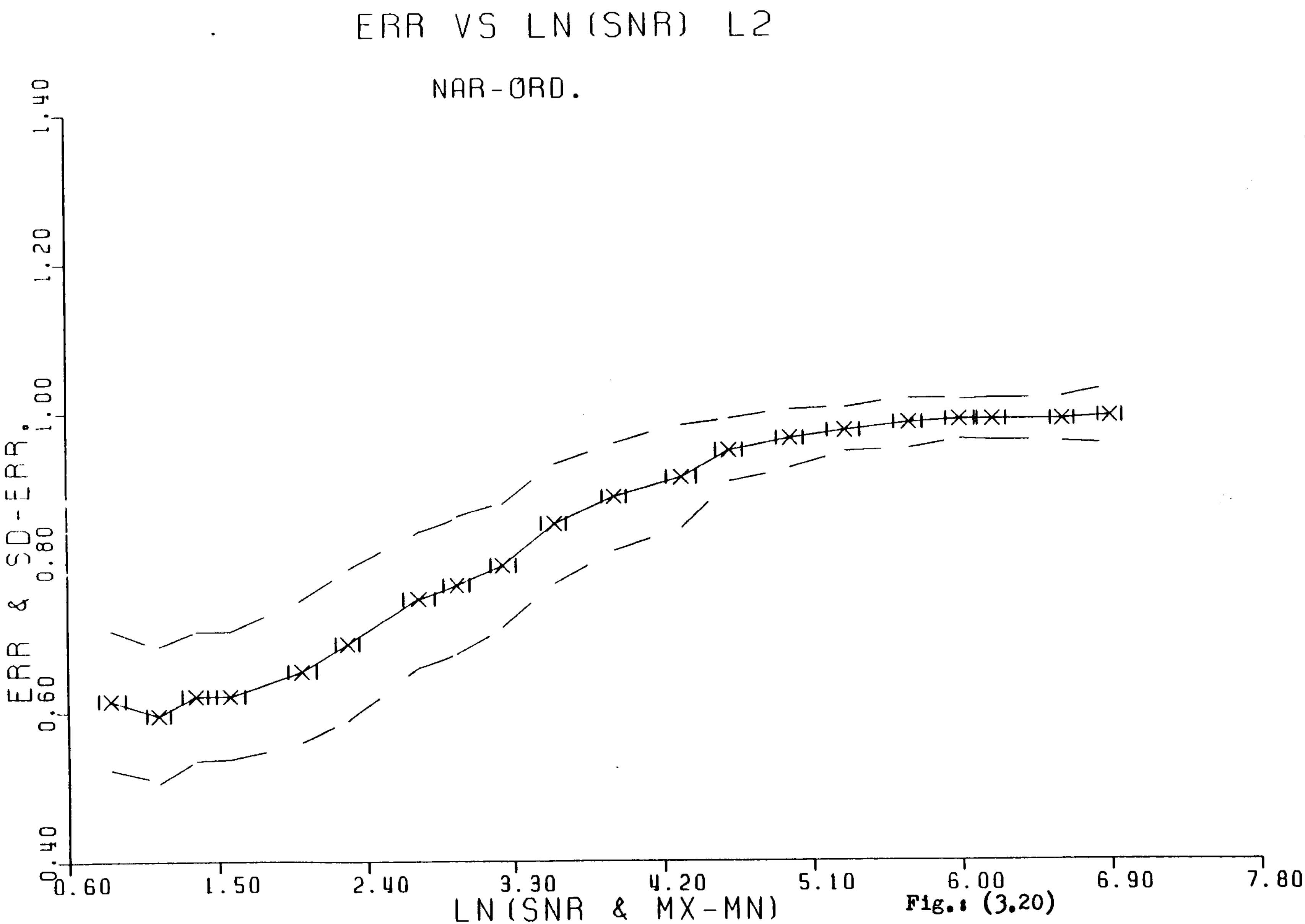

ERR VS LN(SNR) L2
NAR-ØRD.
ERR & SD-ERR.
LN(SNR & MX-MN)
0.40
0.60
0.80
1.00
1.20
1.40
0.60
1.50
2.40
3.30
4.20
5.10
6.00
6.90
7.80

Fig.: (3.20)

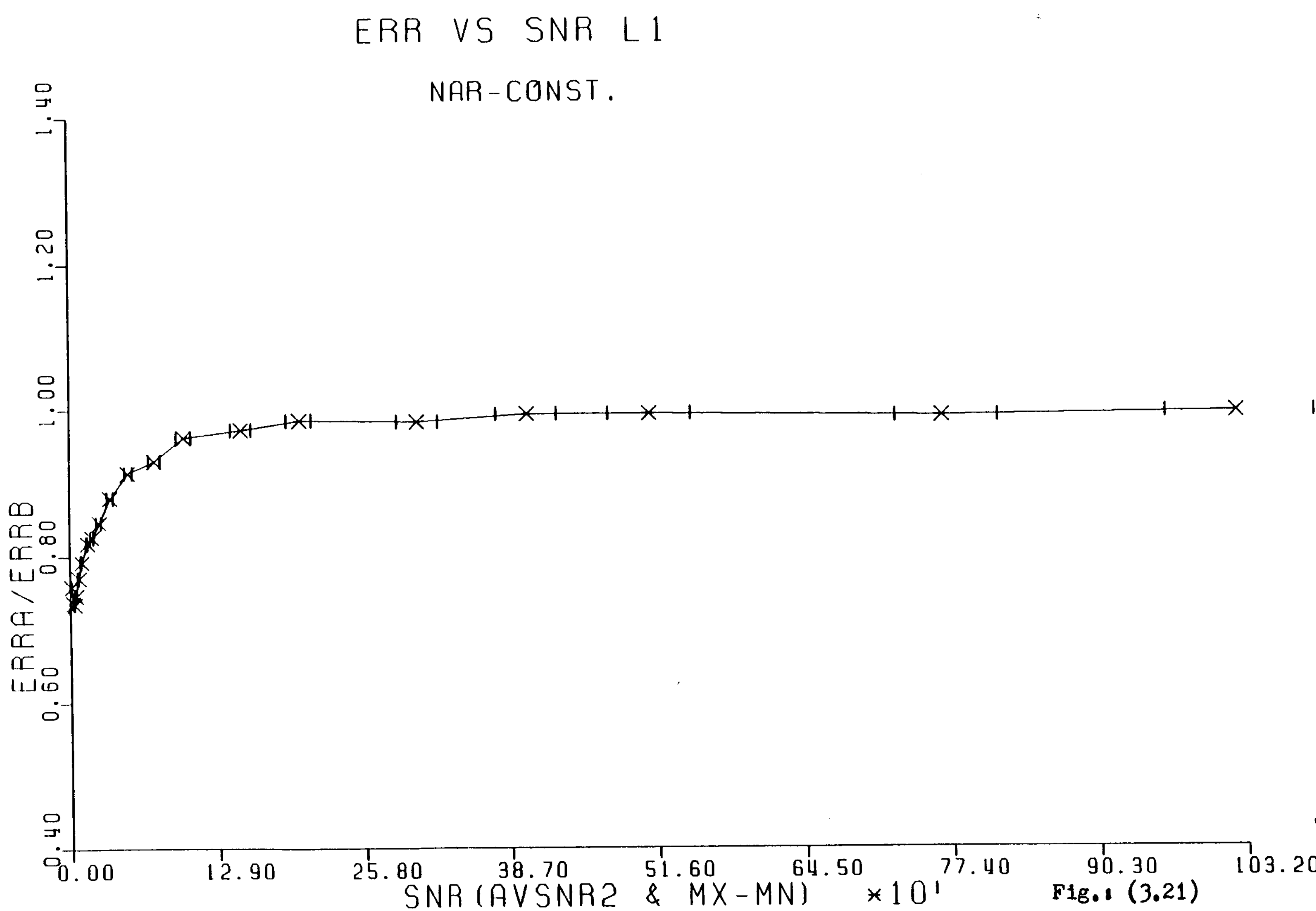

ERR VS SNR L1
NAR-CØNST.
ERRA/ERRB
1.40
1.20
1.00
0.80
0.60
0.40
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR(AVSNR2 & MX-MN) ×10¹

Fig.: (3.21)

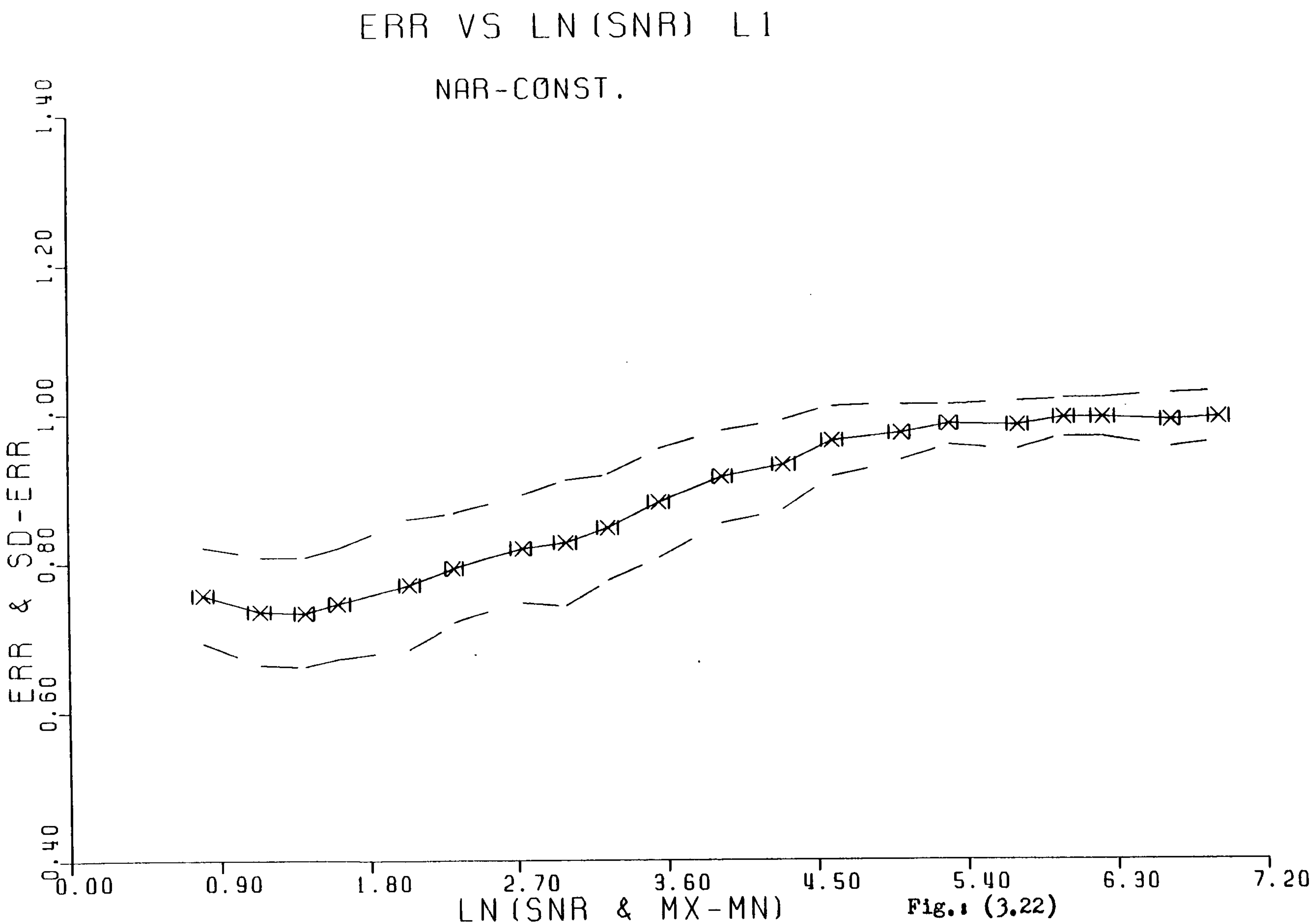

ERR VS LN(SNR) L1
NAR-CØNST.
ERR & SD-ERR
0.40
0.60
0.80
1.00
1.20
1.40
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.22)

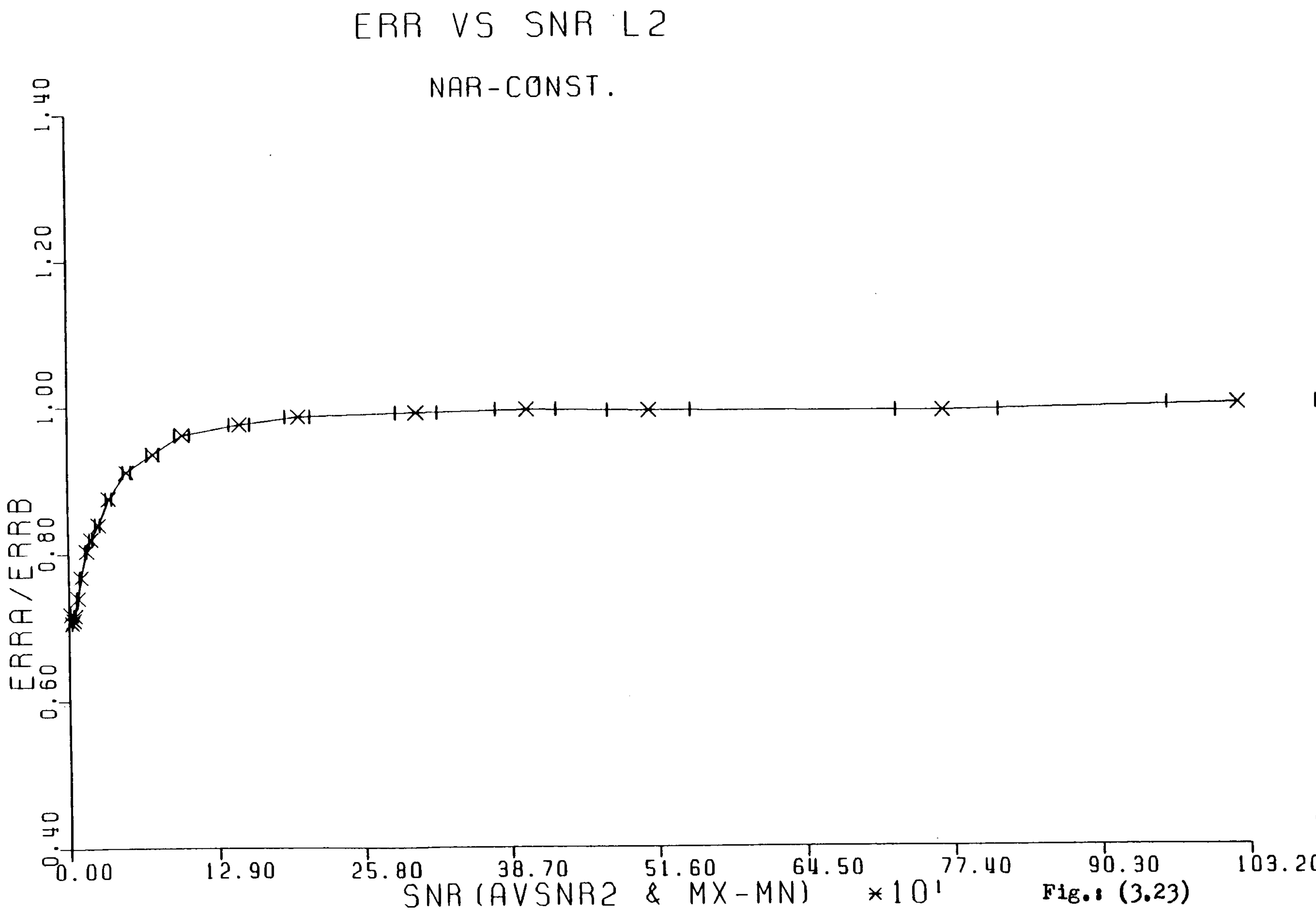
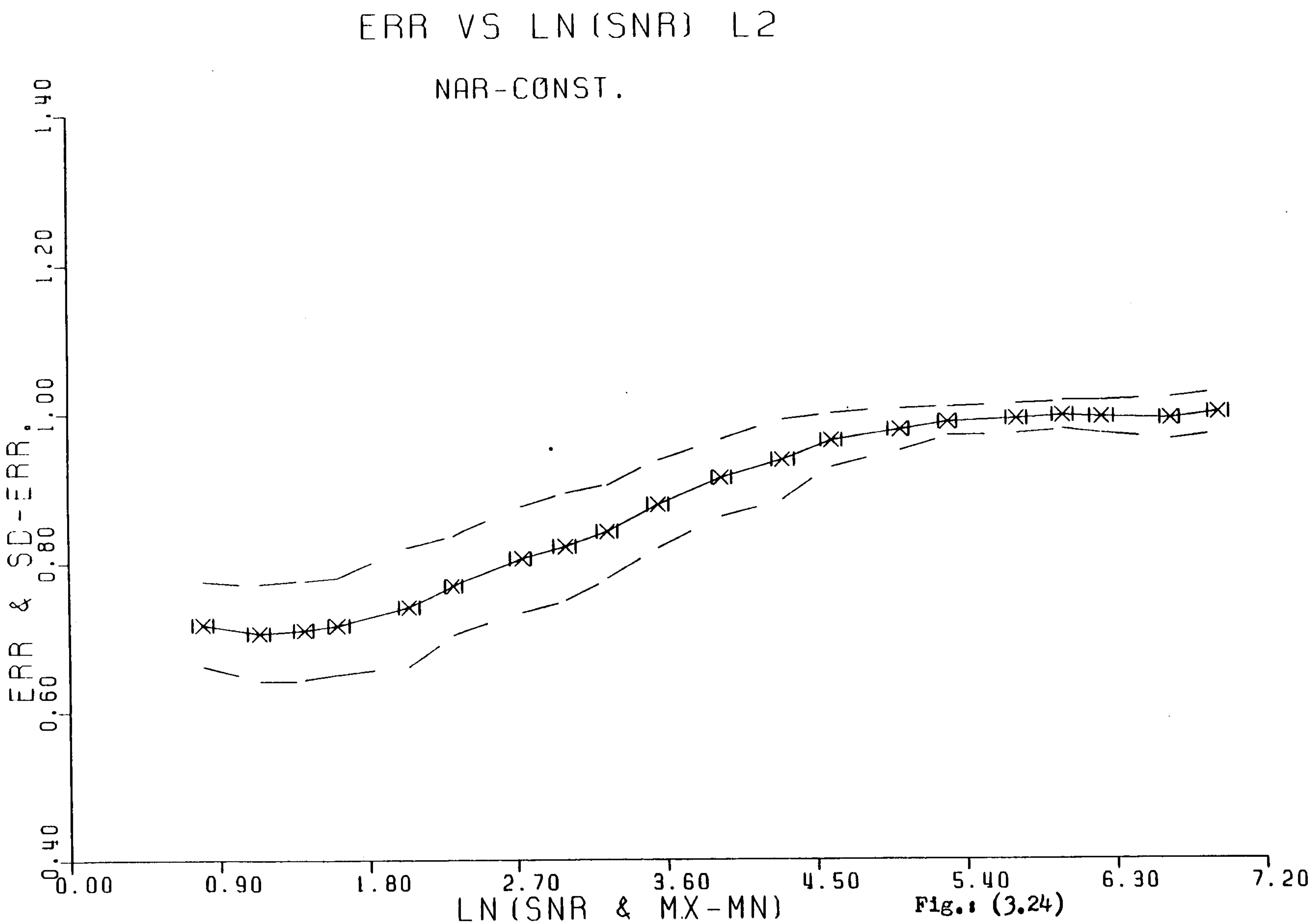

ERR VS SNR L2
NAR-CONST.
ERRA/ERRB
1.40
1.20
1.00
0.80
0.60
0.40
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (3.23)


ERR VS LN(SNR) L2
NAR-CØNST.
ERR & SD-ERR.
1.40
1.20
1.00
0.80
0.60
0.40
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)
Fig.: (3.24)

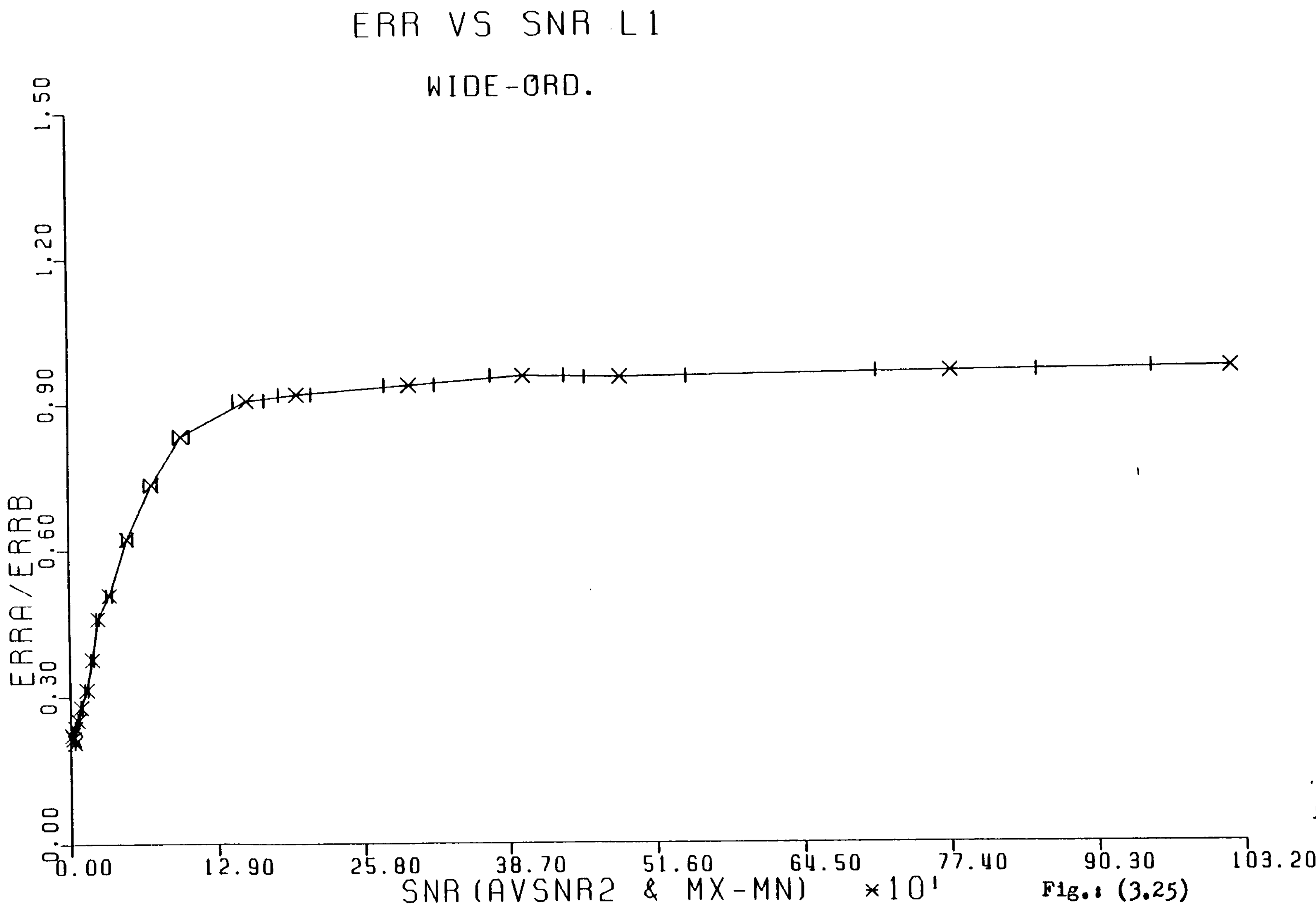

ERR VS SNR L1
WIDE-ØRD.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (3.25)

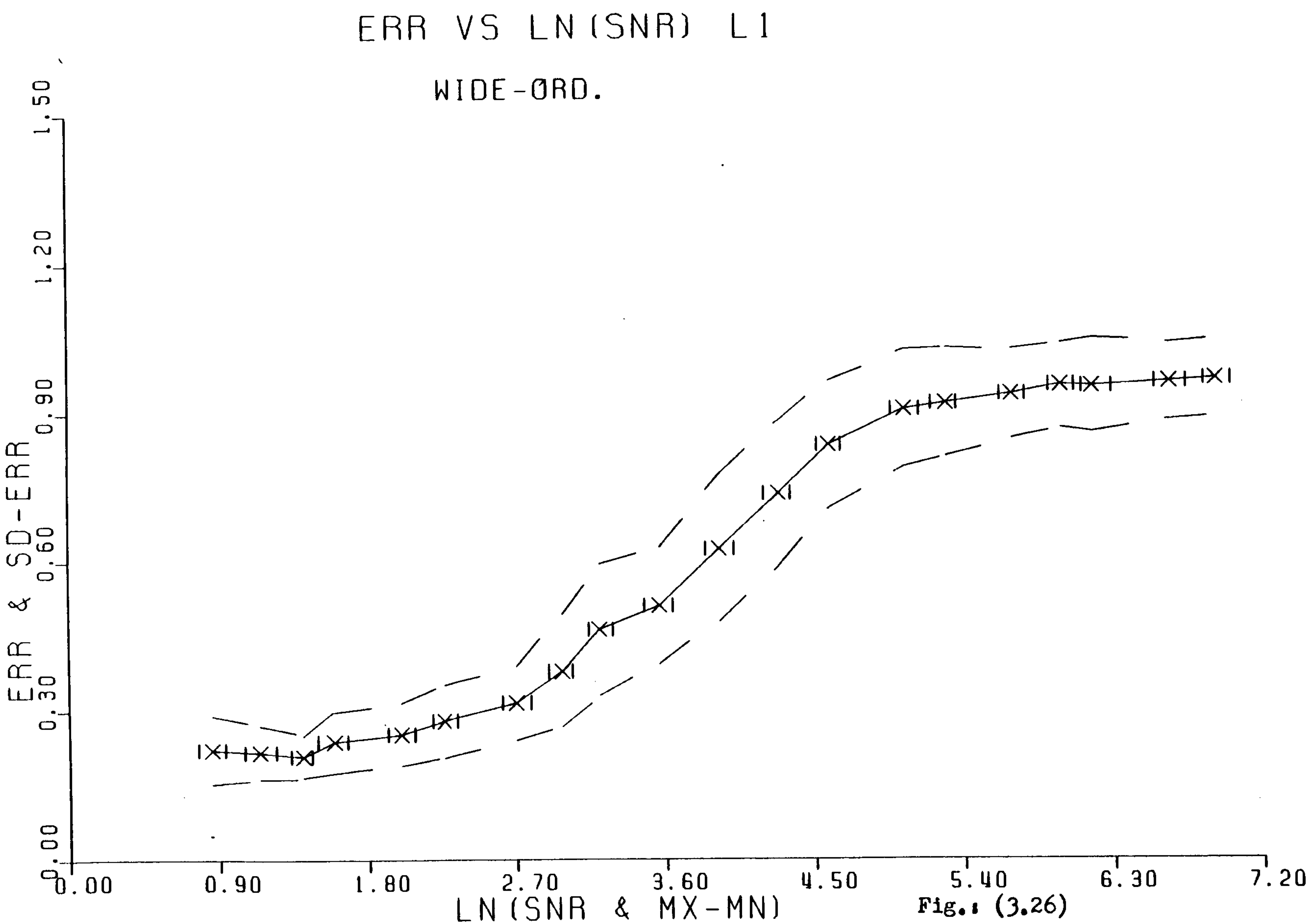

ERR VS LN(SNR) L1
WIDE-ØRD.
ERR & SD-ERR
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.26)

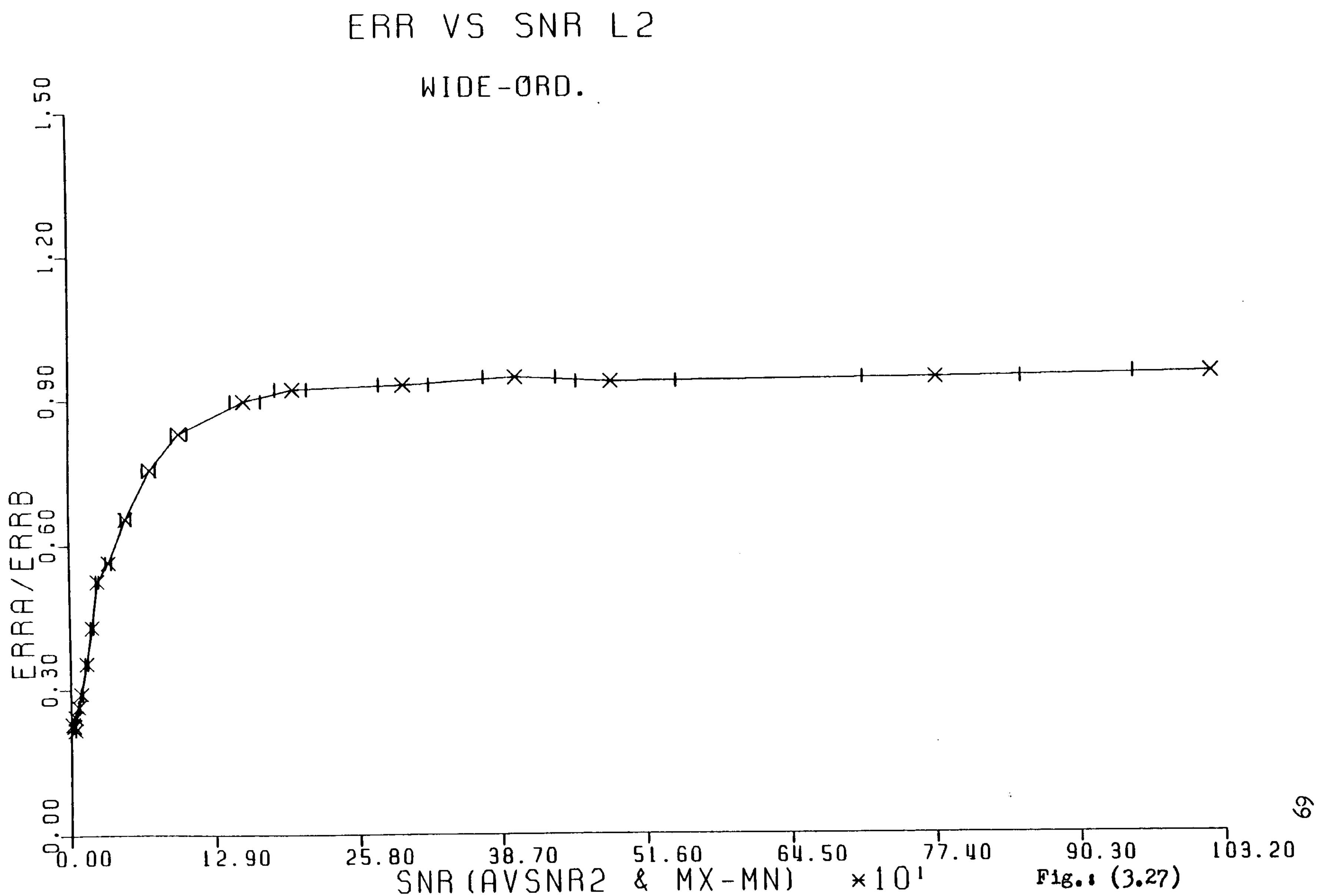

ERR VS SNR L2
WIDE-ØRD.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) $\times 10^1$

Fig.: (3.27)

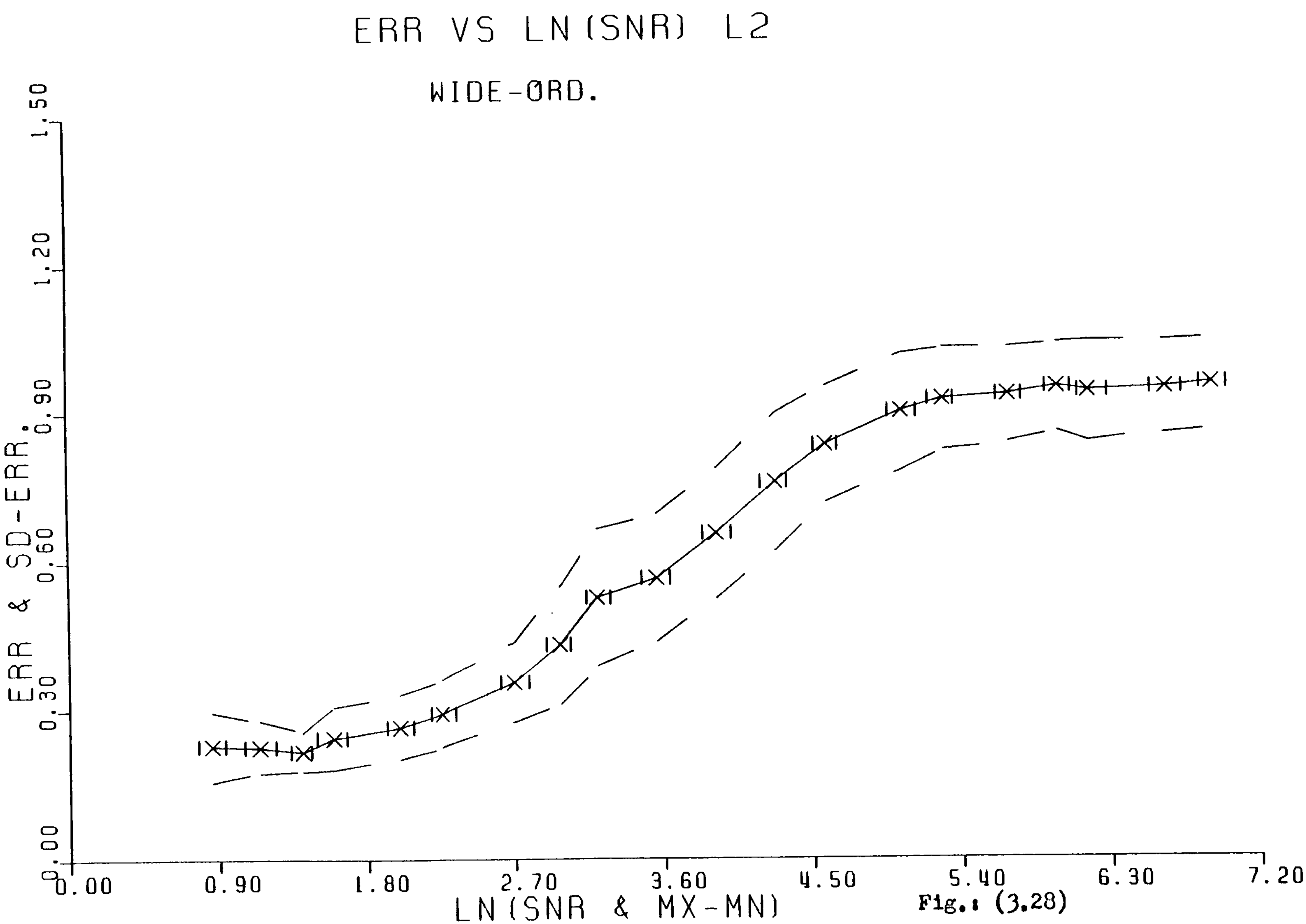

ERR VS LN(SNR) L2
WIDE-ØRD.
ERR & SD-ERR.
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.28)

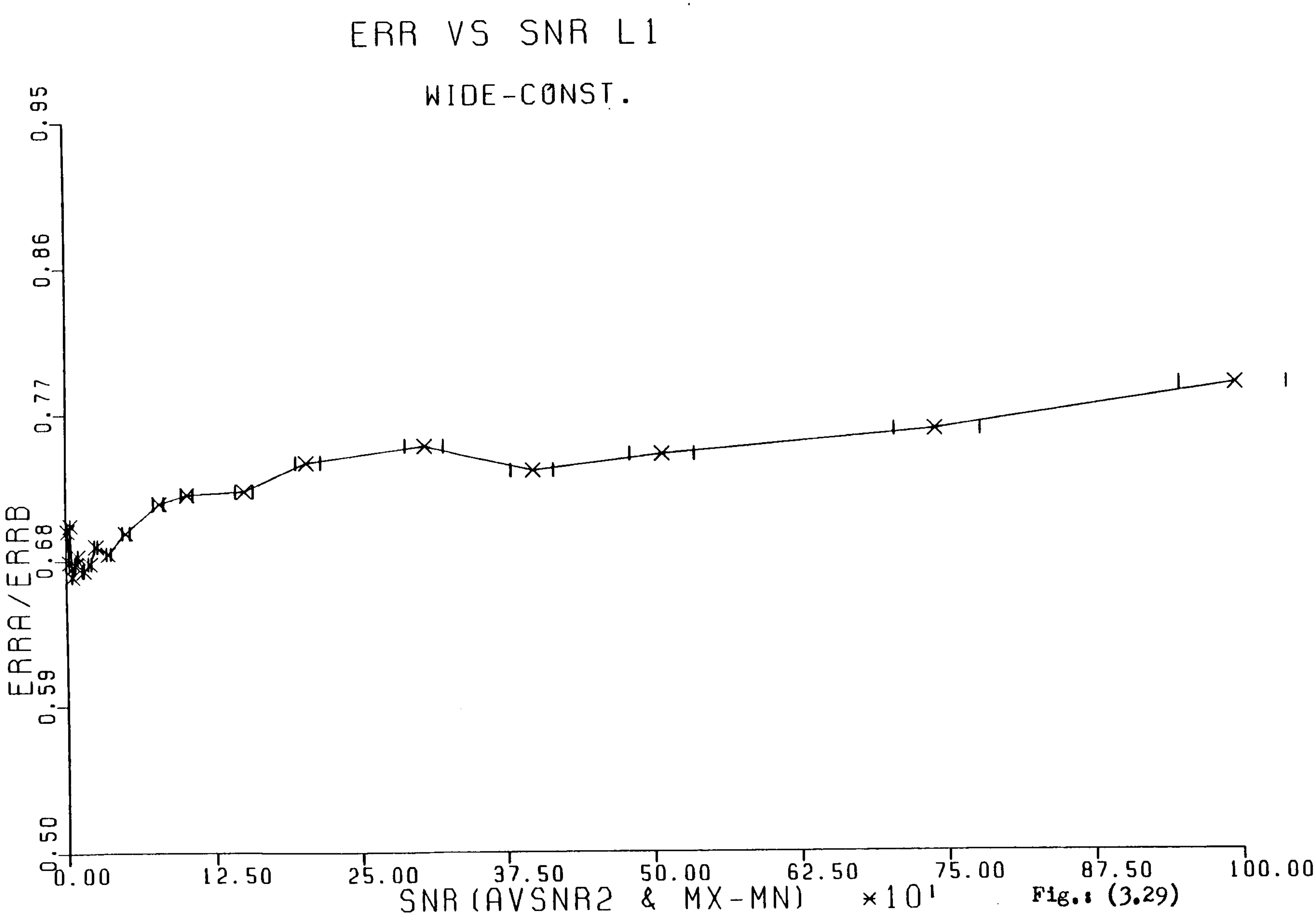

ERR VS SNR L1
WIDE-CØNST.
ERRA/ERRB
0.95
0.86
0.77
0.68
0.59
0.50
0.00
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (3.29)

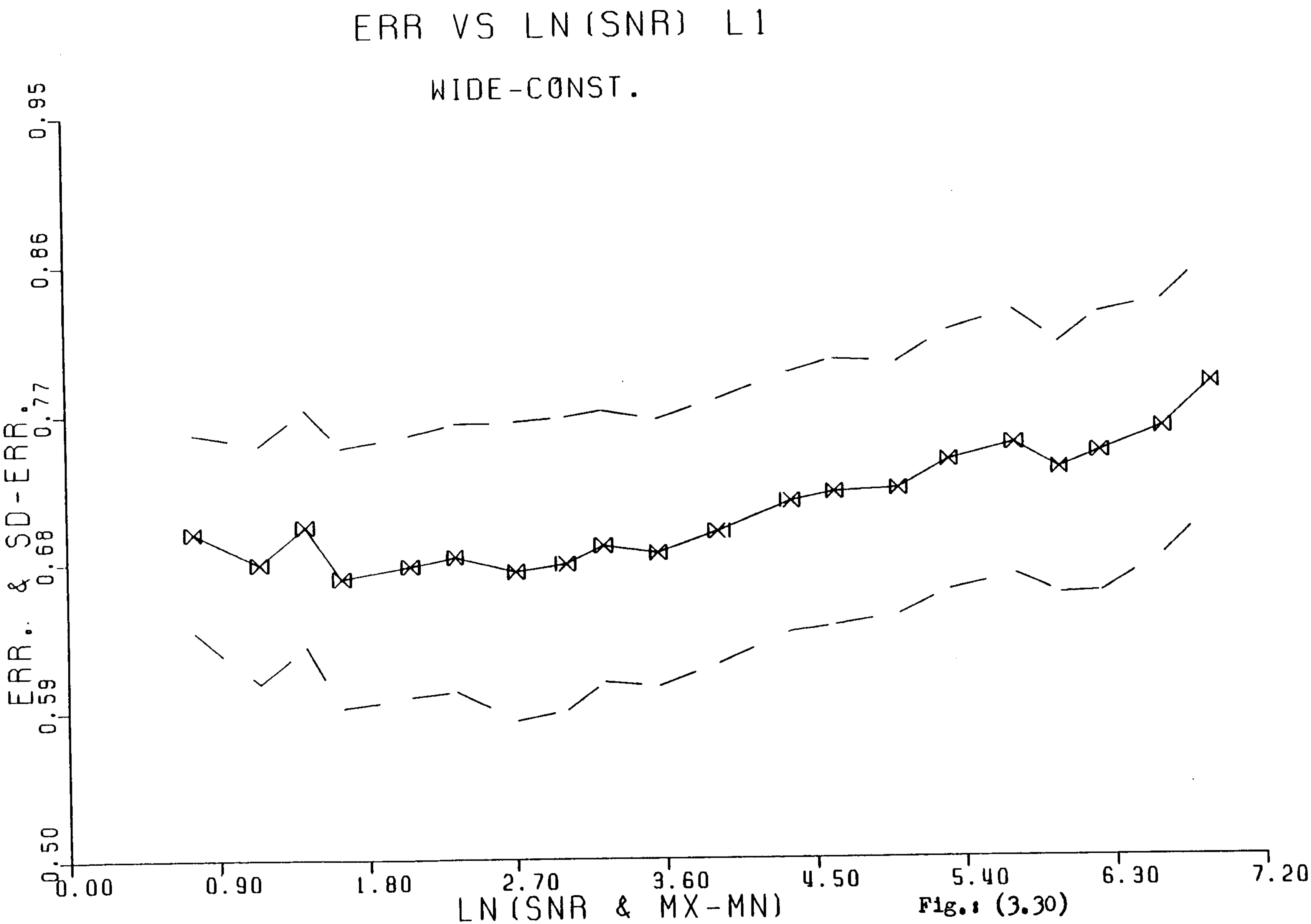

ERR VS LN(SNR) L1
WIDE-CØNST.
ERR. & SD-ERR.
0.95
0.86
0.77
0.68
0.59
0.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.30)

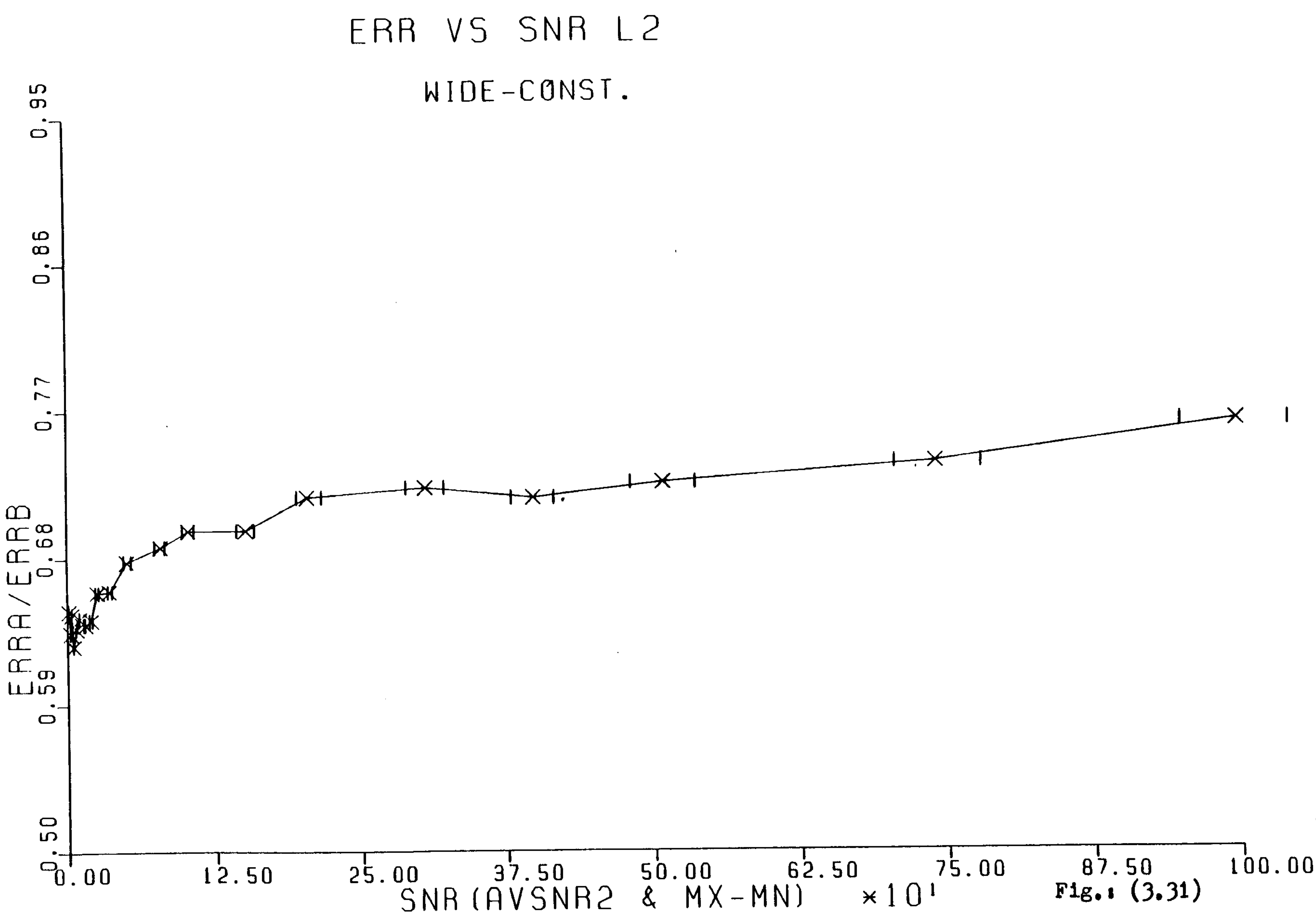

ERR VS SNR L2
WIDE-CØNST.
ERRA/ERRB
0.50
0.59
0.68
0.77
0.86
0.95
0.00
12.50
25.00
37.50
50.00
62.50
75.00
87.50
100.00
SNR (AVSNR2 & MX-MN) $\times 10^{1}$

Fig.: (3.31)

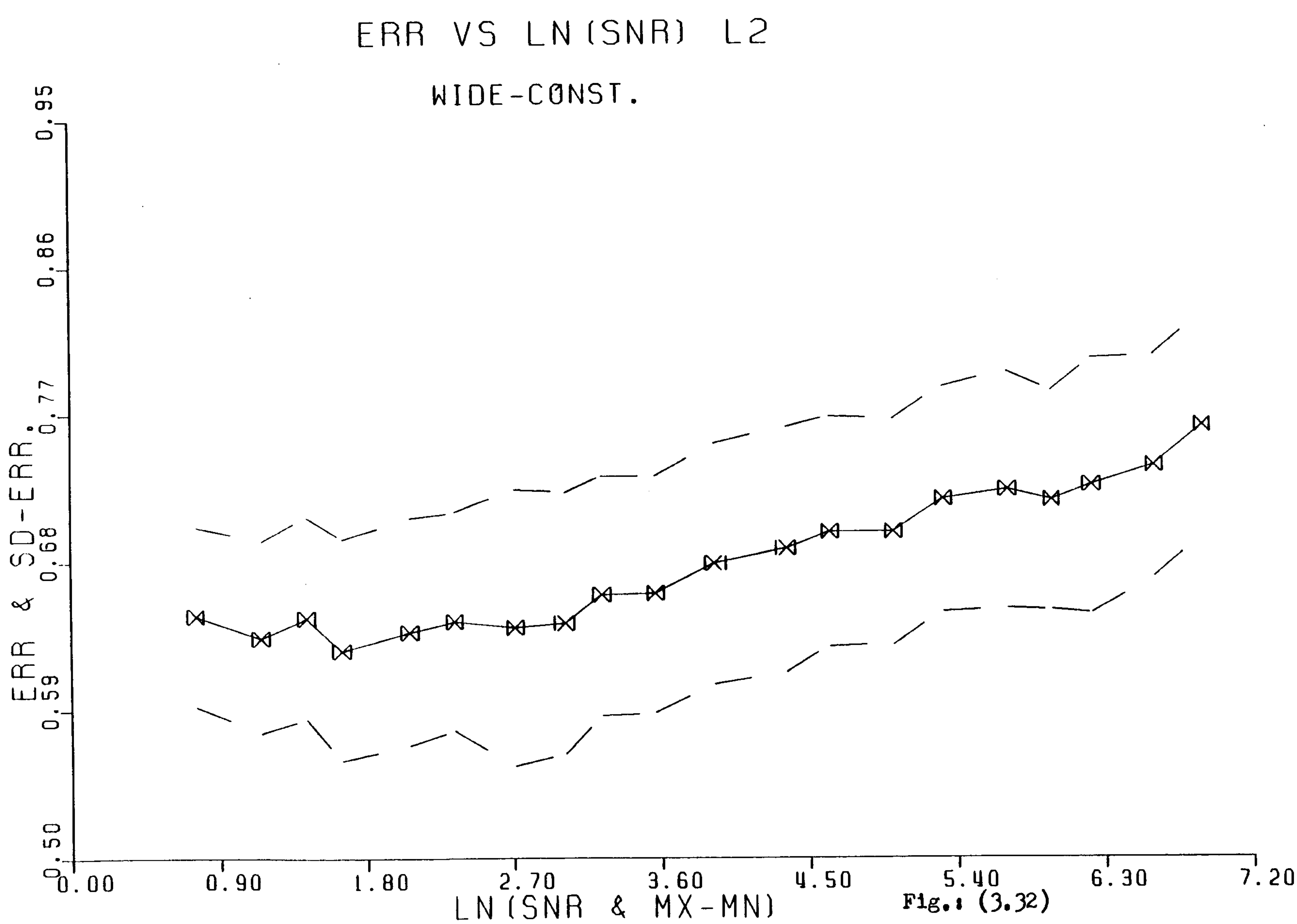

ERR VS LN(SNR) L2
WIDE-CØNST.
ERR & SD-ERR.
0.50
0.59
0.68
0.77
0.86
0.95
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (3.32)

Chapter IV

Morrison's Noise Removal Prior To Deconvolution

This chapter presents the study of the optimum use of Morrison's noise removal prior to deconvolution. After each Morrison iteration is applied to the data, the data are deconvolved by convolution with the two optimum inverse filters, either the 257 point narrow case filter or the 129 point wide case filter. The deconvolved result is then compared to the known input, f, using the L1 and L2 norms. The error in the deconvolution is then stored and compared to the error of the result from the succeeding iteration. The same techniques for convergence used in Chapter III are used in this chapter.

Optimization Procedure

The same experimental procedure used in Chapter III is also used here. Data sets having SNR's of 2 to 1000 are created by varying the NSF. An average SNR, AVSNR, and standard deviation, SDSNR, from the 100 data set for each NSF are calculated in a similar way as in Chapter III. However, there are 50 data sets that are optimized for the deconvolution case instead of 100. The number is reduced to 50 merely to save computer time.

Convergence Criteria

Once again the convergence criteria formulas used are the same as those used in Chapter III. However, in this chapter the convergence values are different. The convergence values of the narrow constant and the narrow ordinate-dependent noise are DF1=0.0005 and DF2=0.00005, and for the wide case the convergence values for the ordinate-dependent and the constant noise are 0.0000 and 0.0000.

These values were chosen according to the expected behavior of increasing optimum iteration number with increasing SNR. Also minimization of error is heavily considered. Similar tables and figures to those listed in Chapter III are also listed in this chapter.

Results For The Narrow Gaussian Iterations

Examining Tables (4.5)-(4.8) or Figures (4.1)-(4.8), one can see that the average number of iterations increase as the AVSNR2 increases for both constant and narrow noise and for both L1 and L2 norms.

It is also noticed that the average iteration number remains at the constant value 1 over the AVSNR2 2.2 to 10 range. For the ordinate-dependent noise the average number of iterations for the L1 norm is slightly higher than that for the L2, and the opposite is true for the constant noise.

Both the ordinate-dependent and the constant noise have nearly the same average number of iterations over the same range.

Results For The Wide Gaussian Iterations

From the investigation of Tables (4.9)-(4.16) or Figures (4.9)-(4.16) it is clear that in the wide case the average number of iterations increases monotonically as AVSNR2 increases for both norms and for both noise types. For both noise types and both norms the average iteration number remains constant at a value of 1 for AVSNR2 in the 2.2 to 10 range.

For both noise types the average iteration number in the L2 case is higher than that of the L1 case.

Error Results For The Narrow Gaussian

From Tables(4.13)-(4.16) or Figures (4.16)-(4.24), one can see that for both noise types and for both norms the average error improvement decreases monotonicaly as the AVSNR2 increases. Once again the largest error improvement takes place in the low AVSNR2 range. The error improvements at the higher AVSNR2 remain constant. The error improvements are nearly the same for both noise types and for both norms.

Error Results For The Wide Gaussian

By examination of Tables (4.17)-(4.20) or Figures (4.24)-(4.32), it is easy to see the monotonic decrease in error improvement as AVSNR2 increases for both constant and ordinate-dependent noise and for both L1 and L2 norms. For both noise types the large error improvement is at the low and middle AVSNR2 range and it decreases monotonically at the higher AVSNR2 range.

Both noise types have nearly the same error improvements over the same range of AVSNR2 for both norms. Also for both noise types the error improvements for the L1 case are greater than that of the L2.

Comparison Between The Narrow And Wide Iterations

Investigating Tables (4.5)-(4.12), one can see that for both noise types, both Gaussians, and both norms, that the average iteration number is constant over the low AVSNR2 range. Also for both Gaussians, both noise types, and both norms, the average number of iterations increases monotonically as the AVSNR2 increases. However, this monotonic increase is very slow in the wide case but it is large for the narrow case. For both noise types and both norms the average iteration number for the narrow case is much higher than that of the wide case over the middle of the AVSNR2 range.

Comparison Between Narrow And Wide Gaussian Errors

Tables(4.13)-(4.20) show that the average error improvement decreases monotonically as the AVSNR2 increases for both Gaussians, both noise types, and both norms. It is also noticed that greater error improvement occurs over the low AVSNR2 range. In the wide case the error improvement is much greater than that of the narrow case for both noise types and both norms, especially over the low AVSNR2 range.

TABLE(4.1)

NARROW ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.35942223E+00	2.55195550E+00	2.18037985E+00	2.56000000E+02
3.00000000E+00	3.14827908E+00	3.47611369E+00	2.87774171E+00	2.22000000E+02
4.00000000E+00	4.08657544E+00	4.32811419E+00	3.80287796E+00	2.23000000E+02
5.00000000E+00	4.92746842E+00	5.34327143E+00	4.48717719E+00	2.23000000E+02
7.50000000E+00	7.40686472E+00	8.02510457E+00	6.80834362E+00	2.20000000E+02
1.00000000E+01	9.63337120E+00	1.05093550E+01	8.96260791E+00	2.21000000E+02
1.50000000E+01	1.48674300E+01	1.63503901E+01	1.37781921E+01	2.38000000E+02
2.00000000E+01	1.97761245E+01	2.10675414E+01	1.81297613E+01	2.30000000E+02
2.50000000E+01	2.48138518E+01	2.68418723E+01	2.32734155E+01	2.34000000E+02
3.50000000E+01	3.53601890E+01	3.84241457E+01	3.25049140E+01	2.24000000E+02
5.00000000E+01	5.07320991E+01	5.53803790E+01	4.69246800E+01	2.23000000E+02
7.50000000E+01	7.26365065E+01	7.82292551E+01	6.64555496E+01	2.45000000E+02
1.00000000E+02	9.86421583E+01	1.06633051E+02	9.21968607E+01	2.44000000E+02
1.50000000E+02	1.56705876E+02	1.71423249E+02	1.44775875E+02	2.39000000E+02
2.00000000E+02	2.00731091E+02	2.13774956E+02	1.84496378E+02	2.16000000E+02
3.00000000E+02	3.00277695E+02	3.23188022E+02	2.78255166E+02	2.28000000E+02
4.00000000E+02	4.02015116E+02	4.37287655E+02	3.73261110E+02	2.17000000E+02
5.00000000E+02	4.86793026E+02	5.44315286E+02	4.55314741E+02	2.17000000E+02
7.50000000E+02	7.76887747E+02	8.53703896E+02	7.11141725E+02	2.44000000E+02
1.00000000E+03	1.02392829E+03	1.12064419E+03	9.53403283E+02	2.45000000E+02

TABLE(4.2)

NARROW CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.22506794E+00	2.38621271E+00	2.10729989E+00	2.38000000E+02
3.00000000E+00	3.16729423E+00	3.37307933E+00	2.94968408E+00	2.33000000E+02
4.00000000E+00	4.17633507E+00	4.39874407E+00	3.92267837E+00	2.28000000E+02
5.00000000E+00	5.04874788E+00	5.38479648E+00	4.76697065E+00	2.12000000E+02
7.50000000E+00	7.78913933E+00	8.35022374E+00	7.18744521E+00	2.08000000E+02
1.00000000E+01	9.94040217E+00	1.06081608E+01	9.40141229E+00	2.15000000E+02
1.50000000E+01	1.54917719E+01	1.64009805E+01	1.45667528E+01	2.53000000E+02
2.00000000E+01	2.03200407E+01	2.17322547E+01	1.91547921E+01	2.29000000E+02
2.50000000E+01	2.47933584E+01	2.62243374E+01	2.35747770E+01	2.27000000E+02
3.50000000E+01	3.54754203E+01	3.75725365E+01	3.31963981E+01	2.48000000E+02
5.00000000E+01	5.08791893E+01	5.38556248E+01	4.82263764E+01	2.61000000E+02
7.50000000E+01	7.49724836E+01	7.90093445E+01	6.98678281E+01	2.31000000E+02
1.00000000E+02	9.97131118E+01	1.05867797E+02	9.53332106E+01	2.65000000E+02
1.50000000E+02	1.55262568E+02	1.65115965E+02	1.45712055E+02	2.55000000E+02
2.00000000E+02	2.00982243E+02	2.13763231E+02	1.90580013E+02	2.48000000E+02
3.00000000E+02	3.08275840E+02	3.26353136E+02	2.91153732E+02	2.26000000E+02
4.00000000E+02	3.98087302E+02	4.30061312E+02	3.76841329E+02	2.16000000E+02
5.00000000E+02	5.08005722E+02	5.41432930E+02	4.77213916E+02	2.23000000E+02
7.50000000E+02	7.37176302E+02	7.81393907E+02	6.91401319E+02	2.28000000E+02
1.00000000E+03	1.00847931E+03	1.07368531E+03	9.50473132E+02	2.42000000E+02

TABLE(4.3)

WIDE ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36908557E+00	2.54620204E+00	2.17664384E+00	2.22000000E+02
3.00000000E+00	3.32565151E+00	3.53831958E+00	3.08710135E+00	2.24000000E+02
4.00000000E+00	4.16380400E+00	4.47283231E+00	3.88946038E+00	2.43000000E+02
5.00000000E+00	5.08401017E+00	5.50212864E+00	4.75998722E+00	2.56000000E+02
7.50000000E+00	7.57849148E+00	8.18519108E+00	7.07193696E+00	2.32000000E+02
1.00000000E+01	1.00019454E+01	1.06249221E+01	9.26366347E+00	2.34000000E+02
1.50000000E+01	1.48934502E+01	1.59908603E+01	1.38295455E+01	2.83000000E+02
2.00000000E+01	2.04109871E+01	2.22254802E+01	1.90220309E+01	2.16000000E+02
2.50000000E+01	2.54015084E+01	2.72926430E+01	2.37011937E+01	2.27000000E+02
3.50000000E+01	3.37608024E+01	3.63190222E+01	3.14019734E+01	2.10000000E+02
5.00000000E+01	4.97626756E+01	5.39967200E+01	4.66571769E+01	2.62000000E+02
7.50000000E+01	7.59405250E+01	8.21798920E+01	7.03716871E+01	2.31000000E+02
1.00000000E+02	1.02569749E+02	1.08799423E+02	9.42931977E+01	2.36000000E+02
1.50000000E+02	1.50024130E+02	1.62124363E+02	1.39140583E+02	2.15000000E+02
2.00000000E+02	1.96266800E+02	2.11735316E+02	1.83233647E+02	2.15000000E+02
3.00000000E+02	3.05491923E+02	3.34209071E+02	2.81305646E+02	2.01000000E+02
4.00000000E+02	3.95705933E+02	4.24479087E+02	3.68538435E+02	2.40000000E+02
5.00000000E+02	5.04784949E+02	5.44022808E+02	4.73036402E+02	2.66000000E+02
7.50000000E+02	7.43756010E+02	7.96960447E+02	6.88875321E+02	2.18000000E+02
1.00000000E+03	1.00215918E+03	1.07810420E+03	9.23955805E+02	2.44000000E+02

TABLE(4.4)

WIDE CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.13617036E+00	2.23292487E+00	2.03430656E+00	2.43000000E+02
3.00000000E+00	3.06970987E+00	3.21422512E+00	2.91768160E+00	2.23000000E+02
4.00000000E+00	4.17820803E+00	4.36720473E+00	3.95343262E+00	2.52000000E+02
5.00000000E+00	5.19199280E+00	5.51821882E+00	4.95895577E+00	2.41000000E+02
7.50000000E+00	7.75653389E+00	8.19688908E+00	7.39199227E+00	2.33000000E+02
1.00000000E+01	1.02489895E+01	1.07574333E+01	9.69724038E+00	2.21000000E+02
1.50000000E+01	1.56627491E+01	1.65028142E+01	1.47471370E+01	2.45000000E+02
2.00000000E+01	2.07805204E+01	2.19570478E+01	1.96380037E+01	2.11000000E+02
2.50000000E+01	2.63070969E+01	2.75395580E+01	2.45881003E+01	2.40000000E+02
3.50000000E+01	3.54470500E+01	3.75805539E+01	3.37509649E+01	2.20000000E+02
5.00000000E+01	5.21702046E+01	5.47469646E+01	4.95191979E+01	2.43000000E+02
7.50000000E+01	7.57792112E+01	7.97732541E+01	7.18080556E+01	2.62000000E+02
1.00000000E+02	1.01793999E+02	1.06562079E+02	9.62485585E+01	2.26000000E+02
1.50000000E+02	1.51220447E+02	1.60335944E+02	1.43938243E+02	2.38000000E+02
2.00000000E+02	2.01899167E+02	2.11110661E+02	1.91443195E+02	2.33000000E+02
3.00000000E+02	3.09997495E+02	3.29111739E+02	2.95737508E+02	2.46000000E+02
4.00000000E+02	4.02217668E+02	4.24484463E+02	3.80854088E+02	2.22000000E+02
5.00000000E+02	5.20585347E+02	5.52692373E+02	4.91882292E+02	2.35000000E+02
7.50000000E+02	7.58035278E+02	7.95541403E+02	7.22598636E+02	2.68000000E+02
1.00000000E+03	1.00259085E+03	1.05152119E+03	9.54887189E+02	2.42000000E+02

TABLE(4.5)

NARROW ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.35942223E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14827908E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.08657544E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.92746842E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.40686472E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
9.63337120E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.48674300E+01	1.04000000E+00	1.95959179E-01	1.20000000E+00	4.00000000E-01
1.97761245E+01	1.20000000E+00	4.89897949E-01	1.76000000E+00	4.71593045E-01
2.48138518E+01	1.40000000E+00	6.63324958E-01	2.24000000E+00	5.85149554E-01
3.53601890E+01	1.84000000E+00	9.87117014E-01	3.08000000E+00	7.70454411E-01
5.07320991E+01	3.64000000E+00	3.14807878E+00	4.78000000E+00	2.22970850E+00
7.26365065E+01	6.34000000E+00	3.99804952E+00	7.72000000E+00	3.08570899E+00
9.86421583E+01	1.12000000E+01	7.98999374E+00	1.18000000E+01	6.79411510E+00
1.56705876E+02	2.50000000E+01	1.36718689E+01	2.11200000E+01	1.12705634E+01
2.00731091E+02	2.85000000E+01	1.44003472E+01	2.63800000E+01	1.33174923E+01
3.00277695E+02	3.55800000E+01	1.57188931E+01	3.47400000E+01	1.54554974E+01
4.02015116E+02	3.98800000E+01	1.52021577E+01	3.96000000E+01	1.55473470E+01
4.86793026E+02	4.18800000E+01	1.43647346E+01	3.98400000E+01	1.56248008E+01
7.76887747E+02	4.69000000E+01	1.39688940E+01	4.59800000E+01	1.50897184E+01
1.02392829E+03	4.84600000E+01	1.28720006E+01	4.67400000E+01	1.32752552E+01

TABLE(4.6)

NARROW ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.20000000E+00	1.00000000E+00	2.00000000E+00
1.20000000E+00	1.00000000E+00	3.00000000E+00	1.76000000E+00	1.00000000E+00	3.00000000E+00
1.40000000E+00	1.00000000E+00	4.00000000E+00	2.24000000E+00	2.00000000E+00	5.00000000E+00
1.84000000E+00	1.00000000E+00	5.00000000E+00	3.08000000E+00	2.00000000E+00	5.00000000E+00
3.64000000E+00	1.00000000E+00	1.80000000E+01	4.78000000E+00	3.00000000E+00	1.60000000E+01
6.34000000E+00	1.00000000E+00	2.30000000E+01	7.72000000E+00	4.00000000E+00	2.30000000E+01
1.12000000E+01	2.00000000E+00	4.30000000E+01	1.18000000E+01	6.00000000E+00	4.10000000E+01
2.50000000E+01	3.00000000E+00	6.00000000E+01	2.11200000E+01	9.00000000E+00	5.20000000E+01
2.85000000E+01	8.00000000E+00	5.60000000E+01	2.63800000E+01	1.10000000E+01	5.80000000E+01
3.55800000E+01	1.70000000E+01	6.30000000E+01	3.47400000E+01	1.60000000E+01	6.30000000E+01
3.98800000E+01	1.80000000E+01	6.60000000E+01	3.96000000E+01	1.80000000E+01	6.60000000E+01
4.18800000E+01	1.70000000E+01	6.60000000E+01	3.98400000E+01	1.80000000E+01	6.80000000E+01
4.69000000E+01	2.30000000E+01	6.80000000E+01	4.59800000E+01	2.30000000E+01	6.60000000E+01
4.84600000E+01	2.50000000E+01	6.60000000E+01	4.67400000E+01	2.50000000E+01	6.80000000E+01

TABLE(4.7)

NARROW CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.22506794E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.16729423E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.17633507E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.04874788E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.78913933E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
9.94040217E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.54917719E+01	1.08000000E+00	2.71293199E-01	1.48000000E+00	4.99599840E-01
2.03200407E+01	1.34000000E+00	5.14198405E-01	2.06000000E+00	3.69323706E-01
2.47933584E+01	1.42000000E+00	5.32541078E-01	2.18000000E+00	3.84187454E-01
3.54754203E+01	2.04000000E+00	7.98999374E-01	3.38000000E+00	8.45931439E-01
5.08791893E+01	3.04000000E+00	1.59949992E+00	5.32000000E+00	1.65456943E+00
7.49724836E+01	5.00000000E+00	2.52190404E+00	8.42000000E+00	4.75011579E+00
9.97131118E+01	1.37200000E+01	9.70781129E+00	1.38000000E+01	7.98498591E+00
1.55262568E+02	2.40600000E+01	1.23861374E+01	2.29400000E+01	1.03911693E+01
2.00982243E+02	2.78200000E+01	1.39279431E+01	2.85600000E+01	1.30754120E+01
3.08275840E+02	3.67600000E+01	1.59418443E+01	3.71000000E+01	1.52541798E+01
3.98087302E+02	4.20400000E+01	1.51577835E+01	4.40600000E+01	1.42216877E+01
5.08005722E+02	4.17200000E+01	1.62222563E+01	4.23600000E+01	1.59884458E+01
7.37176302E+02	4.31800000E+01	1.32494377E+01	4.40000000E+01	1.32090878E+01
1.00847931E+03	4.62600000E+01	1.17793209E+01	4.83600000E+01	1.15477444E+01

TABLE(4.8)

NARROW CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.08000000E+00	1.00000000E+00	2.00000000E+00	1.48000000E+00	1.00000000E+00	2.00000000E+00
1.34000000E+00	1.00000000E+00	3.00000000E+00	2.06000000E+00	1.00000000E+00	3.00000000E+00
1.42000000E+00	1.00000000E+00	3.00000000E+00	2.18000000E+00	2.00000000E+00	3.00000000E+00
2.04000000E+00	1.00000000E+00	4.00000000E+00	3.38000000E+00	2.00000000E+00	6.00000000E+00
3.04000000E+00	1.00000000E+00	7.00000000E+00	5.32000000E+00	4.00000000E+00	1.30000000E+01
5.00000000E+00	1.00000000E+00	1.00000000E+01	8.42000000E+00	5.00000000E+00	3.80000000E+01
1.37200000E+01	2.00000000E+00	4.70000000E+01	1.38000000E+01	6.00000000E+00	4.20000000E+01
2.40600000E+01	9.00000000E+00	5.40000000E+01	2.29400000E+01	1.10000000E+01	5.00000000E+01
2.78200000E+01	1.10000000E+01	6.10000000E+01	2.85600000E+01	1.10000000E+01	5.60000000E+01
3.67600000E+01	1.60000000E+01	6.40000000E+01	3.71000000E+01	1.50000000E+01	6.60000000E+01
4.20400000E+01	1.60000000E+01	6.40000000E+01	4.40600000E+01	1.50000000E+01	6.50000000E+01
4.17200000E+01	1.90000000E+01	6.60000000E+01	4.23600000E+01	1.80000000E+01	6.70000000E+01
4.31800000E+01	2.10000000E+01	6.70000000E+01	4.40000000E+01	2.10000000E+01	6.60000000E+01
4.62600000E+01	2.60000000E+01	6.80000000E+01	4.83600000E+01	2.60000000E+01	6.80000000E+01

TABLE(4.9)

WIDE ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36908557E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.32565151E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.16380400E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.08401017E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.57849148E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.00019454E+01	1.04000000E+00	1.95959179E-01	1.02000000E+00	1.40000000E-01
1.48934502E+01	1.26000000E+00	4.38634244E-01	1.26000000E+00	4.38634244E-01
2.04109871E+01	1.82000000E+00	3.84187454E-01	1.84000000E+00	3.66606056E-01
2.54015084E+01	2.00000000E+00	0.00000000E+00	2.08000000E+00	2.71293199E-01
3.37608024E+01	2.20000000E+00	4.00000000E-01	2.46000000E+00	4.98397432E-01
4.97626756E+01	2.78000000E+00	7.01141926E-01	3.36000000E+00	7.41889480E-01
7.59405250E+01	3.64000000E+00	9.11262860E-01	4.38000000E+00	1.19816526E+00
1.02569749E+02	4.38000000E+00	9.14111591E-01	5.46000000E+00	1.44512975E+00
1.50024130E+02	5.72000000E+00	1.29676521E+00	7.80000000E+00	2.15406592E+00
1.96266800E+02	6.82000000E+00	1.33701159E+00	9.58000000E+00	2.09847564E+00
3.05491923E+02	8.48000000E+00	1.00478853E+00	1.25200000E+01	2.95458965E+00
3.95705933E+02	8.80000000E+00	7.21110255E-01	1.34600000E+01	2.66240493E+00
5.04784949E+02	8.92000000E+00	4.40000000E-01	1.36000000E+01	1.70880075E+00
7.43756010E+02	9.00000000E+00	0.00000000E+00	1.44600000E+01	4.98397432E-01
1.00215918E+03	9.00000000E+00	0.00000000E+00	1.45400000E+01	5.37028863E-01

TABLE(4.10)

WIDE ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.02000000E+00	1.00000000E+00	2.00000000E+00
1.26000000E+00	1.00000000E+00	2.00000000E+00	1.26000000E+00	1.00000000E+00	2.00000000E+00
1.82000000E+00	1.00000000E+00	2.00000000E+00	1.84000000E+00	1.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.08000000E+00	2.00000000E+00	3.00000000E+00
2.20000000E+00	2.00000000E+00	3.00000000E+00	2.46000000E+00	2.00000000E+00	3.00000000E+00
2.78000000E+00	2.00000000E+00	5.00000000E+00	3.36000000E+00	2.00000000E+00	5.00000000E+00
3.64000000E+00	2.00000000E+00	6.00000000E+00	4.38000000E+00	3.00000000E+00	9.00000000E+00
4.38000000E+00	3.00000000E+00	6.00000000E+00	5.46000000E+00	4.00000000E+00	9.00000000E+00
5.72000000E+00	3.00000000E+00	9.00000000E+00	7.80000000E+00	5.00000000E+00	1.50000000E+01
6.82000000E+00	4.00000000E+00	9.00000000E+00	9.58000000E+00	6.00000000E+00	1.40000000E+01
8.48000000E+00	6.00000000E+00	9.00000000E+00	1.25200000E+01	8.00000000E+00	2.50000000E+01
8.80000000E+00	6.00000000E+00	9.00000000E+00	1.34600000E+01	9.00000000E+00	2.60000000E+01
8.92000000E+00	6.00000000E+00	9.00000000E+00	1.36000000E+01	9.00000000E+00	1.50000000E+01
9.00000000E+00	9.00000000E+00	9.00000000E+00	1.44600000E+01	1.40000000E+01	1.50000000E+01
9.00000000E+00	9.00000000E+00	9.00000000E+00	1.45400000E+01	1.40000000E+01	1.60000000E+01

TABLE(4.11)

WIDE CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.13617036E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.06970987E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.17820803E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.19199280E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.75653389E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.02489895E+01	1.04000000E+00	1.95959179E-01	1.08000000E+00	2.71293199E-01
1.56627491E+01	1.38000000E+00	4.85386444E-01	1.52000000E+00	4.99599840E-01
2.07805204E+01	1.80000000E+00	4.00000000E-01	1.92000000E+00	2.71293199E-01
2.63070969E+01	2.00000000E+00	0.00000000E+00	2.00000000E+00	0.00000000E+00
3.54470500E+01	2.00000000E+00	0.00000000E+00	2.00000000E+00	0.00000000E+00
5.21702046E+01	2.00000000E+00	0.00000000E+00	2.08000000E+00	3.91918359E-01
7.57792112E+01	2.00000000E+00	0.00000000E+00	2.68000000E+00	9.47417543E-01
1.01793999E+02	2.08000000E+00	3.91918359E-01	3.40000000E+00	1.24899960E+00
1.51220447E+02	2.42000000E+00	9.18477000E-01	4.52000000E+00	6.99714227E-01
2.01899167E+02	3.26000000E+00	1.26190332E+00	5.14000000E+00	1.57492857E+00
3.09997495E+02	4.50000000E+00	7.00000000E-01	5.14000000E+00	6.00333241E-01
4.02217668E+02	4.92000000E+00	2.71293199E-01	6.58000000E+00	2.85720143E+00
5.20585347E+02	5.34000000E+00	1.08830143E+00	8.62000000E+00	4.14675777E+00
7.58035278E+02	5.28000000E+00	8.25590698E-01	1.36200000E+01	4.99955998E+00
1.00259085E+03	5.66000000E+00	1.08830143E+00	1.63800000E+01	4.59952171E+00

TABLE(4.12)

WIDE CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.08000000E+00	1.00000000E+00	2.00000000E+00
1.38000000E+00	1.00000000E+00	2.00000000E+00	1.52000000E+00	1.00000000E+00	2.00000000E+00
1.80000000E+00	1.00000000E+00	2.00000000E+00	1.92000000E+00	1.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.08000000E+00	2.00000000E+00	4.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.68000000E+00	2.00000000E+00	4.00000000E+00
2.08000000E+00	2.00000000E+00	4.00000000E+00	3.40000000E+00	2.00000000E+00	5.00000000E+00
2.42000000E+00	2.00000000E+00	5.00000000E+00	4.52000000E+00	2.00000000E+00	5.00000000E+00
3.26000000E+00	2.00000000E+00	5.00000000E+00	5.14000000E+00	4.00000000E+00	1.50000000E+01
4.50000000E+00	2.00000000E+00	5.00000000E+00	5.14000000E+00	5.00000000E+00	9.00000000E+00
4.92000000E+00	4.00000000E+00	5.00000000E+00	6.58000000E+00	5.00000000E+00	1.50000000E+01
5.34000000E+00	5.00000000E+00	9.00000000E+00	8.62000000E+00	5.00000000E+00	2.30000000E+01
5.28000000E+00	5.00000000E+00	9.00000000E+00	1.36200000E+01	5.00000000E+00	2.20000000E+01
5.66000000E+00	5.00000000E+00	9.00000000E+00	1.63800000E+01	6.00000000E+00	2.40000000E+01

TABLE(4.13)

NARROW ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.35942223E+00	2.23465862E-01	6.87068277E-02	2.27789051E-01	7.18021953E-02
3.14827908E+00	2.17162394E-01	5.49828842E-02	2.27476960E-01	5.22195013E-02
4.08657544E+00	2.08224927E-01	4.33854533E-02	2.17590447E-01	3.96498783E-02
4.92746842E+00	2.37778984E-01	6.15989690E-02	2.43798306E-01	6.23681282E-02
7.40686472E+00	2.53202762E-01	6.29698506E-02	2.65960953E-01	6.45311168E-02
9.63337120E+00	2.79907104E-01	7.34586655E-02	2.93567504E-01	6.86270805E-02
1.48674300E+01	3.15608969E-01	7.34138058E-02	3.54589587E-01	7.91802455E-02
1.97761245E+01	3.80329613E-01	1.11927113E-01	4.29040459E-01	1.19572679E-01
2.48138518E+01	4.62701085E-01	1.32096233E-01	5.26482280E-01	1.38270004E-01
3.53601890E+01	5.11201301E-01	1.16153013E-01	5.65108597E-01	1.28069331E-01
5.07320991E+01	6.26474837E-01	1.48440135E-01	6.54477441E-01	1.30730019E-01
7.26365065E+01	7.36611756E-01	1.47171193E-01	7.57694627E-01	1.37281652E-01
9.86421583E+01	8.35151704E-01	1.28324544E-01	8.32092193E-01	1.16669296E-01
1.56705876E+02	9.08195866E-01	1.19329846E-01	8.97289194E-01	1.17939907E-01
2.00731091E+02	9.19841421E-01	1.09299135E-01	9.22522234E-01	1.03477302E-01
3.00277695E+02	9.36473848E-01	8.96145837E-02	9.30444262E-01	9.60248044E-02
4.02015116E+02	9.54646165E-01	8.57538718E-02	9.45577184E-01	9.04211796E-02
4.86793026E+02	9.53204850E-01	9.55024182E-02	9.37761841E-01	1.02235833E-01
7.76887747E+02	9.61064968E-01	7.72980094E-02	9.44539909E-01	9.39978771E-02
1.02392829E+03	9.67952030E-01	7.77357467E-02	9.50690672E-01	9.31389767E-02

TABLE(4.14)

NARROW ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.23465862E-01	1.38749296E-01	5.24996750E-01	2.27789051E-01	1.45636156E-01	5.22303122E-01
2.17162394E-01	1.34314583E-01	4.52019607E-01	2.27476960E-01	1.49834134E-01	4.02409086E-01
2.08224927E-01	1.36712440E-01	3.12636238E-01	2.17590447E-01	1.55476258E-01	3.12267748E-01
2.37778984E-01	1.23746642E-01	4.25984384E-01	2.43798306E-01	1.39953825E-01	4.23917764E-01
2.53202762E-01	1.28155003E-01	4.68806003E-01	2.65960953E-01	1.35701891E-01	4.52808007E-01
2.79907104E-01	1.62182768E-01	4.99940032E-01	2.93567504E-01	1.62712876E-01	4.66587946E-01
3.15608969E-01	1.96186042E-01	5.43619593E-01	3.54589587E-01	2.06633108E-01	5.75021141E-01
3.80329613E-01	2.03969722E-01	7.75096250E-01	4.29040459E-01	2.18061880E-01	8.27537797E-01
4.62701085E-01	2.54741443E-01	8.60999453E-01	5.26482280E-01	3.04955974E-01	9.40853601E-01
5.11201301E-01	3.25449130E-01	8.38688642E-01	5.65108597E-01	3.37886583E-01	8.58088128E-01
6.26474837E-01	3.26000764E-01	9.70714000E-01	6.54477441E-01	3.81555436E-01	9.91231101E-01
7.36611756E-01	4.16852000E-01	1.16653598E+00	7.57694627E-01	4.50703231E-01	1.00469451E+00
8.35151704E-01	5.60645861E-01	1.08949918E+00	8.32092193E-01	5.36060344E-01	1.00465866E+00
9.08195866E-01	4.65590401E-01	1.02819694E+00	8.97289194E-01	4.73527076E-01	1.00662570E+00
9.19841421E-01	5.56468718E-01	1.00936991E+00	9.22522234E-01	5.68073321E-01	1.01164428E+00
9.36473848E-01	6.46242584E-01	1.03759816E+00	9.30444262E-01	6.14244635E-01	1.00588630E+00
9.54646165E-01	6.19580655E-01	1.00794349E+00	9.45577184E-01	6.36624230E-01	1.00597306E+00
9.53204850E-01	6.00903168E-01	1.01397836E+00	9.37761841E-01	5.99774965E-01	1.00909873E+00
9.61064968E-01	6.90451955E-01	1.01583990E+00	9.44539909E-01	6.42194120E-01	1.01040433E+00
9.67952030E-01	7.36503886E-01	1.02459982E+00	9.50690672E-01	6.29378877E-01	1.01739100E+00

TABLE(4.15)

NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.22506794E+00	2.61572337E-01	7.23569787E-02	2.59328326E-01	6.63261462E-02
3.16729423E+00	2.49007239E-01	5.19744572E-02	2.51859748E-01	4.81167033E-02
4.17633507E+00	2.50863412E-01	6.26550067E-02	2.49211023E-01	5.75519707E-02
5.04874788E+00	2.65531831E-01	5.50985368E-02	2.67386613E-01	5.43607844E-02
7.78913933E+00	3.00359035E-01	7.81617225E-02	3.06055672E-01	7.59105057E-02
9.94040217E+00	3.05965237E-01	6.80139116E-02	3.21719095E-01	7.34314991E-02
1.54917719E+01	3.66874399E-01	8.49501522E-02	4.10543690E-01	9.12843140E-02
2.03200407E+01	3.97951967E-01	7.37874524E-02	4.46430983E-01	8.02317581E-02
2.47933584E+01	4.33549476E-01	9.82788796E-02	4.98262378E-01	1.11882416E-01
3.54754203E+01	5.05593142E-01	9.87166084E-02	5.76159353E-01	1.19325114E-01
5.08791893E+01	6.34962891E-01	1.24141983E-01	6.87163388E-01	1.28376959E-01
7.49724836E+01	7.42711346E-01	1.49461440E-01	7.77268093E-01	1.36718934E-01
9.97131118E+01	8.29514694E-01	1.33218289E-01	8.56579403E-01	1.23258107E-01
1.55262568E+02	9.07464566E-01	1.19040988E-01	9.20737271E-01	1.07246949E-01
2.00982243E+02	9.33553350E-01	9.54151415E-02	9.40132245E-01	8.46004879E-02
3.08275840E+02	9.30911175E-01	1.05375164E-01	9.47161019E-01	8.96644412E-02
3.98087302E+02	9.57961764E-01	1.02750853E-01	9.63867824E-01	9.63273688E-02
5.08005722E+02	9.38378336E-01	1.07471536E-01	9.48146278E-01	9.48909258E-02
7.37176302E+02	9.36006975E-01	1.26627211E-01	9.38359820E-01	1.17510581E-01
1.00847931E+03	9.61676498E-01	9.00314233E-02	9.68960211E-01	7.92261446E-02

TABLE(4.16)

NARROW CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.61572337E-01	1.50658256E-01	5.19108680E-01	2.59328326E-01	1.60930807E-01	4.92956385E-01
2.49007239E-01	1.69445040E-01	4.08107596E-01	2.51859748E-01	1.55301524E-01	4.12502047E-01
2.50863412E-01	1.48285735E-01	4.40646460E-01	2.49211023E-01	1.68070025E-01	4.16581587E-01
2.65531831E-01	1.62348326E-01	3.86121937E-01	2.67386613E-01	1.53394524E-01	3.94422051E-01
3.00359035E-01	1.41029174E-01	5.42899853E-01	3.06055672E-01	1.46641310E-01	5.40399504E-01
3.05965237E-01	1.62216280E-01	4.78198128E-01	3.21719095E-01	1.62965068E-01	5.31140538E-01
3.66874399E-01	2.47319974E-01	5.97010659E-01	4.10543690E-01	2.66918635E-01	6.42768268E-01
3.97951967E-01	2.35099576E-01	5.58433316E-01	4.46430983E-01	2.51084799E-01	6.46312357E-01
4.33549476E-01	2.58327117E-01	7.49688662E-01	4.98262378E-01	2.61603784E-01	8.16225214E-01
5.05593142E-01	3.03615771E-01	7.28001061E-01	5.76159353E-01	3.25035163E-01	8.26863899E-01
6.34962891E-01	3.11088647E-01	9.06811491E-01	6.87163388E-01	3.82753908E-01	9.77924778E-01
7.42711346E-01	3.90327279E-01	1.09471773E+00	7.77268093E-01	4.11657543E-01	1.00466115E+00
8.29514694E-01	5.34419138E-01	1.00553847E+00	8.56579403E-01	5.71972487E-01	1.00498649E+00
9.07464566E-01	5.92858451E-01	1.01898147E+00	9.20737271E-01	6.23477340E-01	1.00777455E+00
9.33553350E-01	6.35883698E-01	1.00564716E+00	9.40132245E-01	6.62871049E-01	1.00574841E+00
9.30911175E-01	5.36790289E-01	1.00597984E+00	9.47161019E-01	5.77283699E-01	1.00559805E+00
9.57961764E-01	3.95148929E-01	1.01020913E+00	9.63867824E-01	4.35435724E-01	1.00608624E+00
9.38378336E-01	5.53520257E-01	1.00986926E+00	9.48146278E-01	6.04540217E-01	1.00671157E+00
9.36006975E-01	4.48923110E-01	1.01507748E+00	9.38359820E-01	5.01514435E-01	1.01337017E+00
9.61676498E-01	6.38425080E-01	1.02073145E+00	9.68960211E-01	6.61114216E-01	1.01691789E+00

TABLE(4.17)

WIDE ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36908557E+00	2.11639157E-06	1.19969739E-06	2.44505455E-06	1.40461793E-06
3.32565151E+00	2.46924481E-06	1.47349727E-06	2.97061810E-06	1.82670401E-06
4.16380400E+00	2.40482596E-06	1.18023859E-06	2.68063312E-06	1.24169516E-06
5.08401017E+00	2.55498487E-06	1.21431441E-06	2.94703947E-06	1.41936350E-06
7.57849148E+00	2.81538246E-06	1.41253475E-06	3.21232082E-06	1.59670316E-06
1.00019454E+01	3.58364329E-06	1.87830088E-06	3.98926246E-06	1.96122280E-06
1.48934502E+01	5.86115488E-06	2.65046454E-06	6.93163601E-06	3.16447805E-06
2.04109871E+01	6.17457790E-06	3.03585112E-06	7.52450855E-06	3.66801303E-06
2.54015084E+01	8.75455444E-06	5.06158993E-06	1.05737841E-05	6.24724486E-06
3.37608024E+01	9.50872478E-06	5.26433214E-06	1.17854350E-05	6.40762946E-06
4.97626756E+01	1.19494306E-05	6.29608127E-06	1.44622270E-05	7.02431786E-06
7.59405250E+01	1.92407951E-05	1.13099550E-05	2.39623373E-05	1.29445560E-05
1.02569749E+02	2.56385452E-05	1.26100518E-05	3.20450664E-05	1.50979740E-05
1.50024130E+02	3.26249694E-05	1.60899480E-05	4.18434459E-05	2.07728954E-05
1.96266800E+02	4.33187752E-05	2.74932762E-05	5.55954367E-05	3.60311161E-05
3.05491923E+02	6.40072992E-05	4.93850358E-05	8.53228191E-05	6.19909623E-05
3.95705933E+02	7.88187243E-05	4.16985505E-05	1.00940058E-04	4.82924160E-05
5.04784949E+02	8.18080613E-05	3.24950691E-05	1.10477352E-04	3.96623850E-05
7.43756010E+02	1.36643444E-04	7.10822269E-05	1.84674039E-04	9.25273853E-05
1.00215918E+03	1.66715064E-04	9.64749910E-05	2.18427115E-04	1.19683397E-04

TABLE(4.18)

WIDE ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.11639157E-06	1.01488019E-06	9.53443393E-06	2.44505455E-06	1.16976199E-06	1.10171935E-05
2.46924481E-06	6.88328172E-07	7.58191525E-06	2.97061810E-06	9.53849170E-07	9.31538882E-06
2.40482596E-06	8.48634196E-07	6.06417930E-06	2.68063312E-06	9.77257924E-07	6.47194076E-06
2.55498487E-06	9.36613759E-07	6.81058204E-06	2.94703947E-06	1.17189869E-06	7.80432139E-06
2.81538246E-06	1.19292011E-06	7.50858593E-06	3.21232082E-06	1.41433535E-06	8.70674602E-06
3.58364329E-06	1.40039600E-06	9.60378430E-06	3.98926246E-06	1.82571715E-06	1.11441427E-05
5.86115488E-06	1.54716432E-06	1.36113860E-05	6.93163601E-06	1.98112247E-06	1.58127153E-05
6.17457790E-06	2.61863838E-06	1.95732558E-05	7.52450855E-06	3.16031051E-06	2.26686000E-05
8.75455444E-06	2.72111993E-06	2.73955060E-05	1.05737841E-05	3.67186852E-06	3.29654427E-05
9.50872478E-06	2.63143542E-06	3.05614654E-05	1.17854350E-05	3.39214316E-06	4.09514121E-05
1.19494306E-05	4.17261101E-06	3.22435763E-05	1.44622270E-05	6.23976713E-06	3.84505259E-05
1.92407951E-05	6.24241460E-06	6.42019776E-05	2.39623373E-05	8.86535447E-06	6.82840588E-05
2.56385452E-05	7.08862439E-06	5.47352025E-05	3.20450664E-05	1.07673411E-05	6.38644281E-05
3.26249694E-05	1.17341240E-05	9.49872823E-05	4.18434459E-05	1.67249081E-05	1.13324421E-04
4.33187752E-05	1.55536336E-05	1.85373892E-04	5.55954367E-05	2.06708474E-05	2.34341883E-04
6.40072992E-05	1.93153763E-05	3.14420154E-04	8.53228191E-05	2.36829314E-05	3.57243746E-04
7.88187243E-05	2.85718196E-05	1.89535565E-04	1.00940058E-04	3.90850426E-05	2.23851678E-04
8.18080613E-05	3.87319990E-05	1.85372209E-04	1.10477352E-04	5.53643001E-05	2.31432148E-04
1.36643444E-04	4.22881607E-05	4.23653130E-04	1.84674039E-04	5.66180388E-05	5.46588803E-04
1.66715064E-04	6.25803677E-05	6.74765430E-04	2.18427115E-04	8.18985213E-05	8.24100638E-04

TABLE(4.19)

WIDE CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.13617036E+00	2.55274910E-06	8.91097563E-07	2.63199233E-06	8.46186307E-07
3.06970987E+00	3.08100430E-06	1.26018456E-06	3.20586239E-06	1.26079121E-06
4.17820803E+00	3.09443257E-06	1.27162884E-06	3.20729086E-06	1.27859925E-06
5.19199280E+00	3.01467780E-06	1.16546033E-06	3.15777502E-06	1.16595741E-06
7.75653389E+00	3.31089807E-06	1.16445859E-06	3.63496493E-06	1.25944639E-06
1.02489895E+01	3.91267979E-06	1.52702470E-06	4.30261599E-06	1.49845028E-06
1.56627491E+01	5.82387550E-06	2.50936231E-06	6.91299897E-06	2.97135264E-06
2.07805204E+01	6.19526287E-06	2.65322365E-06	7.50350123E-06	2.86566701E-06
2.63070969E+01	7.77212750E-06	3.13907668E-06	9.64235708E-06	3.88808492E-06
3.54470500E+01	9.63891747E-06	4.05453140E-06	1.25606388E-05	5.02128903E-06
5.21702046E+01	1.26930207E-05	4.74050318E-06	1.72343842E-05	6.02449726E-06
7.57792112E+01	1.51482335E-05	5.84918269E-06	2.12340699E-05	7.64594029E-06
1.01793999E+02	2.23613646E-05	7.11882247E-06	3.04854834E-05	9.29565284E-06
1.51220447E+02	3.51176244E-05	1.26661660E-05	4.72918622E-05	1.69714758E-05
2.01899167E+02	4.21519940E-05	1.90155931E-05	5.67474003E-05	2.32892176E-05
3.09997495E+02	5.52837134E-05	2.47655338E-05	7.98474408E-05	3.41636263E-05
4.02217668E+02	7.21030064E-05	2.87480369E-05	1.04108153E-04	4.30277314E-05
5.20585347E+02	9.01295016E-05	4.38166282E-05	1.29229379E-04	5.61794265E-05
7.58035278E+02	1.55980294E-04	7.78186310E-05	2.13562374E-04	9.79256280E-05
1.00259085E+03	1.68881524E-04	5.92312273E-05	2.29339745E-04	8.12109524E-05

TABLE(4.20)

WIDE CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.55274910E-06	1.27580460E-06	5.18414673E-06	2.63199233E-06	1.45891935E-06	4.96674531E-06
3.08100430E-06	1.44703389E-06	7.31695955E-06	3.20586239E-06	1.27006162E-06	6.89703498E-06
3.09443257E-06	1.08943829E-06	7.54225779E-06	3.20729086E-06	1.32456042E-06	8.12316003E-06
3.01467780E-06	1.31589503E-06	7.40158776E-06	3.15777502E-06	1.22569557E-06	6.54498818E-06
3.31089807E-06	1.54718885E-06	6.40355825E-06	3.63496493E-06	1.68419903E-06	6.89402347E-06
3.91267979E-06	1.82130669E-06	1.00823391E-05	4.30261599E-06	2.18392713E-06	9.63826742E-06
5.82387550E-06	2.20035847E-06	1.33780320E-05	6.91299897E-06	2.70652587E-06	1.45367508E-05
6.19526287E-06	2.83801116E-06	1.57697539E-05	7.50350123E-06	3.39720676E-06	1.88128088E-05
7.77212750E-06	3.12293827E-06	1.80943367E-05	9.64235708E-06	3.97897363E-06	2.38430329E-05
9.63891747E-06	2.74966647E-06	2.45647862E-05	1.25606388E-05	3.88065321E-06	2.90029629E-05
1.26930207E-05	5.22802806E-06	3.07251388E-05	1.72343842E-05	7.38879565E-06	3.76434378E-05
1.51482335E-05	6.76301515E-06	3.45884980E-05	2.12340699E-05	9.31424990E-06	4.66162813E-05
2.23613646E-05	8.73178441E-06	4.43393016E-05	3.04854834E-05	1.29983098E-05	5.38089014E-05
3.51176244E-05	1.65045509E-05	7.17975039E-05	4.72918622E-05	2.02767361E-05	1.01216482E-04
4.21519940E-05	1.85019957E-05	1.20288087E-04	5.67474003E-05	2.55956594E-05	1.28337793E-04
5.52837134E-05	2.16189381E-05	1.42133730E-04	7.98474408E-05	3.45455152E-05	2.08307012E-04
7.21030064E-05	3.50243514E-05	1.98802753E-04	1.04108153E-04	5.49154882E-05	3.06714408E-04
9.01295016E-05	4.29408313E-05	2.48126386E-04	1.29229379E-04	6.92401689E-05	3.30796689E-04
1.55980294E-04	4.91742921E-05	4.63151752E-04	2.13562374E-04	6.88067274E-05	5.33252325E-04
1.68881524E-04	6.86885631E-05	3.46372711E-04	2.29339745E-04	1.06888648E-04	4.85481344E-04

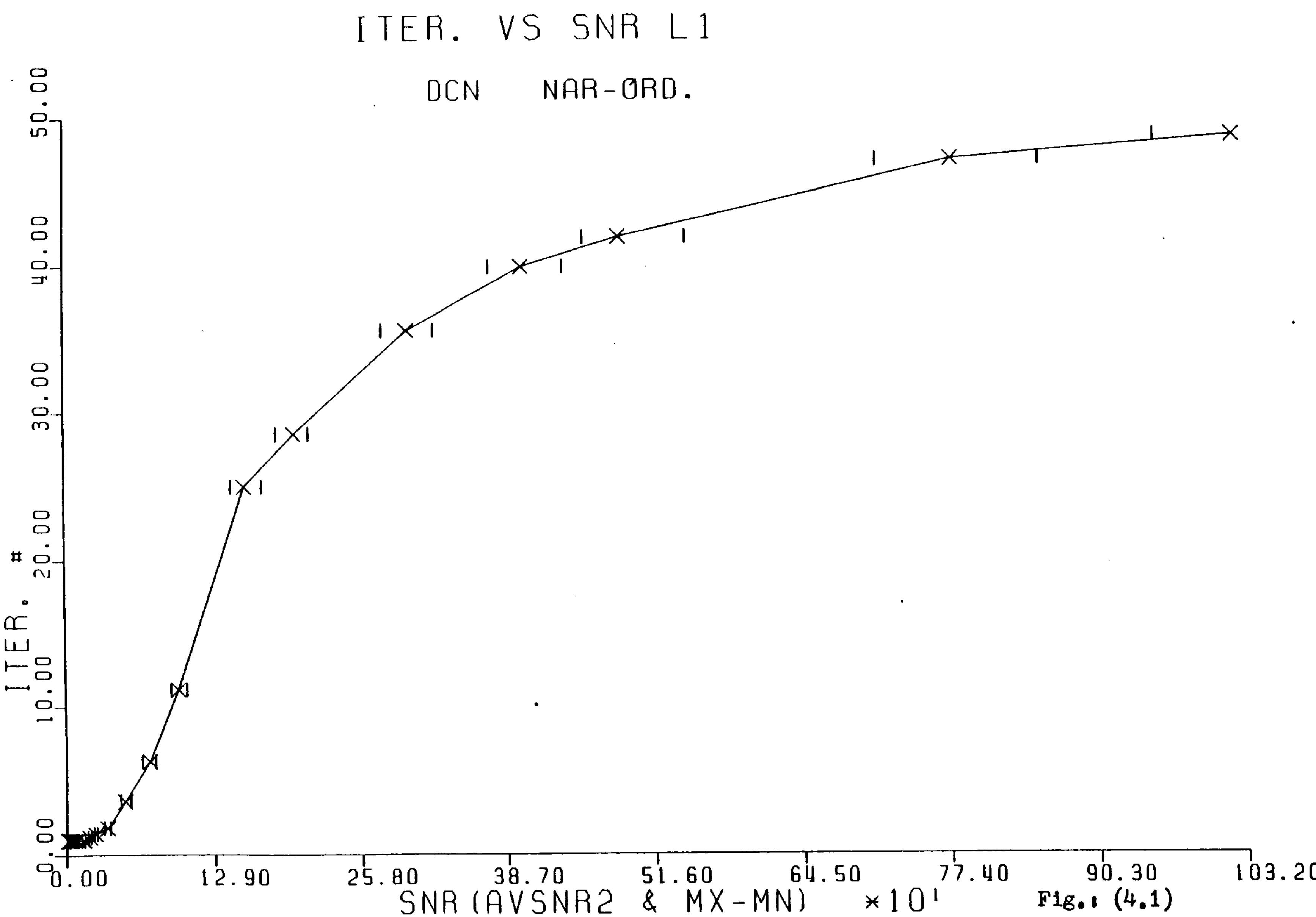
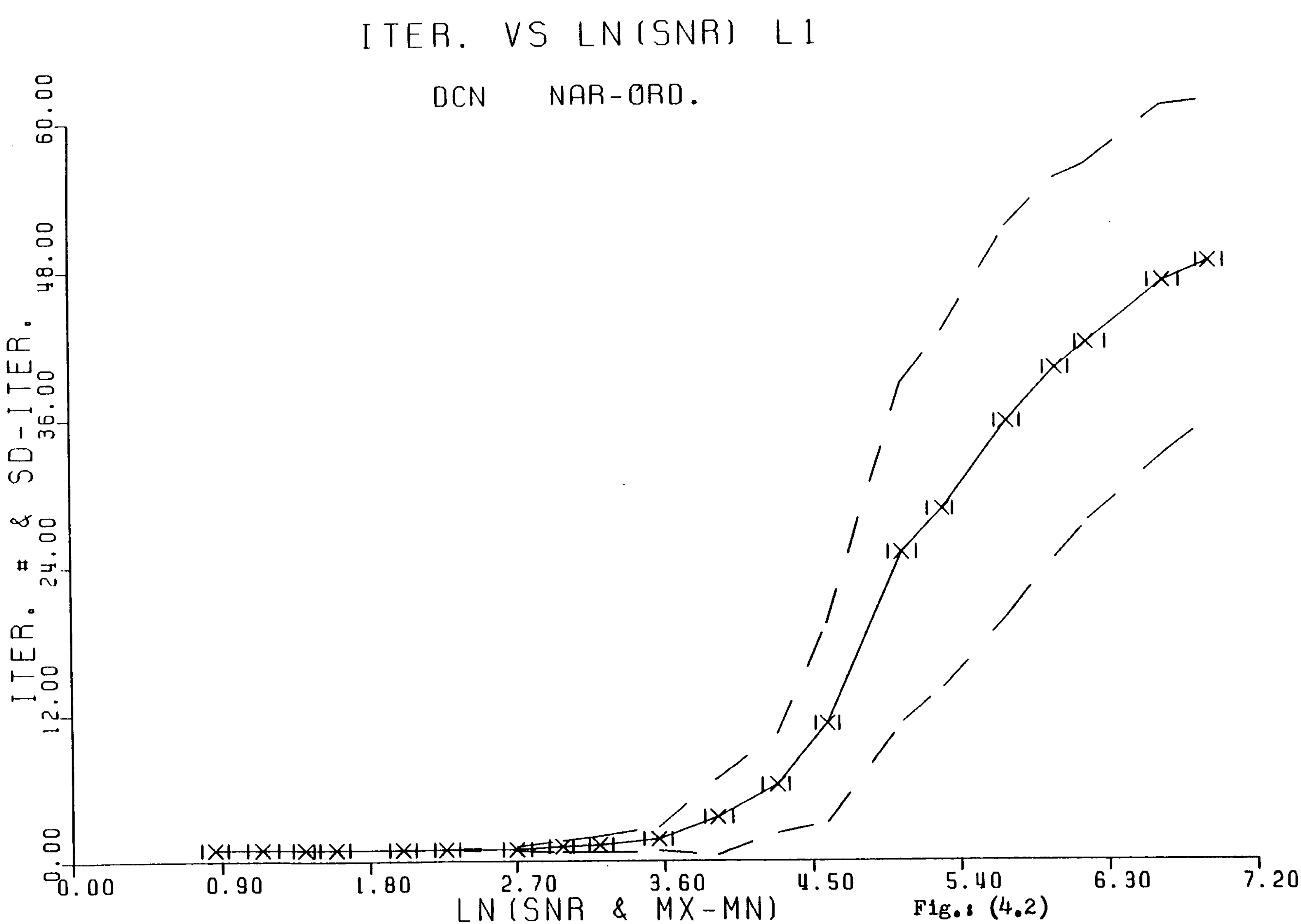

ITER. VS SNR L1
DCN NAR-ØRD.
ITER. #
0.00
10.00
20.00
30.00
40.00
50.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (4.1)


ITER. VS LN(SNR) L1
DCN NAR-ØRD.
ITER. # & SD-ITER.
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12.00
24.00
36.00
48.00
60.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)
Fig.: (4.2)

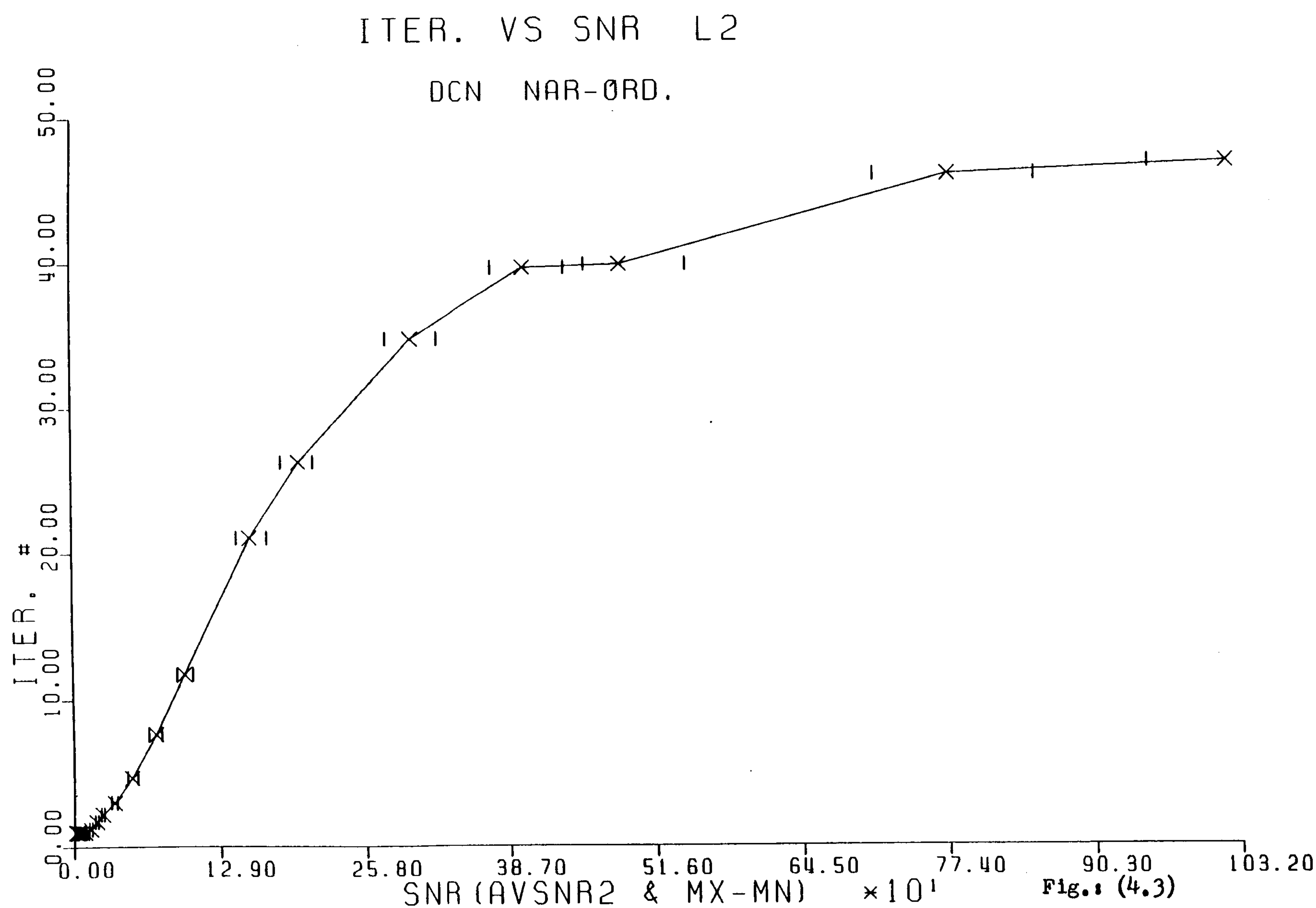

ITER. VS SNR L2
DCN NAR-ØRD.
ITER. #
0.00
10.00
20.00
30.00
40.00
50.00
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (4.3)

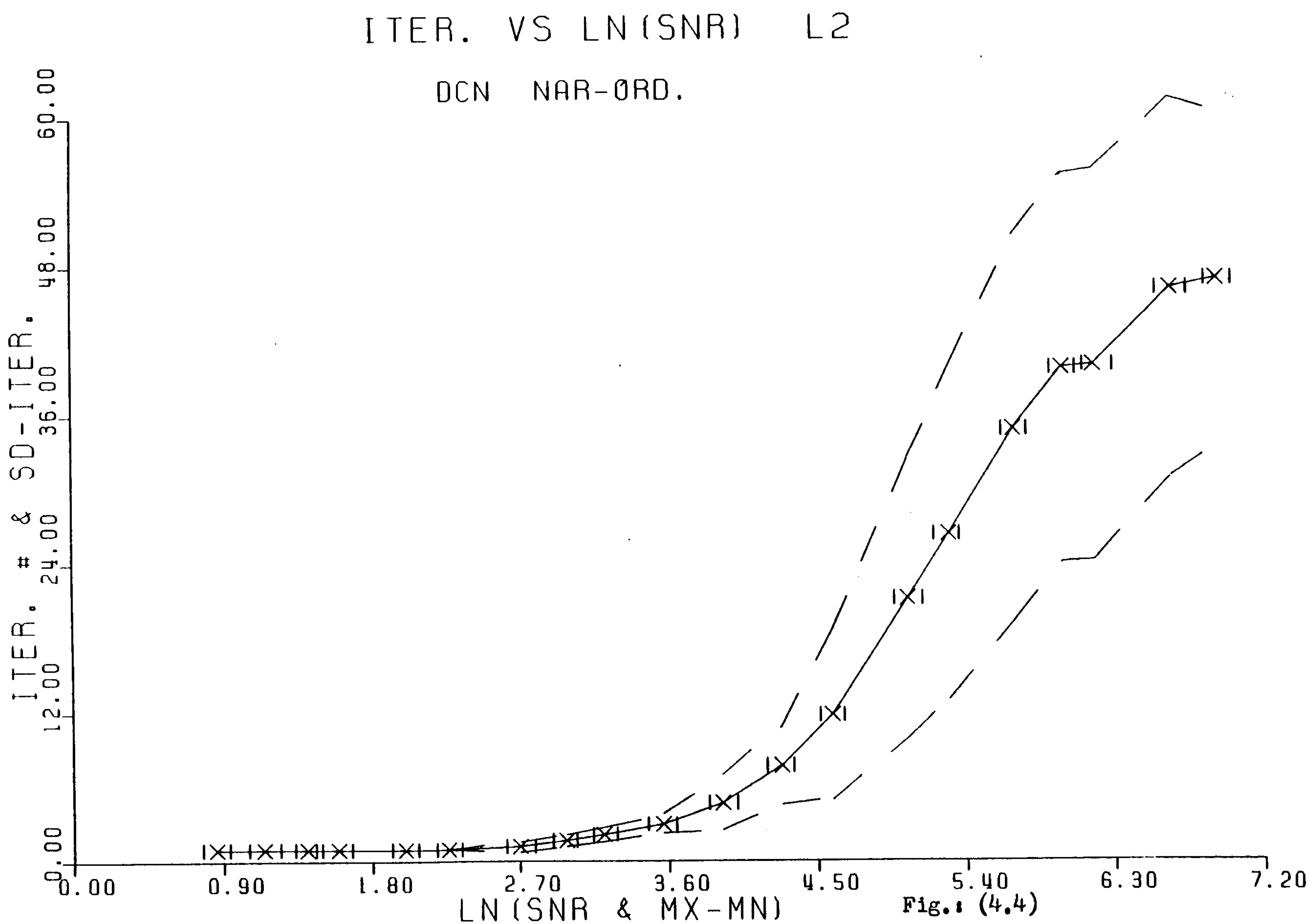
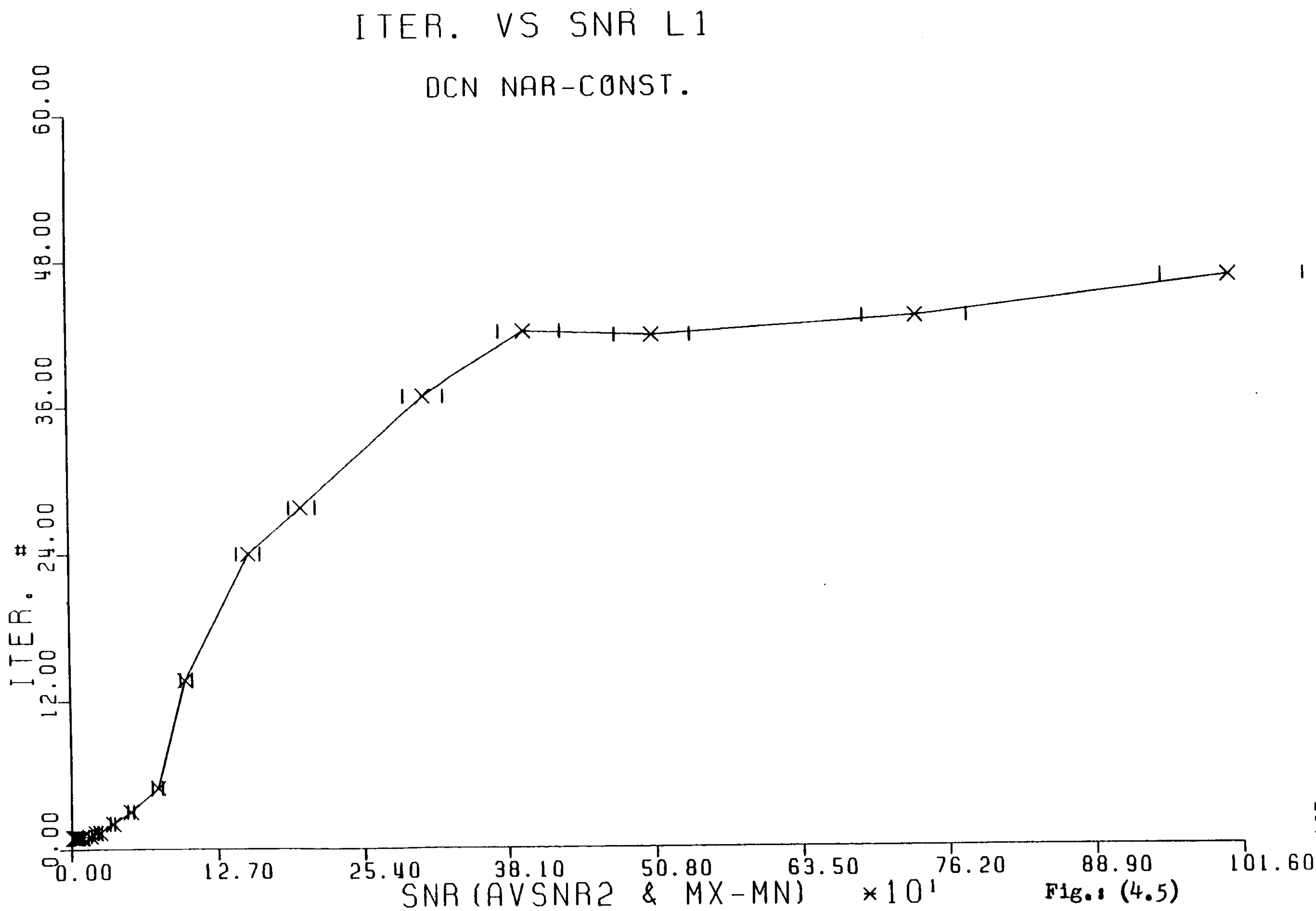

ITER. VS LN(SNR) L2
DCN NAR-ØRD.
ITER. # & SD-ITER.
0.00
12.00
24.00
36.00
48.00
60.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.4)


ITER. VS SNR L1
DCN NAR-CØNST.
ITER. #
0.00
12.00
24.00
36.00
48.00
60.00
0.00
12.70
25.40
38.10
50.80
63.50
76.20
88.90
101.60
SNR (AVSNR2 & MX-MN) ×10¹
Fig.: (4.5)

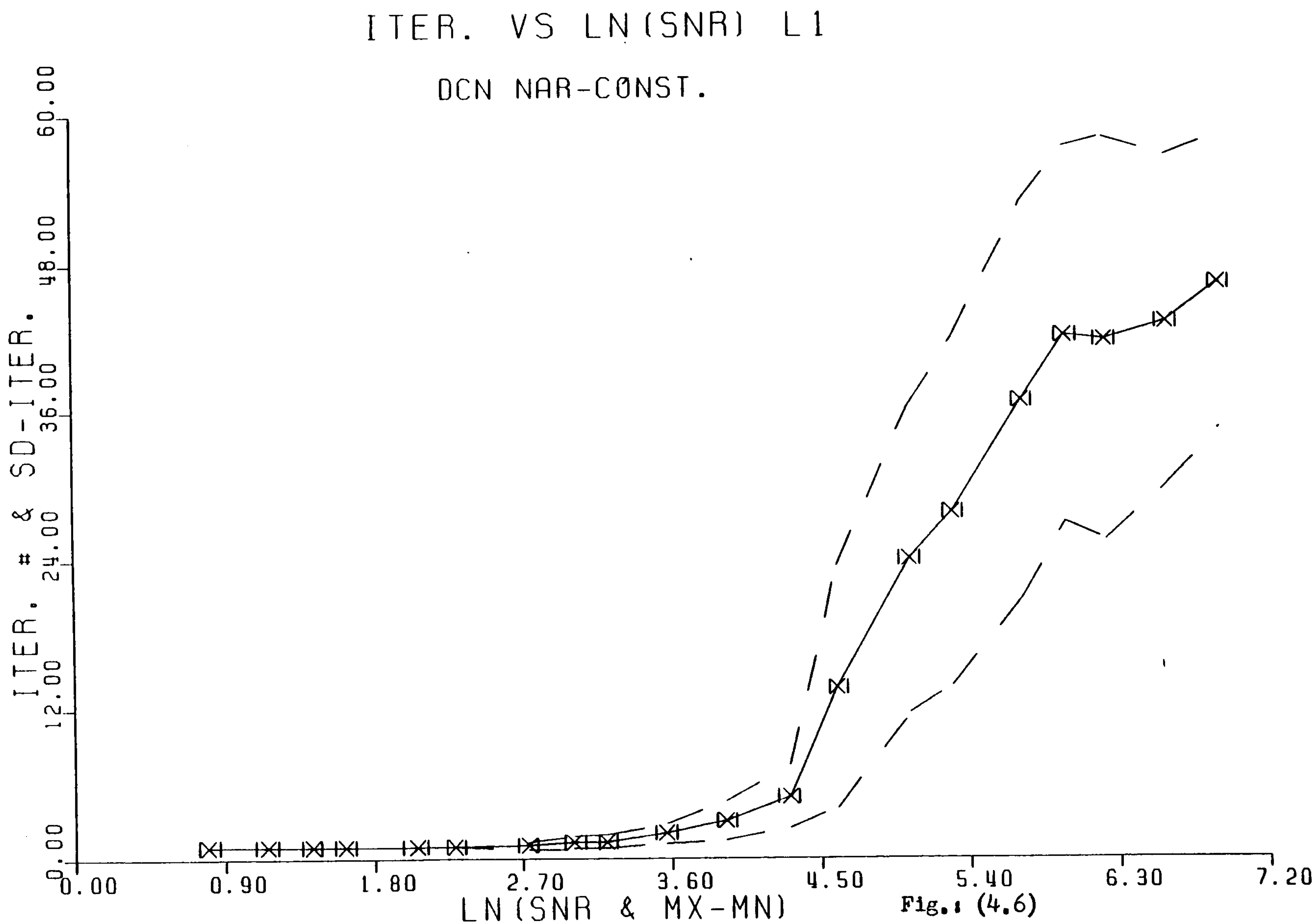
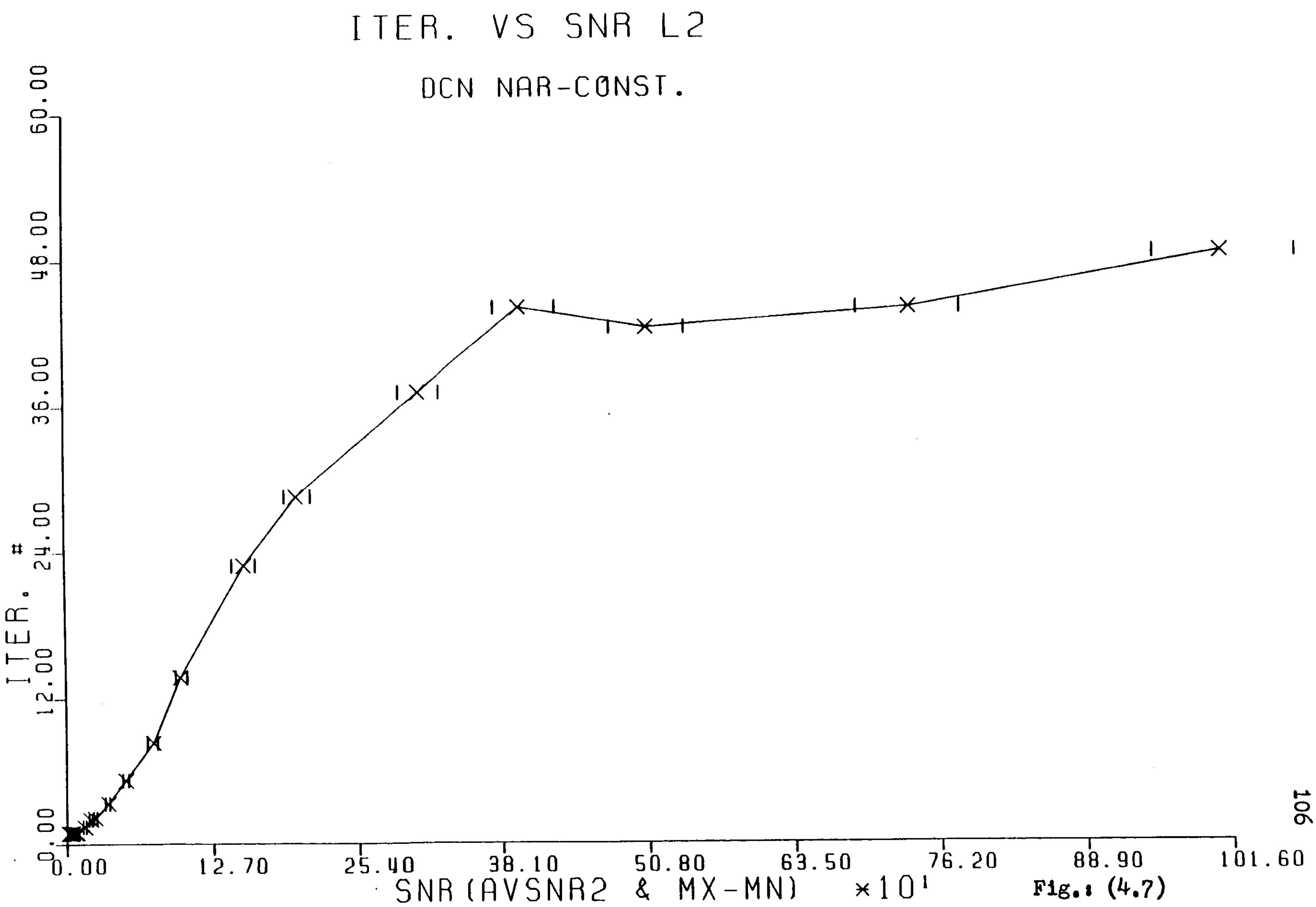
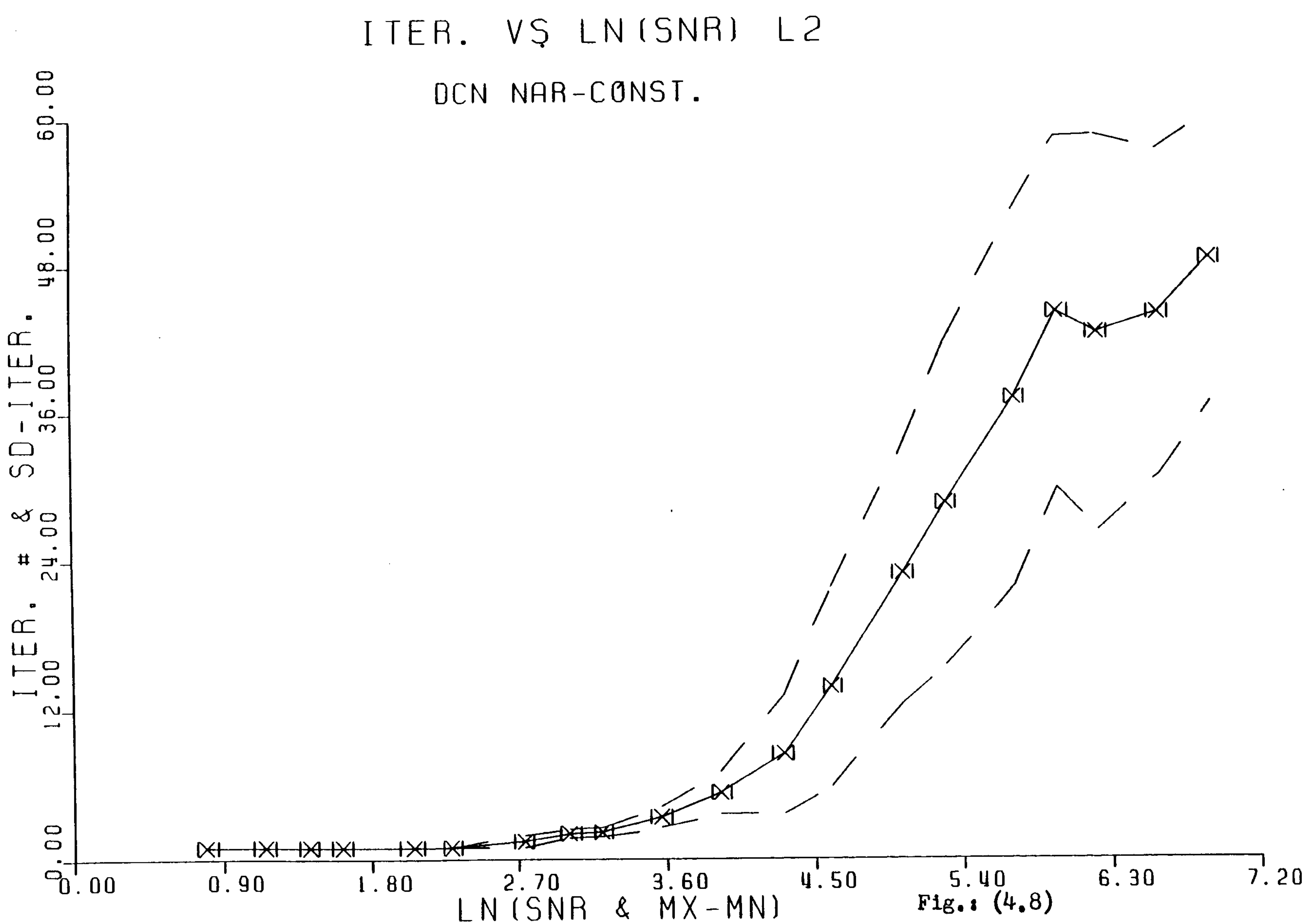

ITER. VS LN(SNR) L1
DCN NAR-CØNST.
ITER. # & SD-ITER.
0.00
12.00
24.00
36.00
48.00
60.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.6)



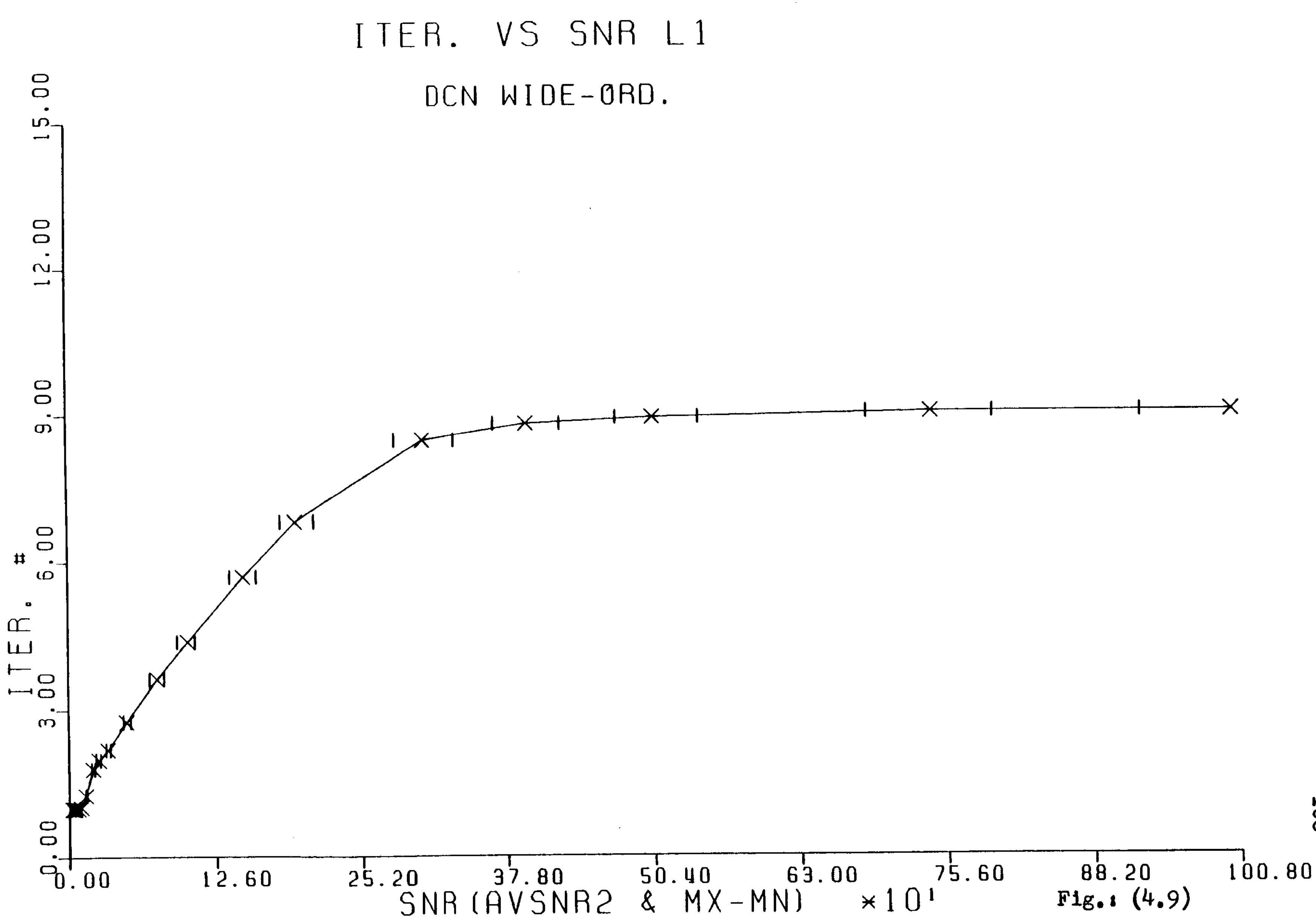
ITER. VS SNR L2
DCN NAR-CØNST.
ITER. #
60.00
48.00
36.00
24.00
12.00
0.00
0.00
12.70
25.40
38.10
50.80
63.50
76.20
88.90
101.60
SNR(AVSNR2 & MX-MN) ×10¹

Fig.: (4.7)



ITER. VŞ LN(SNR) L2
DCN NAR-CØNST.
ITER. # & SD-ITER.
0.00
12.00
24.00
36.00
48.00
60.00
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.8)


ITER. VS SNR L1
DCN WIDE-ØRD.
ITER. #
0.00
3.00
6.00
9.00
12.00
15.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10¹
Fig.: (4.9)

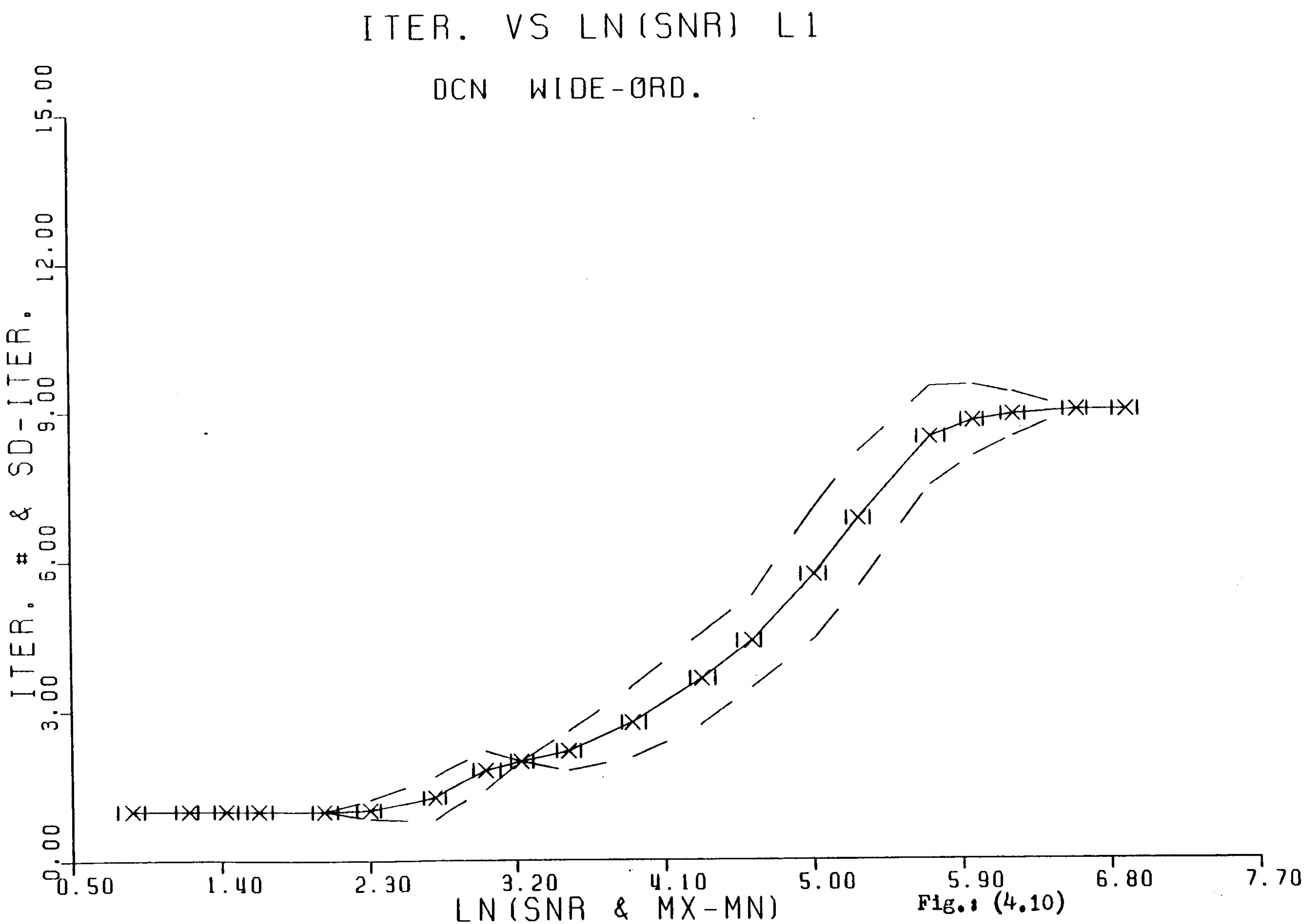

ITER. VS LN(SNR) L1
DCN WIDE-ØRD.
ITER. # & SD-ITER.
0.00
3.00
6.00
9.00
12.00
15.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.10)

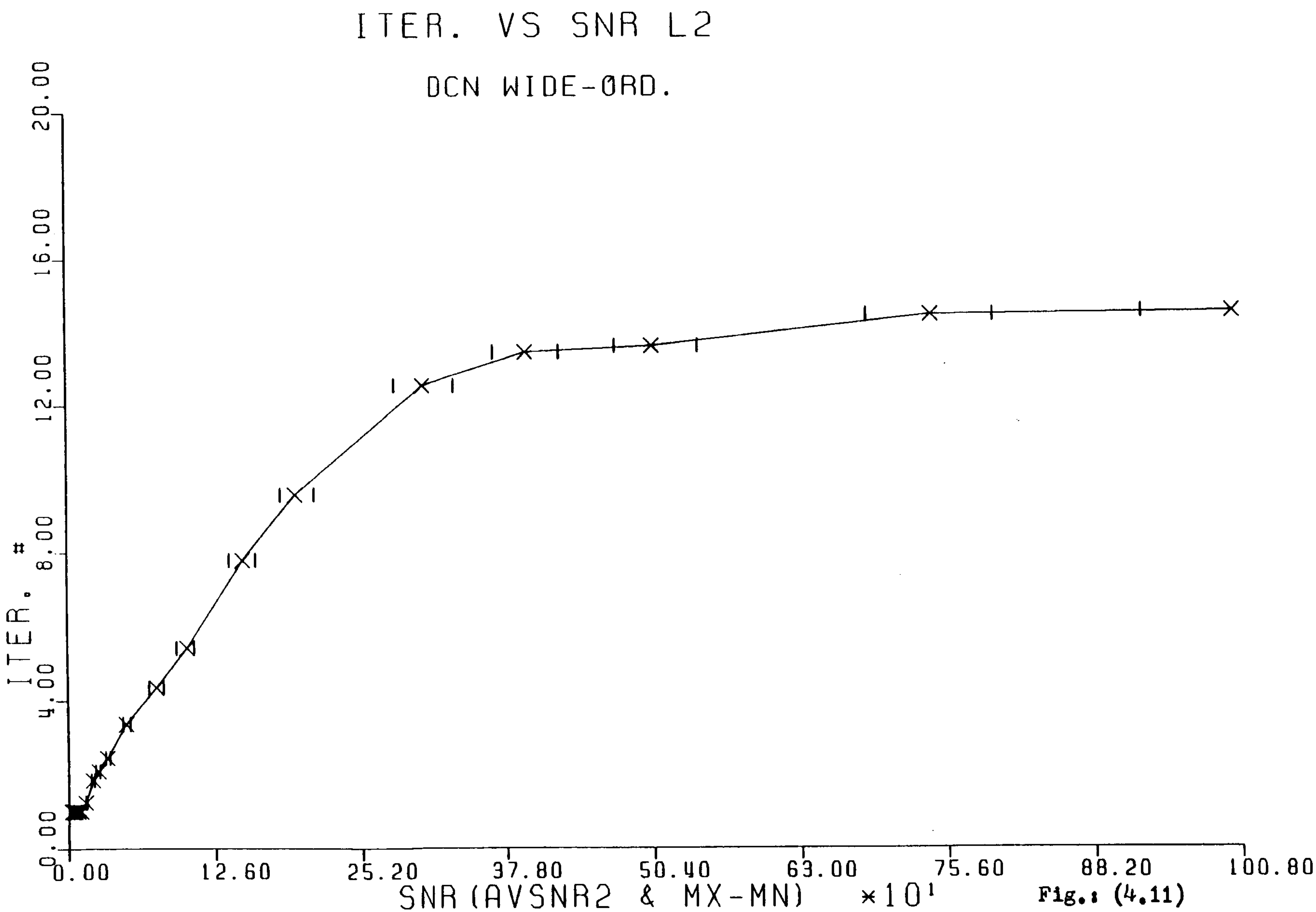

ITER. VS SNR L2
DCN WIDE-ØRD.
ITER. #
0.00
4.00
8.00
12.00
16.00
20.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10^1

Fig.: (4.11)

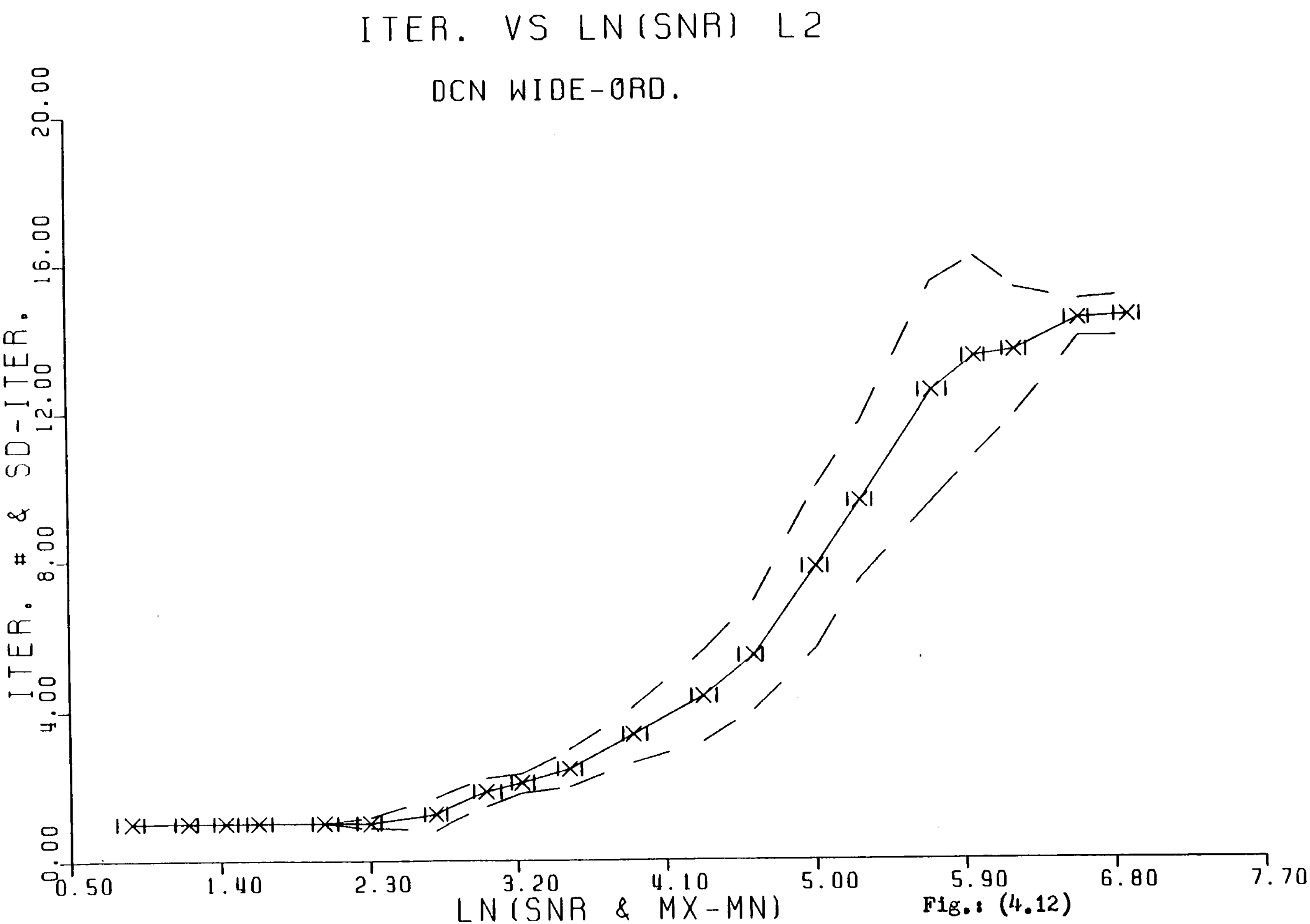

ITER. VS LN(SNR) L2
DCN WIDE-ØRD.
ITER. # & SD-ITER.
0.00
4.00
8.00
12.00
16.00
20.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.12)

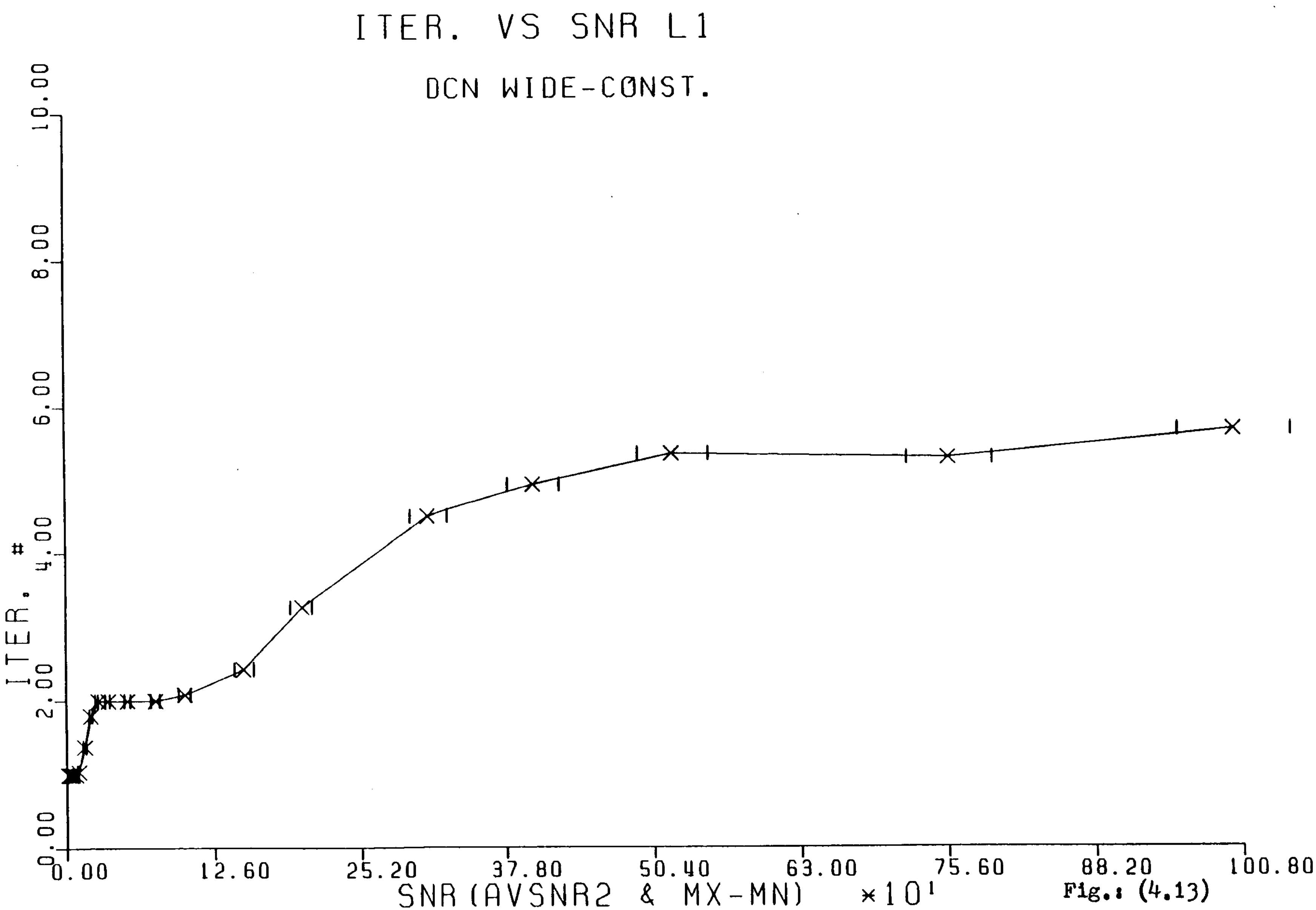

ITER. VS SNR L1
DCN WIDE-CØNST.
ITER. #
0.00
2.00
4.00
6.00
8.00
10.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (4.13)

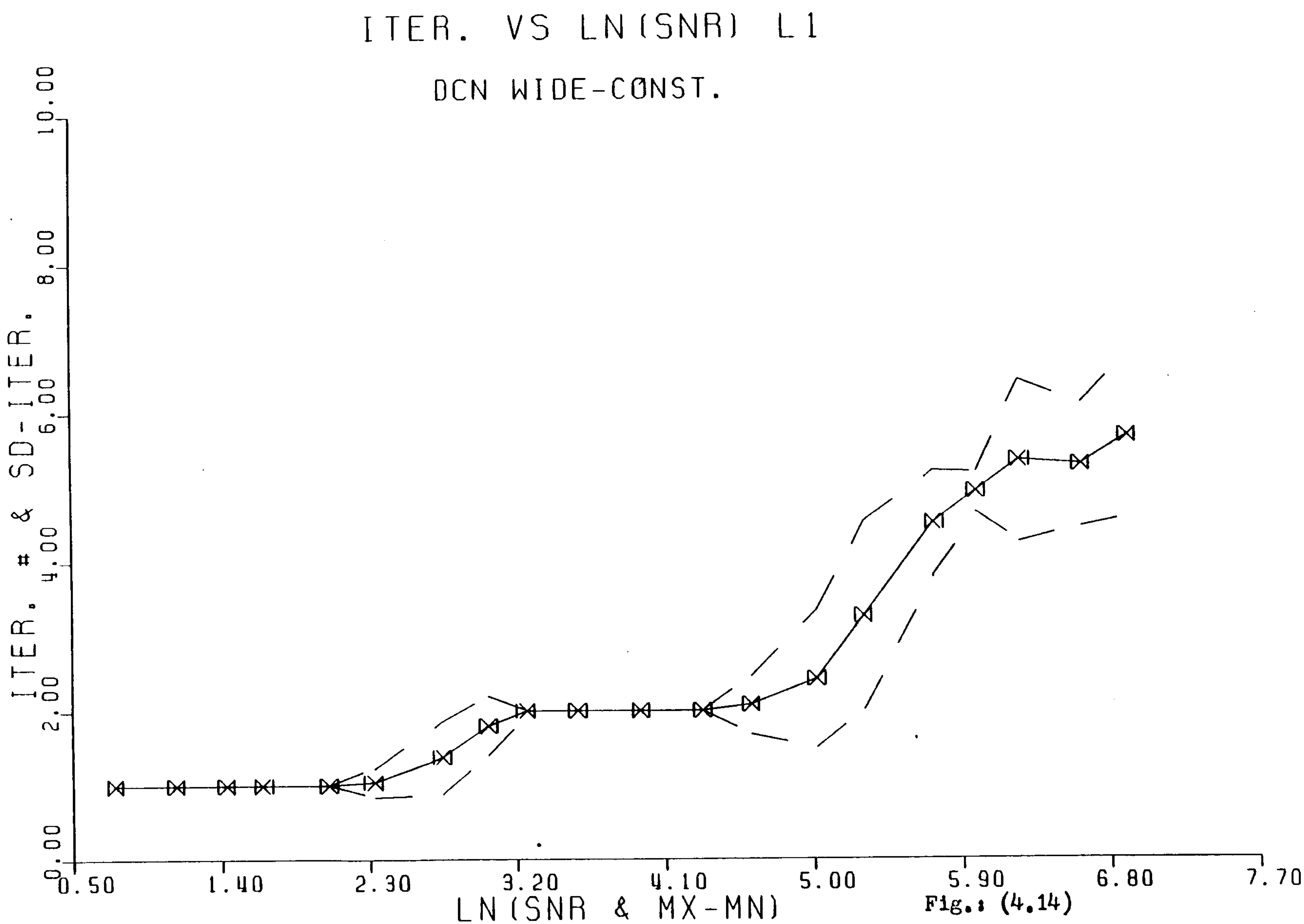

ITER. VS LN(SNR) L1
DCN WIDE-CØNST.
ITER. # & SD-ITER.
0.00
2.00
4.00
6.00
8.00
10.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.14)

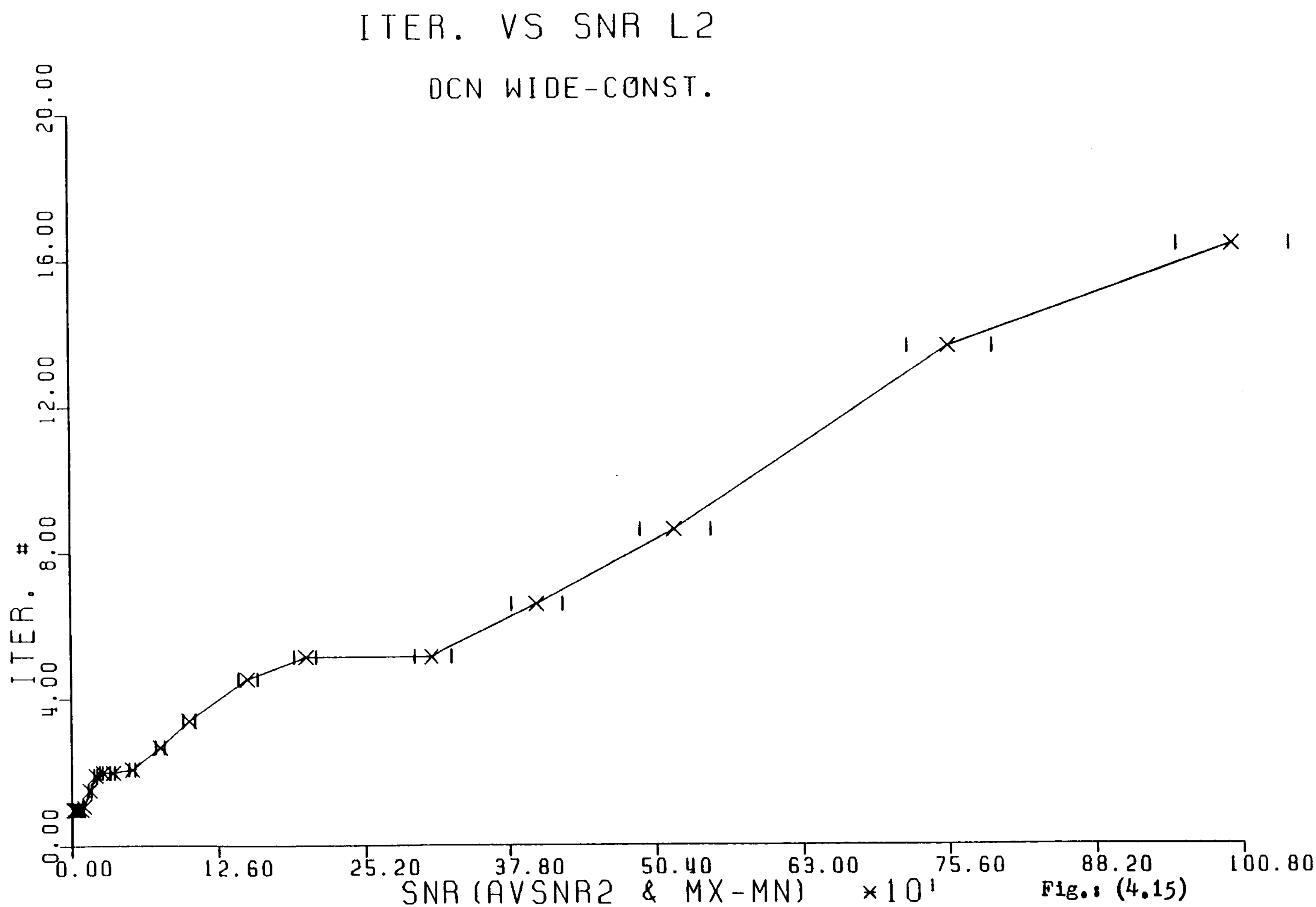

ITER. VS SNR L2
DCN WIDE-CØNST.
ITER. #
0.00
4.00
8.00
12.00
16.00
20.00
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (4.15)

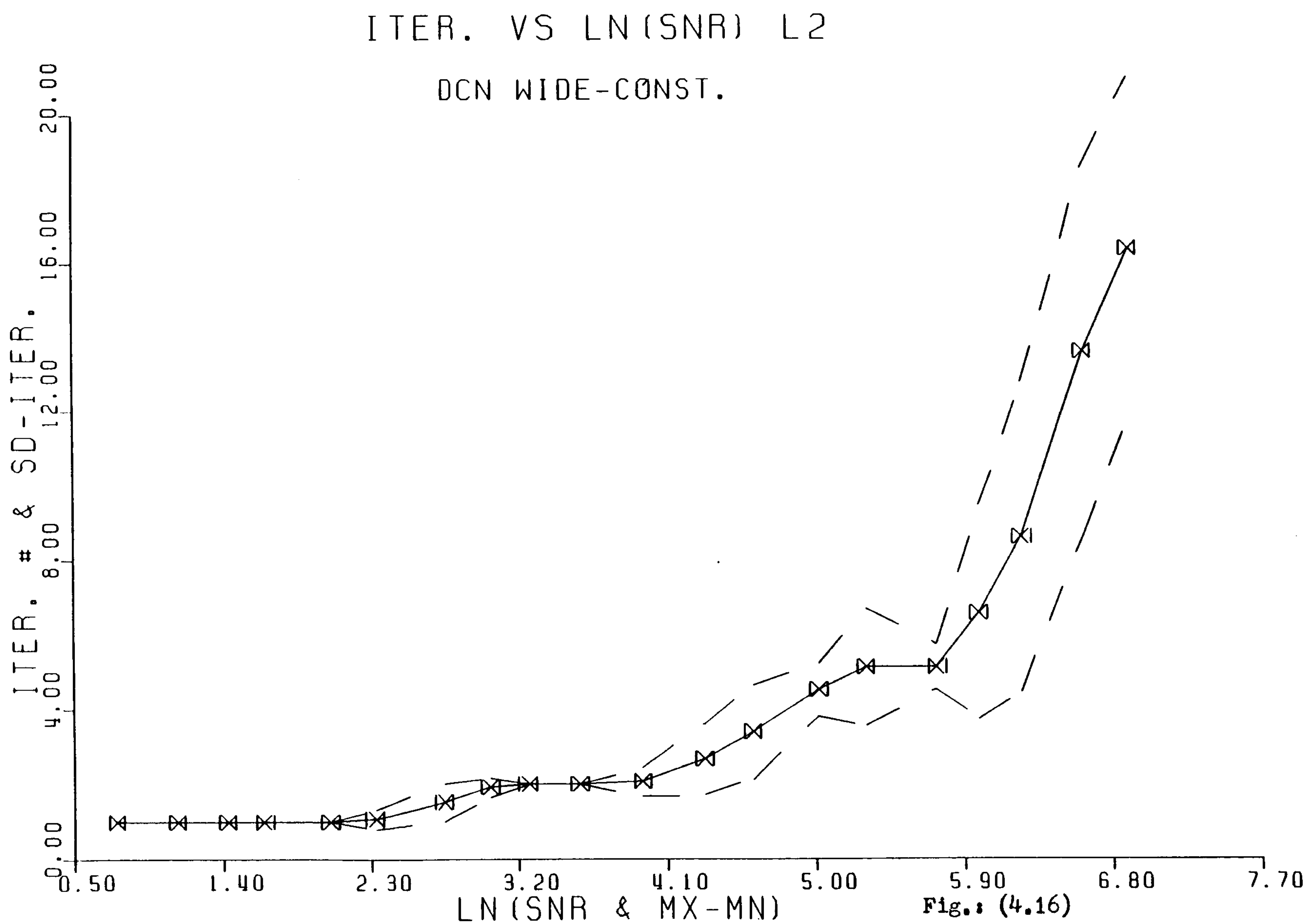

ITER. VS LN(SNR) L2
DCN WIDE-CØNST.
ITER. # & SD-ITER.
0.00
4.00
8.00
12.00
16.00
20.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.16)

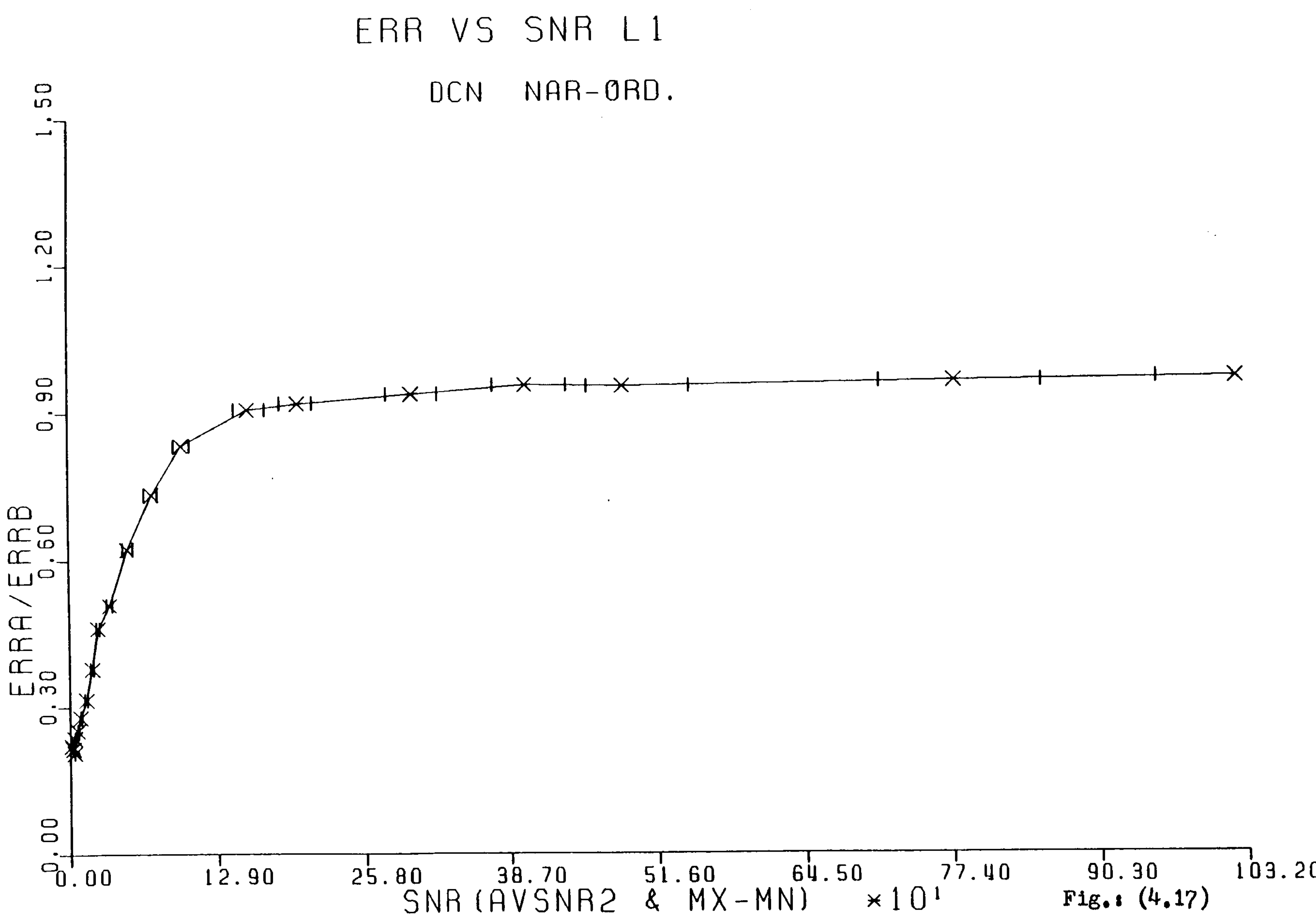

ERR VS SNR L1
DCN NAR-ØRD.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.90
25.80
38.70
51.60
64.50
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (4.17)

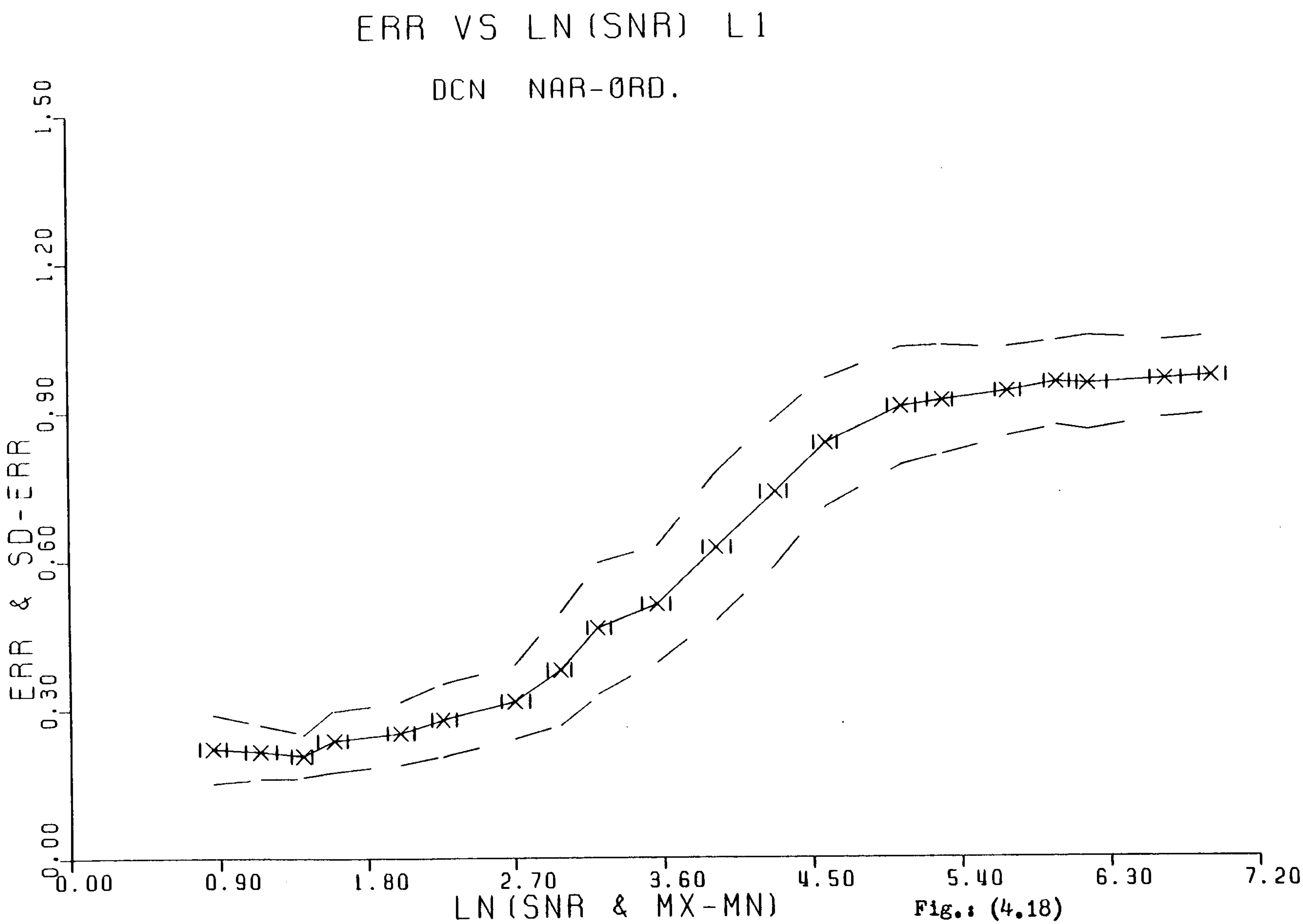

ERR VS LN(SNR) L1
DCN NAR-ØRD.
ERR & SD-ERR
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.18)

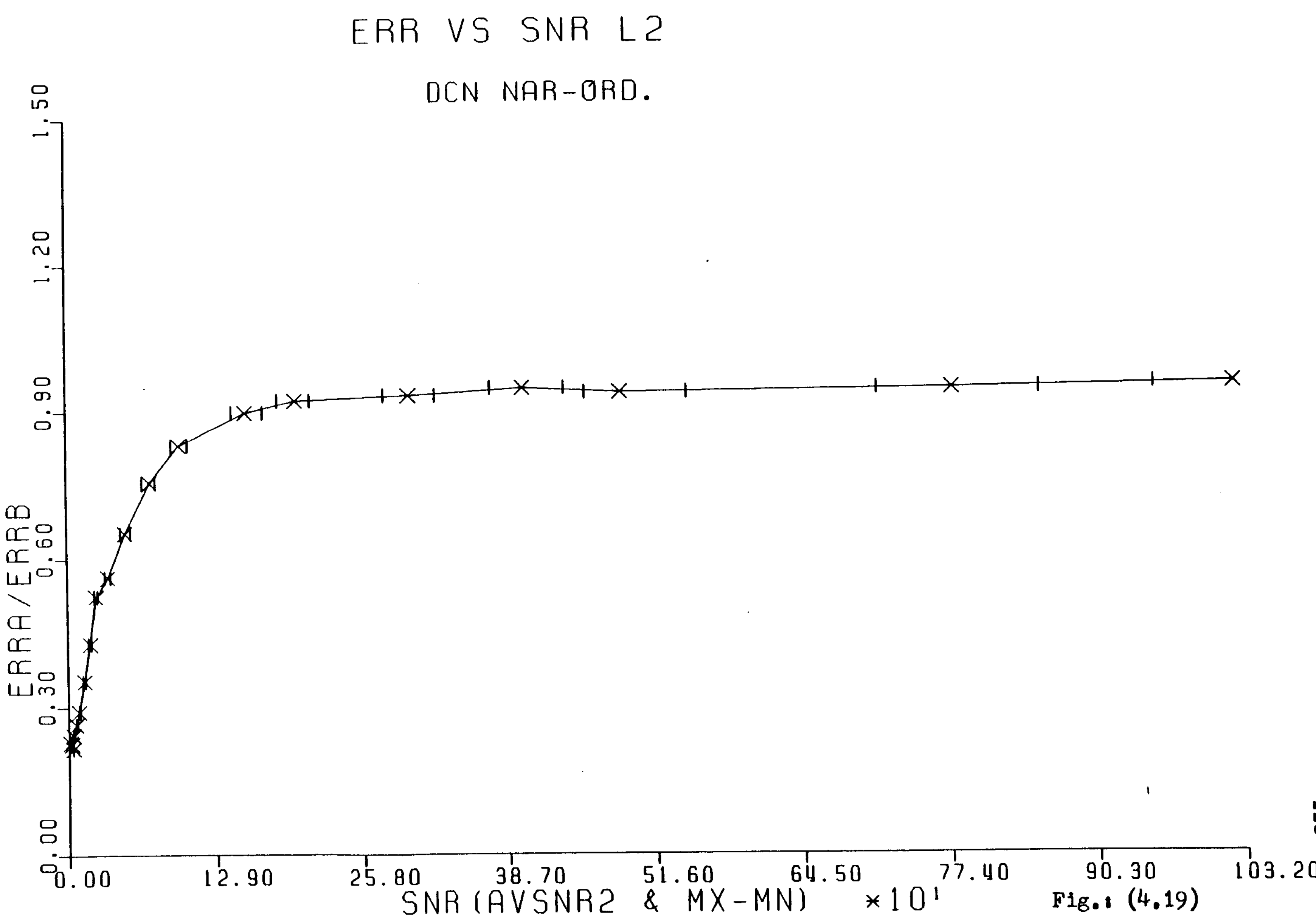

ERR VS SNR L2
DCN NAR-ØRD.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.90
25.80
38.70
64.50
51.60
77.40
90.30
103.20
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (4.19)

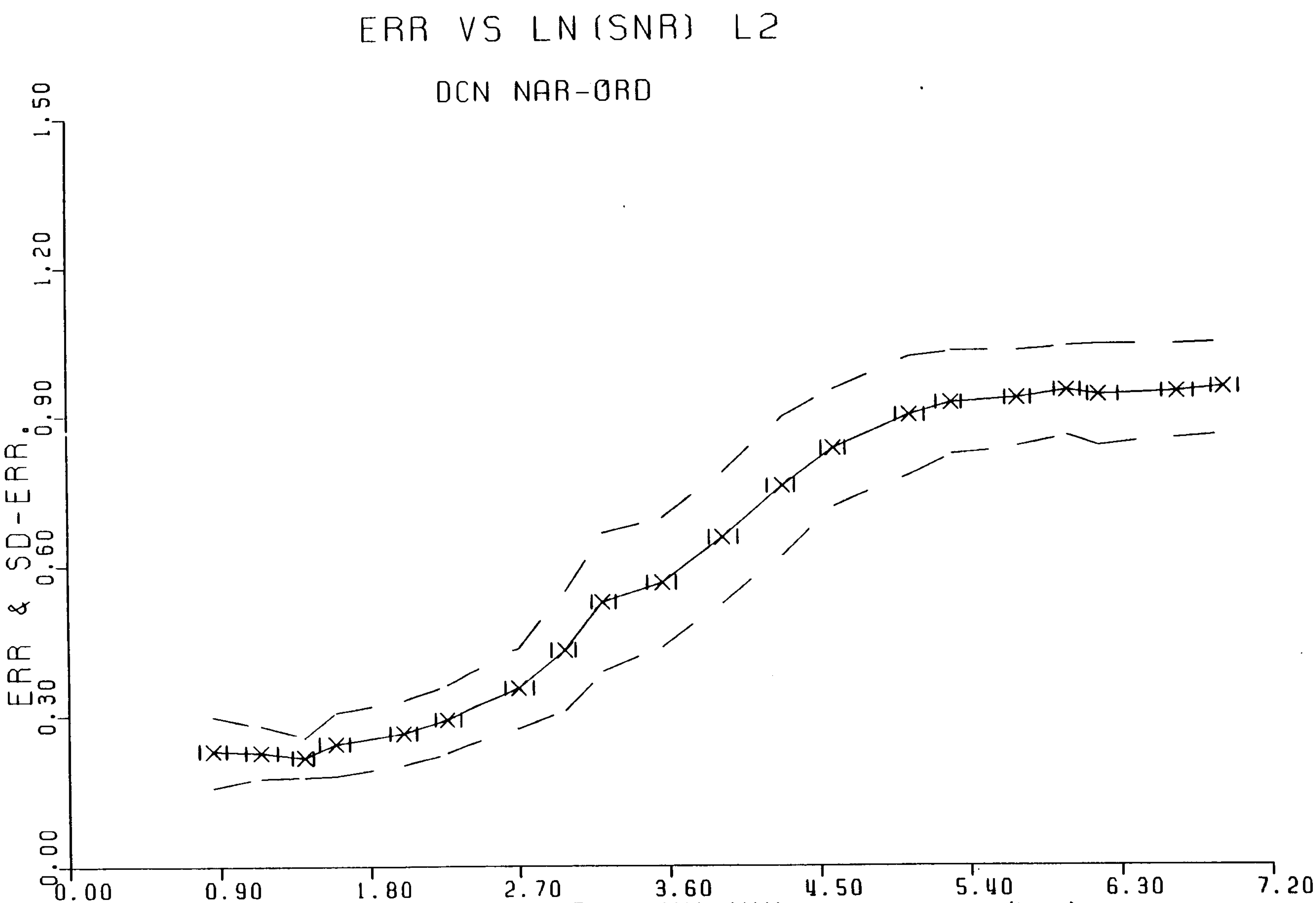

ERR VS LN(SNR) L2
DCN NAR-ØRD
ERR & SD-ERR.
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.20)

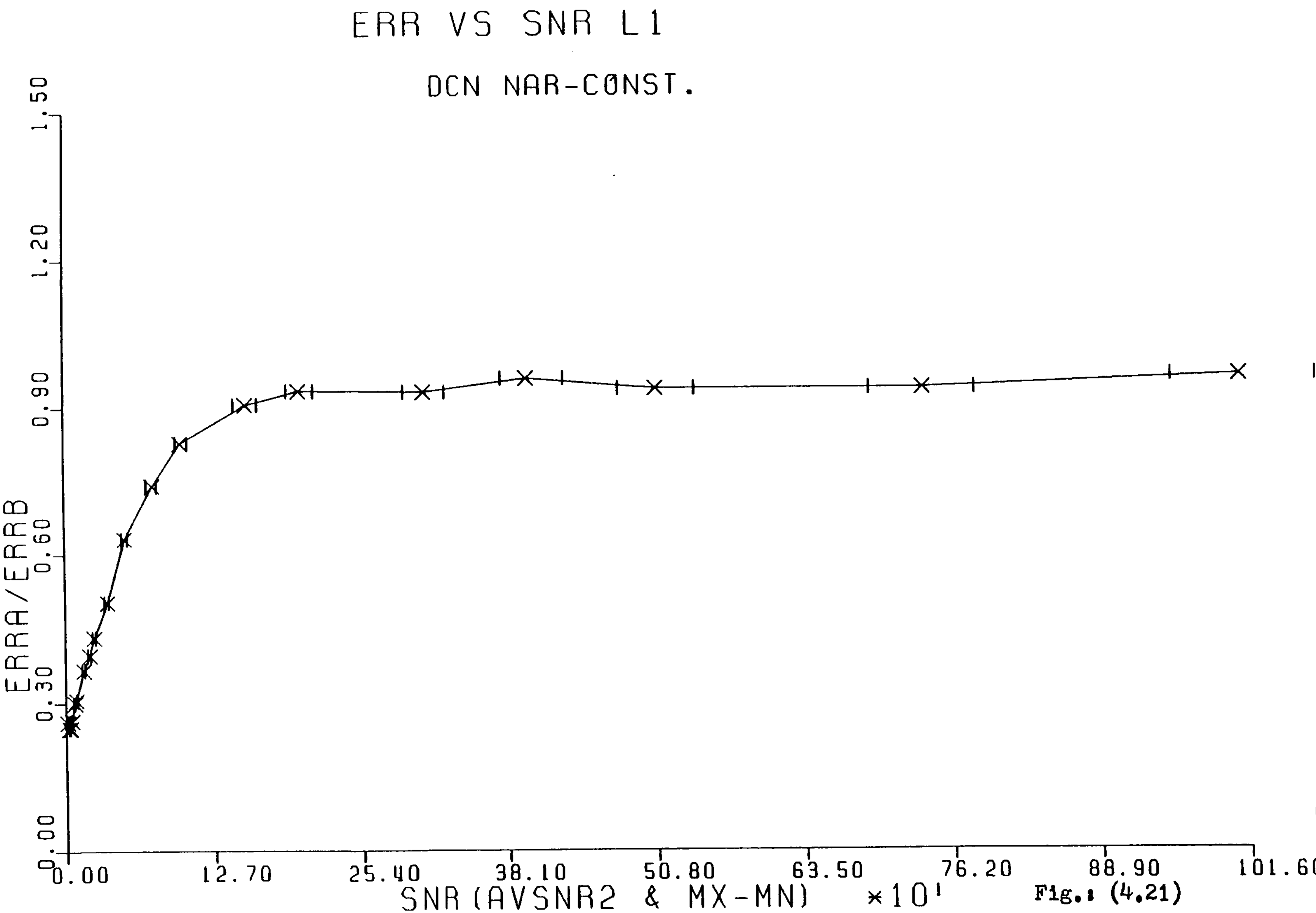

ERR VS SNR L1
DCN NAR-CØNST.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.70
25.40
38.10
50.80
63.50
76.20
88.90
101.60
SNR (AVSNR2 & MX-MN) *10¹

Fig.: (4.21)

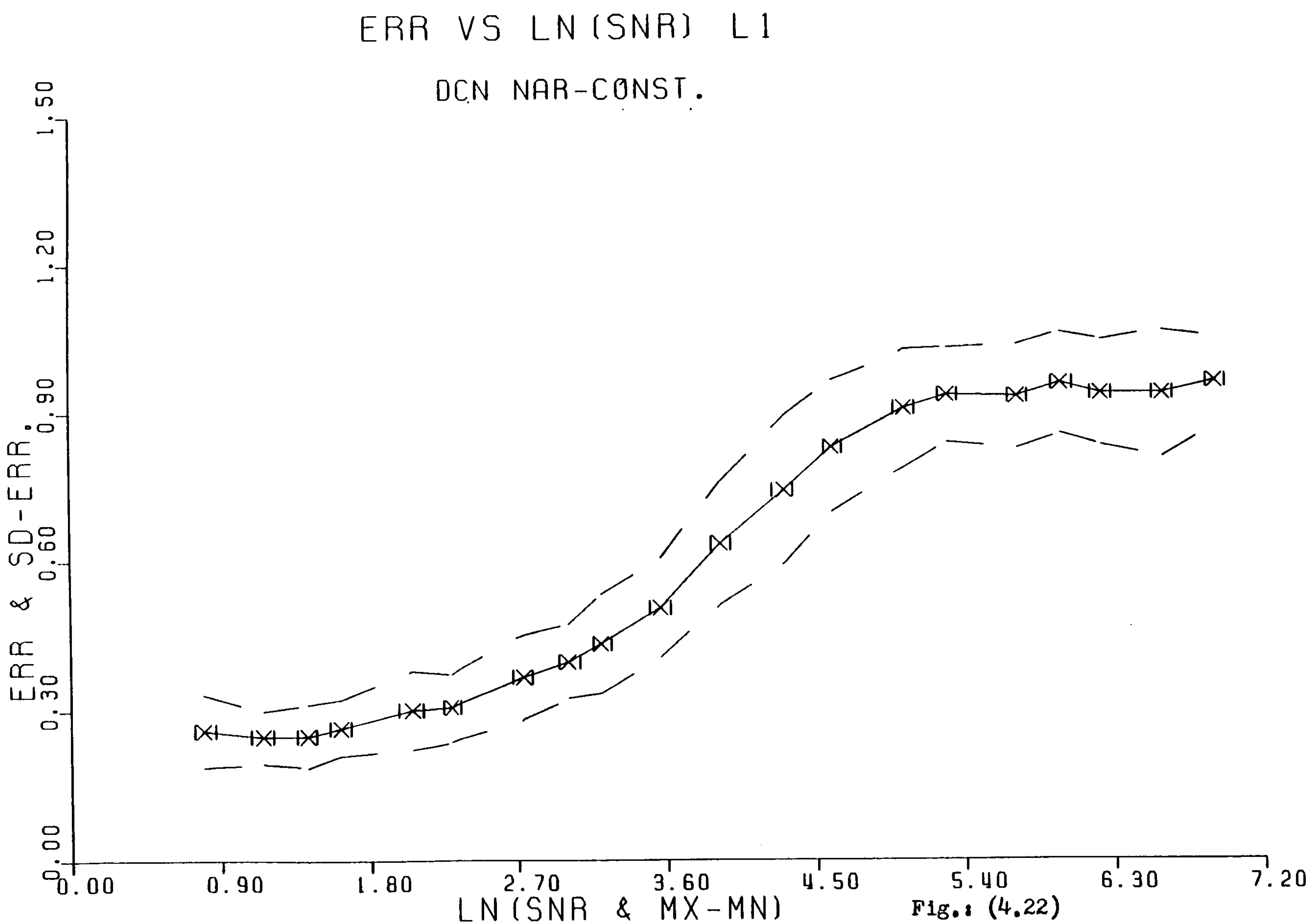

ERR VS LN(SNR) L1
DCN NAR-CONST.
ERR & SD-ERR.
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.22)

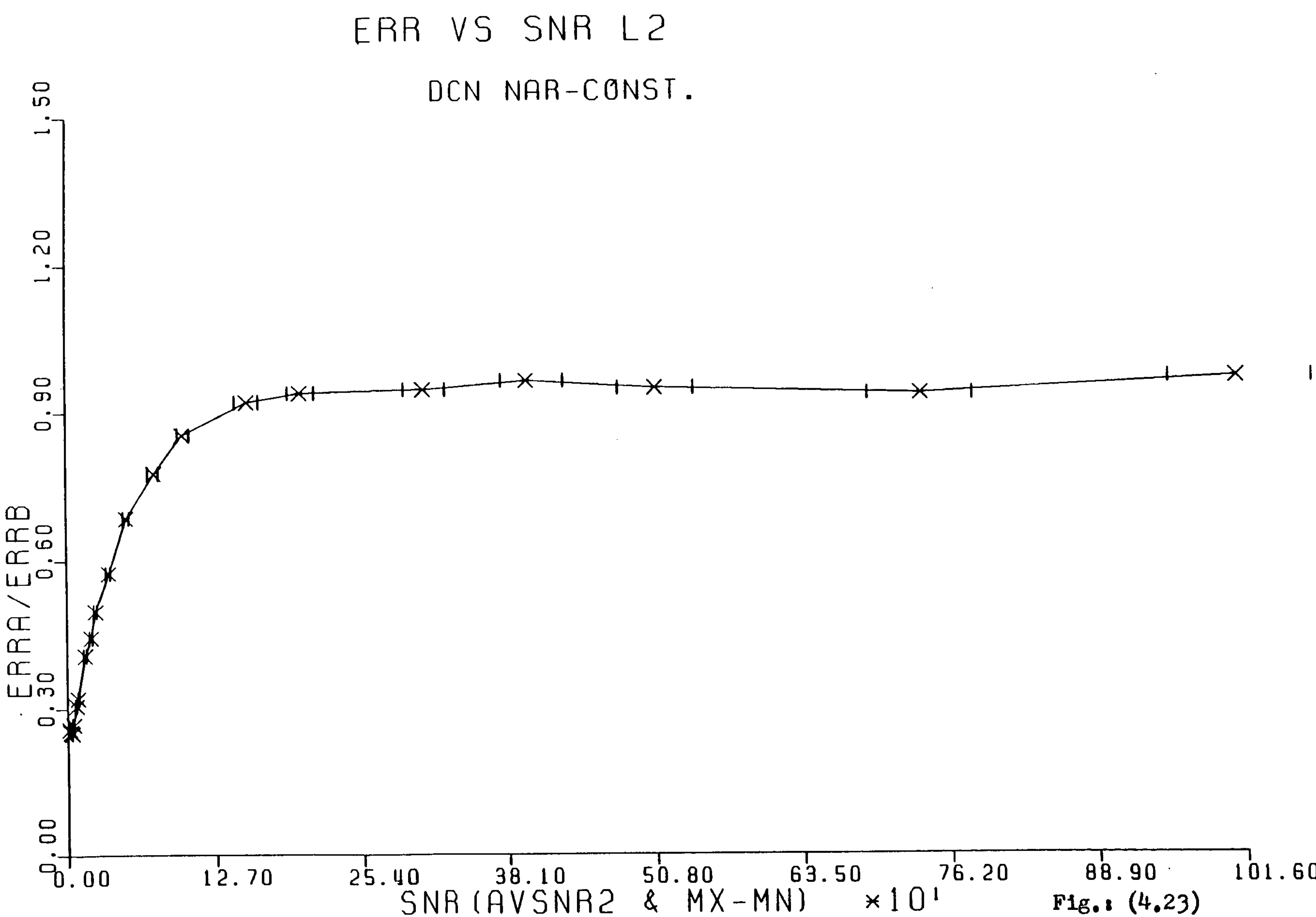

ERR VS SNR L2
DCN NAR-CØNST.
ERRA/ERRB
0.00
0.30
0.60
0.90
1.20
1.50
0.00
12.70
25.40
38.10
50.80
63.50
76.20
88.90
101.60
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (4.23)

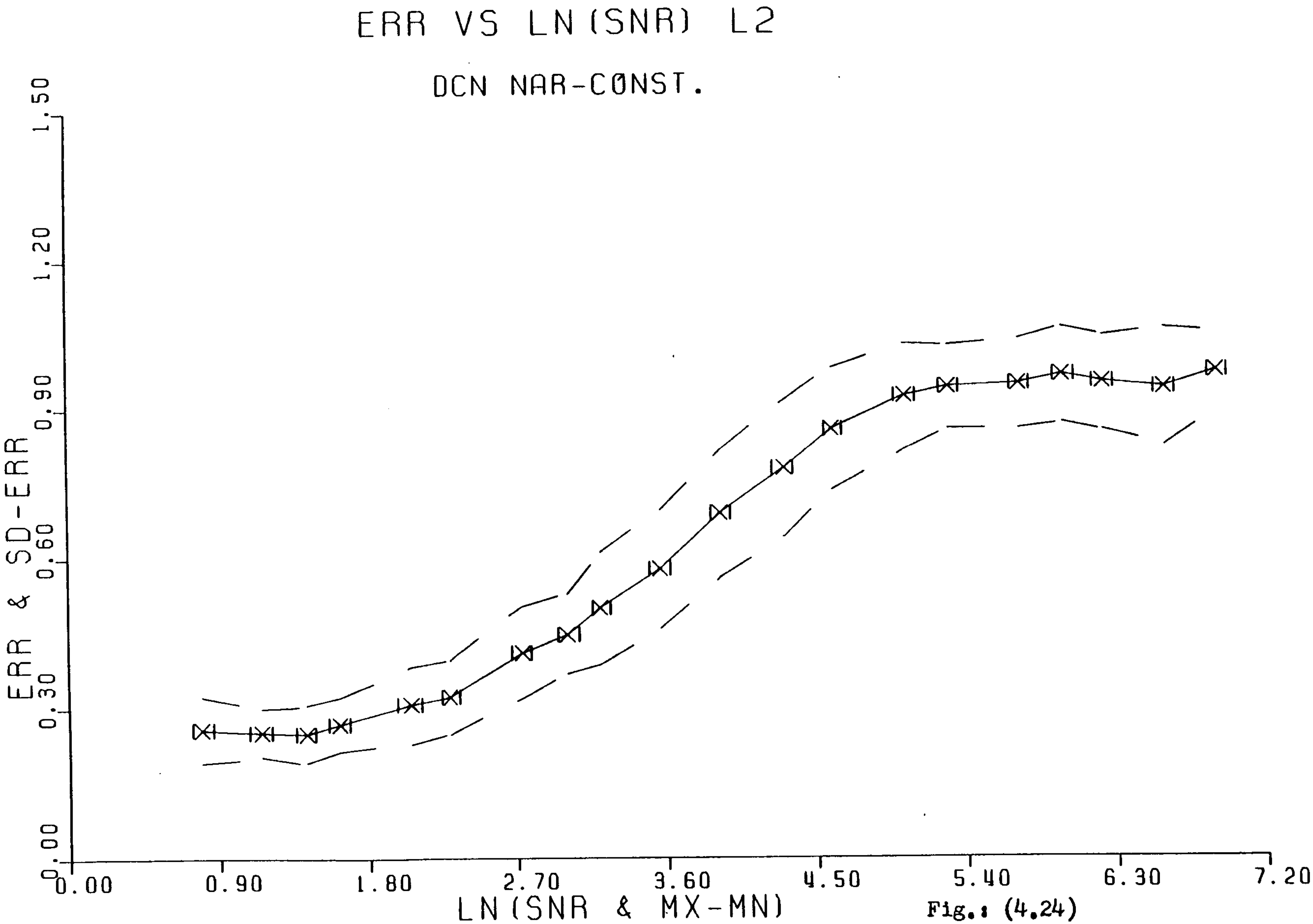

ERR VS LN(SNR) L2
DCN NAR-CØNST.
ERR & SD-ERR
0.00
0.30
0.60
0.90
1.20
1.50
0.00
0.90
1.80
2.70
3.60
4.50
5.40
6.30
7.20
LN(SNR & MX-MN)

Fig.: (4.24)

ERR VS SNR L1

DCN WIDE-ØRD.

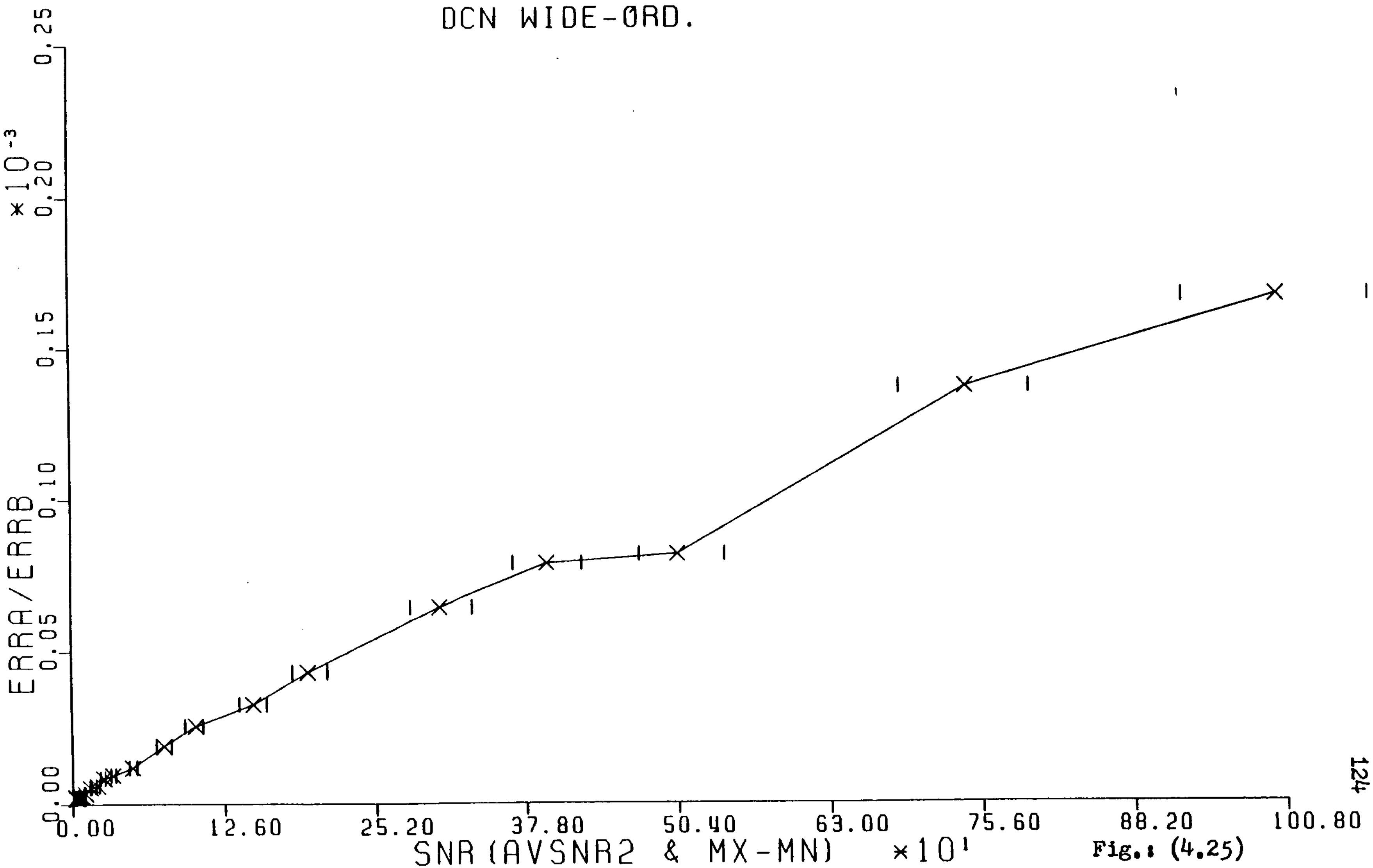


Fig.: (4.25)

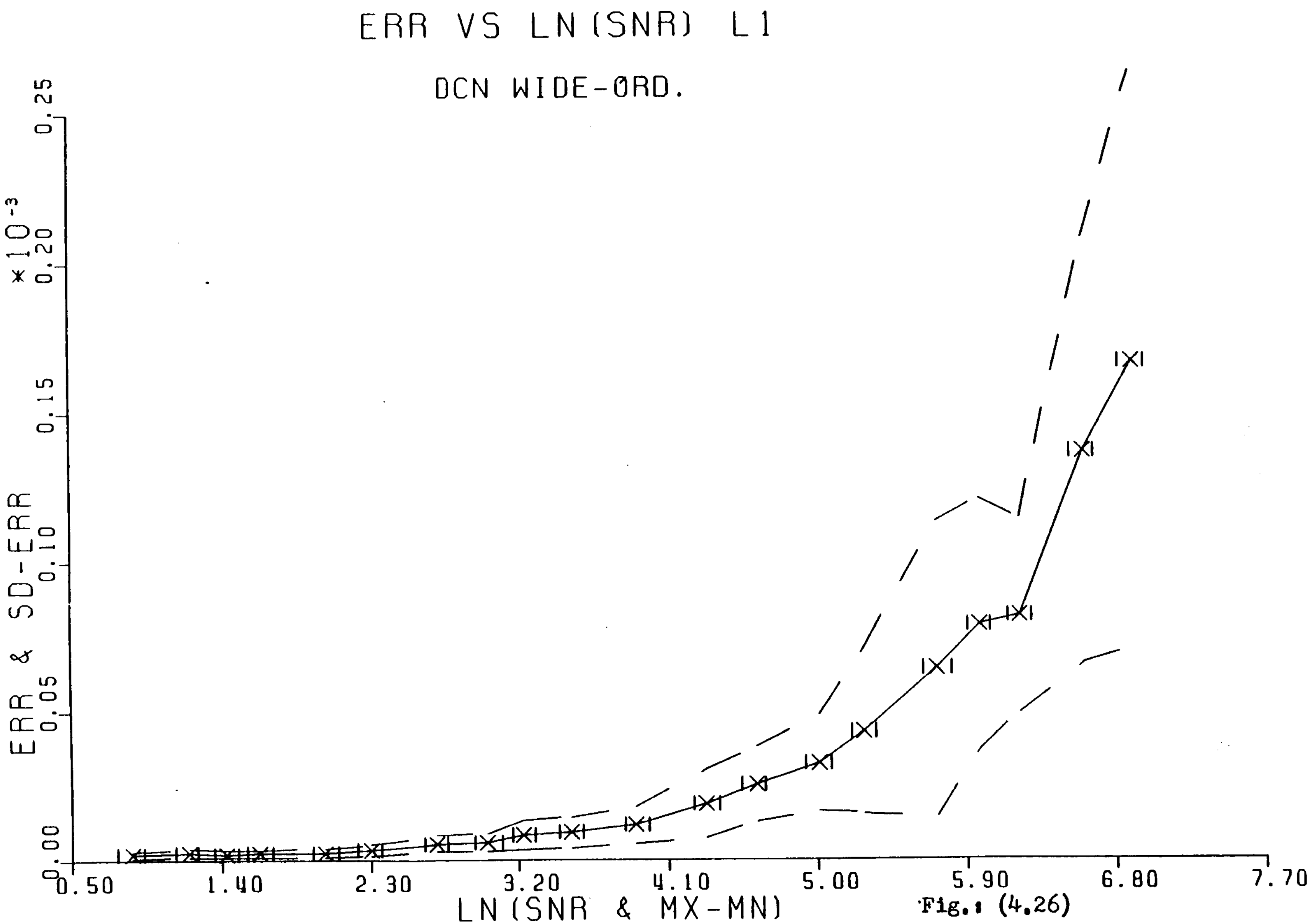

ERR VS LN(SNR) L1
DCN WIDE-ØRD.
ERR & SD-ERR
$\times 10^{-3}$
0.00
0.05
0.10
0.15
0.20
0.25
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.26)

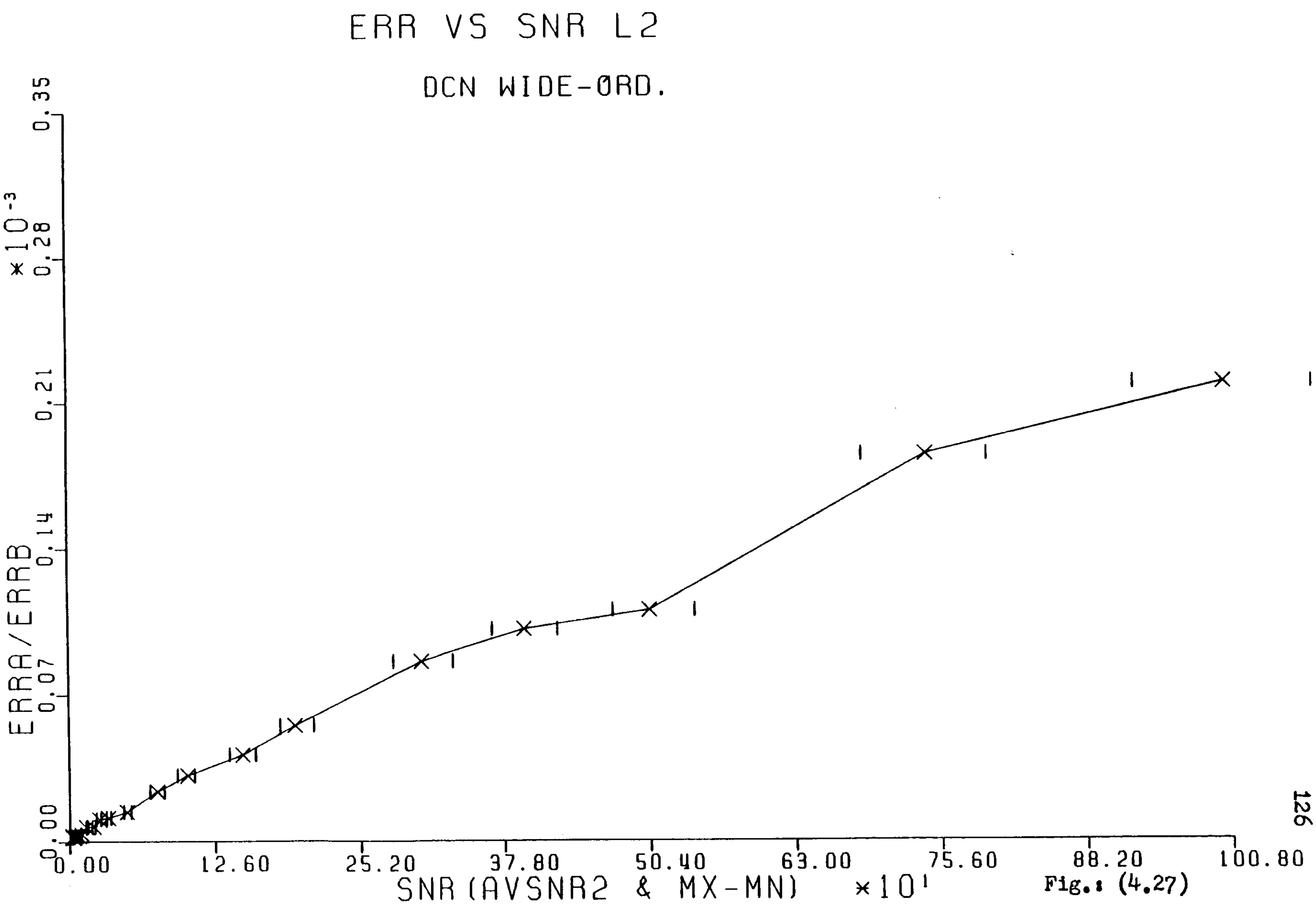

ERR VS SNR L2
DCN WIDE-ØRD.
ERRA/ERRB
*10^-3
0.00
0.07
0.14
0.21
0.28
0.35
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10^1

Fig.: (4.27)

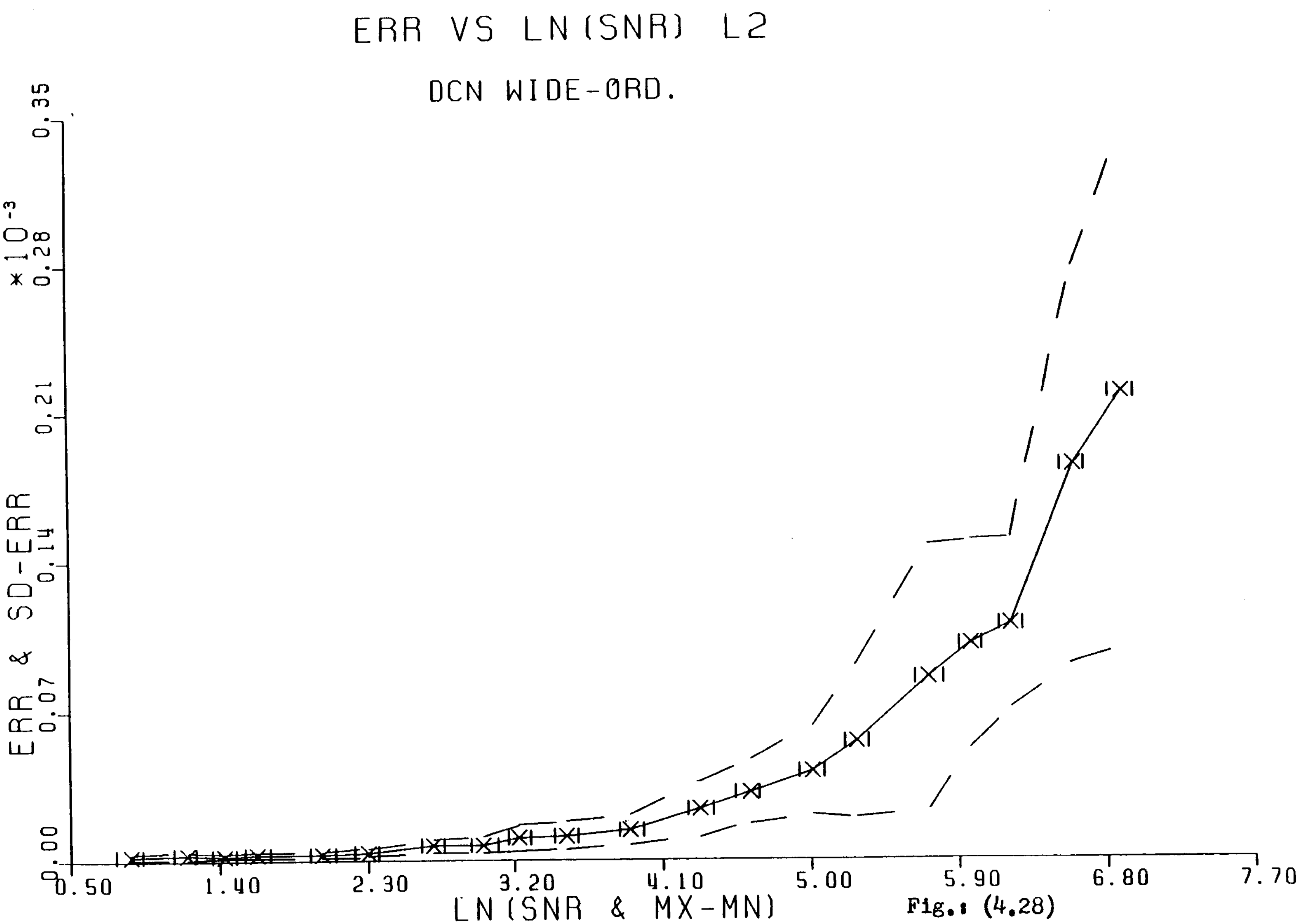

ERR VS LN(SNR) L2
DCN WIDE-ØRD.
ERR & SD-ERR
*10^-3
0.00
0.07
0.14
0.21
0.28
0.35
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.28)

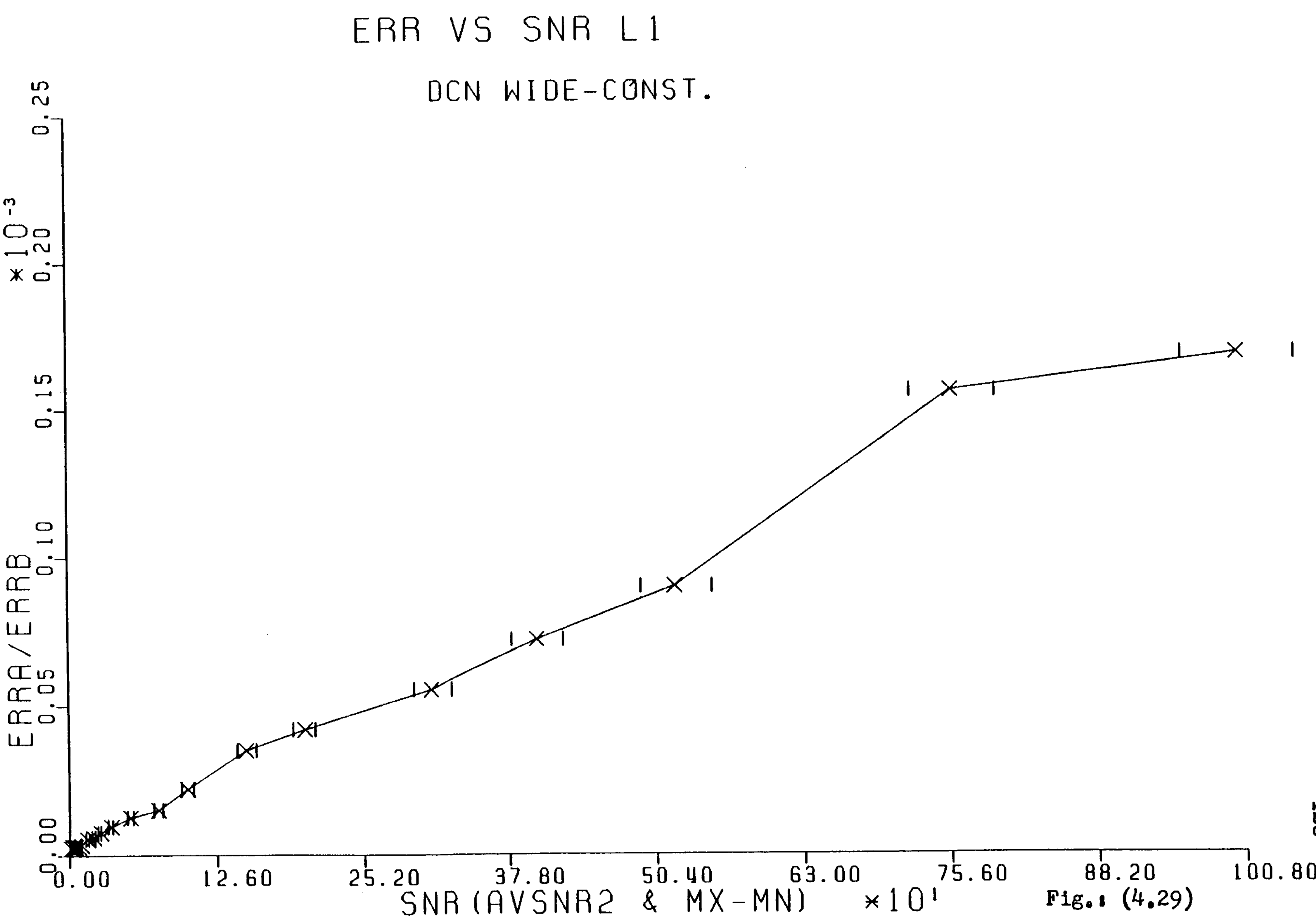

ERR VS SNR L1
DCN WIDE-CONST.
ERRA/ERRB
*10^-3
0.00
0.05
0.10
0.15
0.20
0.25
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) *10^1

Fig.: (4.29)

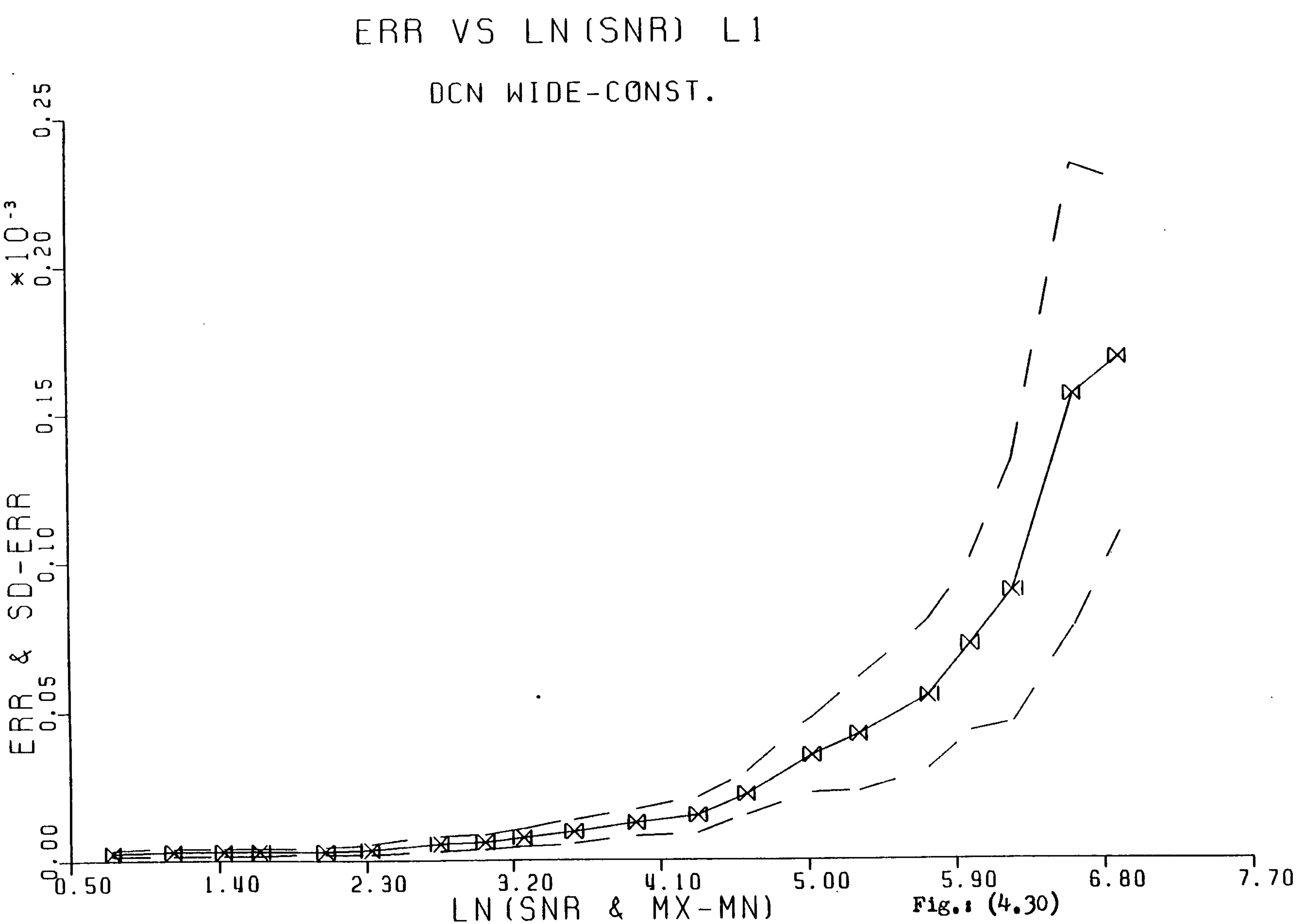
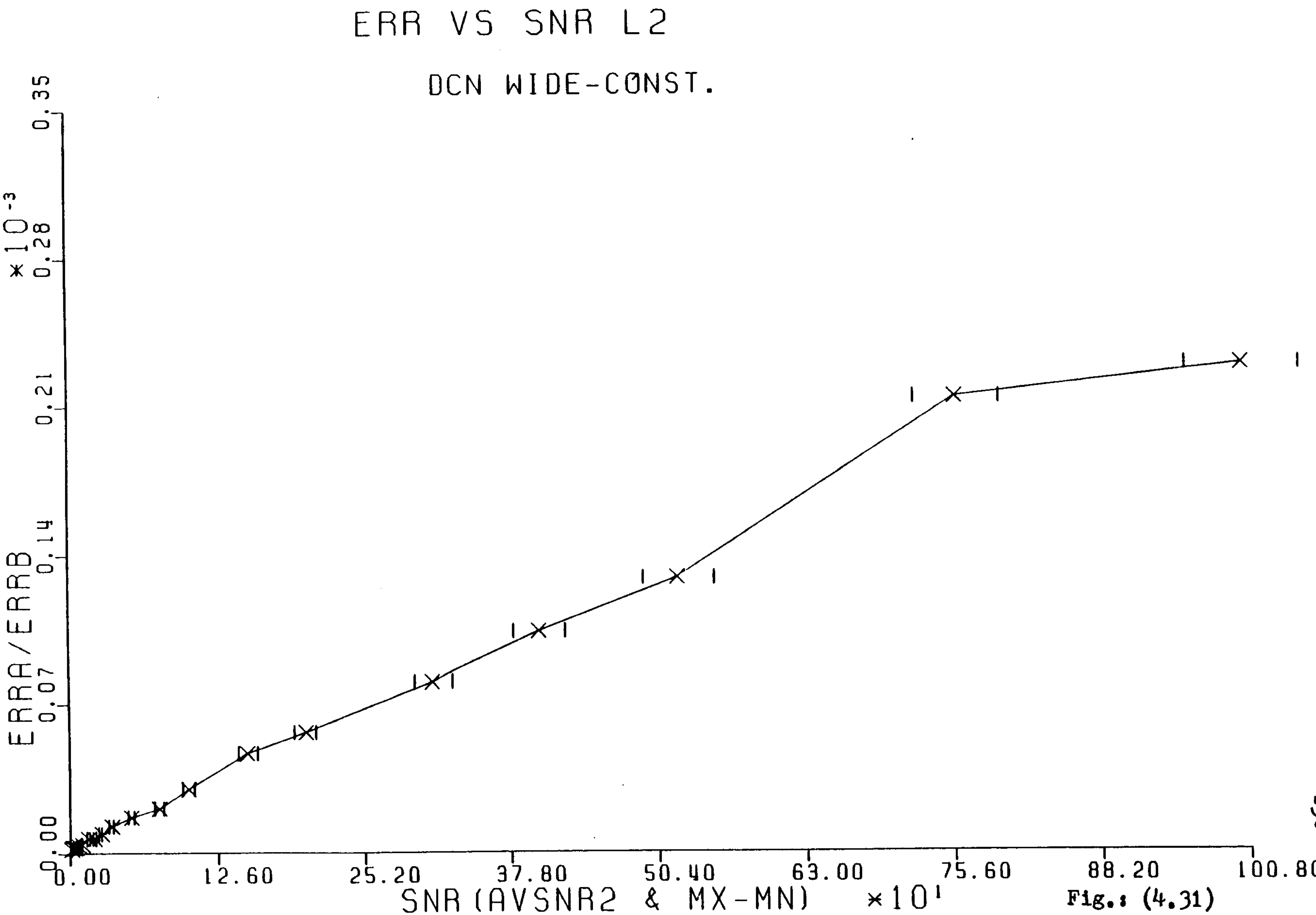

ERR VS LN(SNR) L1
DCN WIDE-CONST.
ERR & SD-ERR
*10^-3
0.00
0.05
0.10
0.15
0.20
0.25
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.30)



ERR VS SNR L2
DCN WIDE-CONST.
ERRA/ERRB
×10⁻³
0.00
0.07
0.14
0.21
0.28
0.35
0.00
12.60
25.20
37.80
50.40
63.00
75.60
88.20
100.80
SNR (AVSNR2 & MX-MN) ×10¹

Fig.: (4.31)

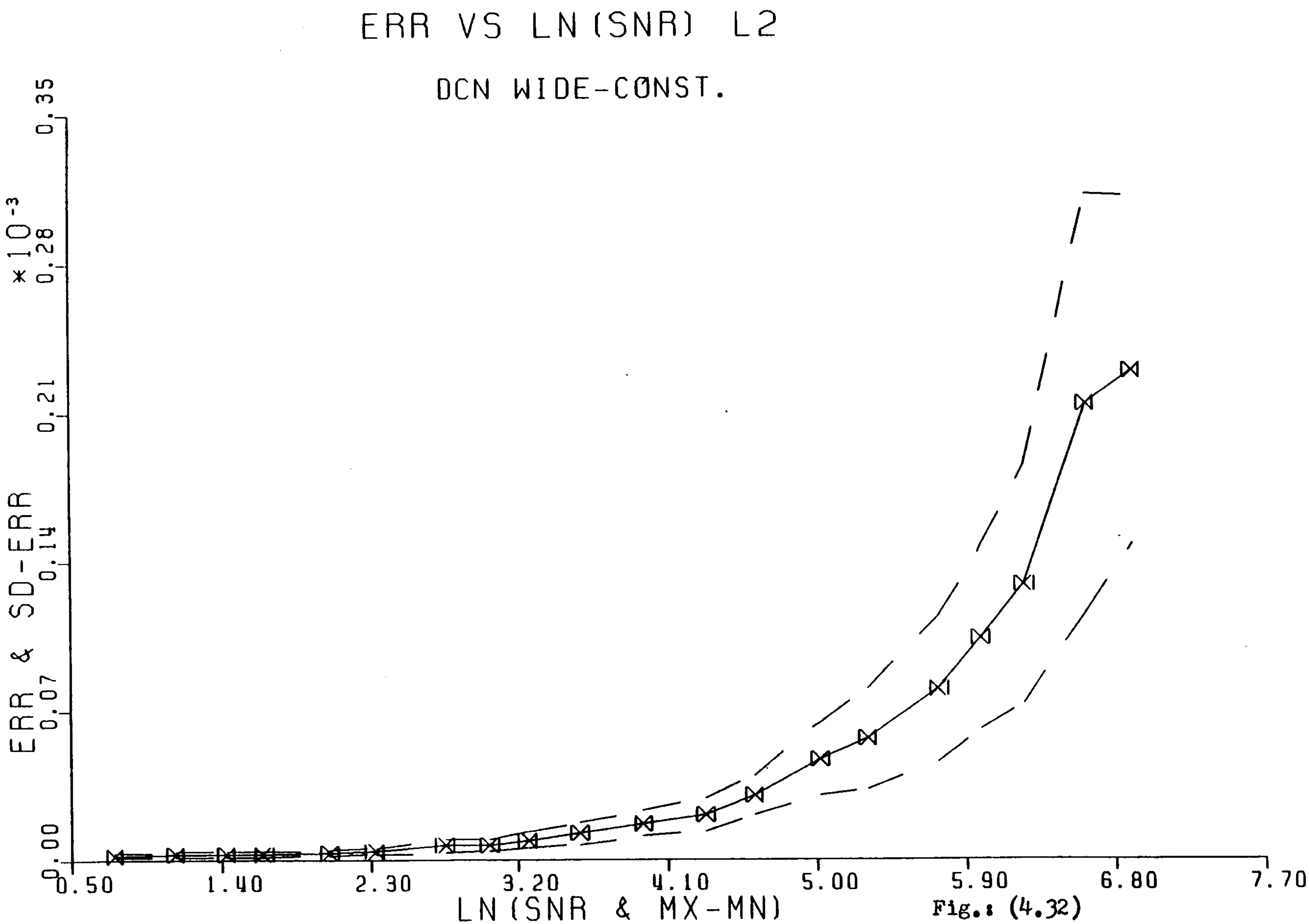

ERR VS LN(SNR) L2
DCN WIDE-CONST.
0.35
0.28
0.21
0.14
0.07
0.00
*10^-3
ERR & SD-ERR
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR & MX-MN)

Fig.: (4.32)

Chapter V

Scaled Input

The effect of the size of the input on the convergence criteria, the optimum iteration number, and the error improvement when using Morrison's noise removal alone and prior to deconvolution is discussed in this chapter.

The input used is the same input used before, except that its size has been reduced to one fourth of the previous input. The same labels f, g, and h, as in the previous chapters, are used in this chapter. Similar figures and tables to those listed in Chapter III and IV are also presented in this chapter.

With the new f the convergence value has to be changed. However, DF1 remains the same because the numerator and the denominator are both divided by one fourth. DF2 has to be divided by one fourth to obtain the new convergence criterion. It has been found that with the given convergence criteria, exactly the same optimum iteration numbers and the same error improvements are obtained. An additional table with convergence values of DF1=0.0000 and DF2 =0.0000 for noise removal alone is also presented.

Tables (5.1)-(5.20) correspond to tables listed in Chapter III and Tables (5.20)-(5.40) correspond to tables listed in Chapter IV. Since they are listed and unchanged, there is no need to replot the figures. One can refer to those figures in Chapter III and Chapter IV for more information.

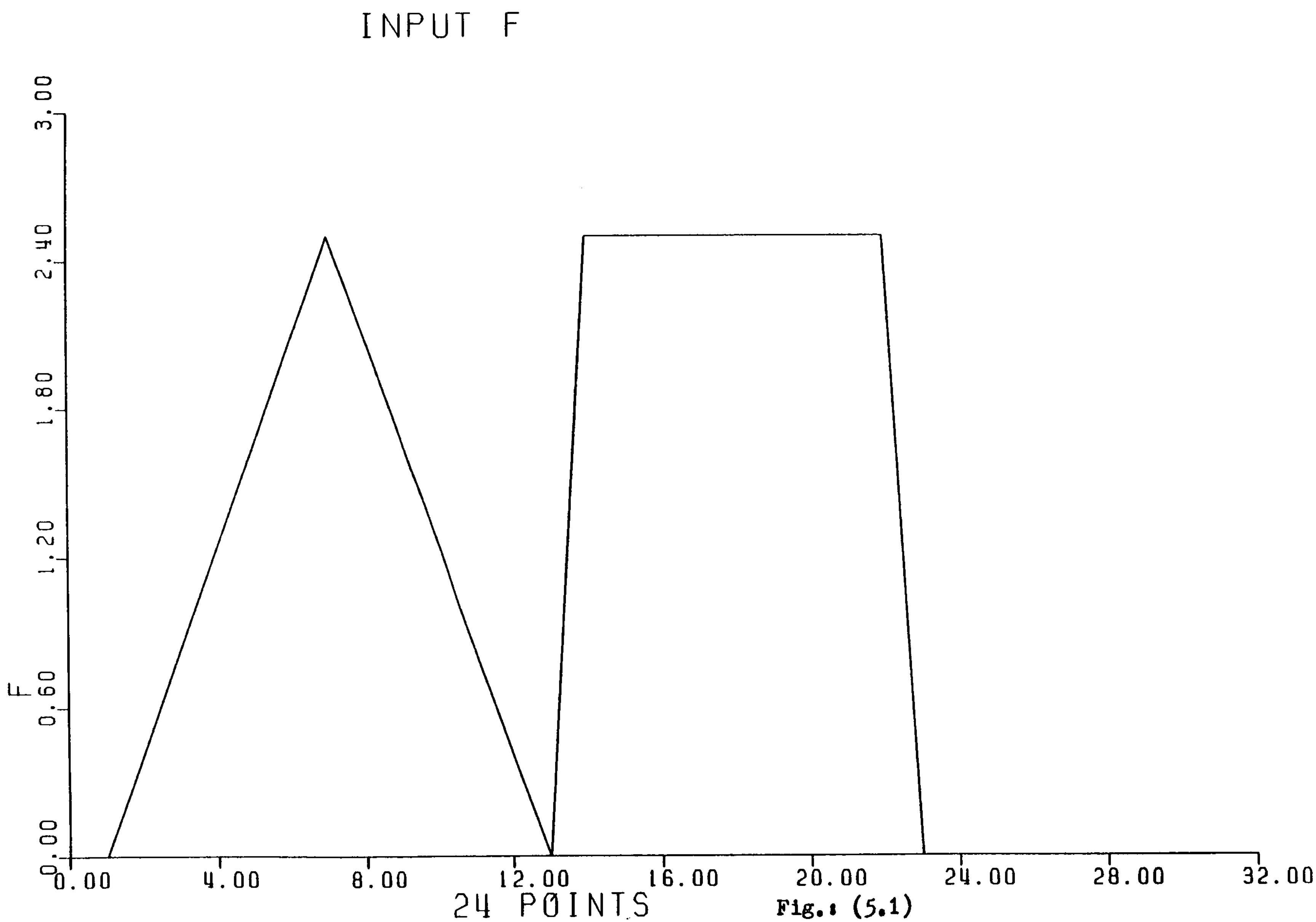

INPUT F
F
0.00
0.60
1.20
1.80
2.40
3.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
24 PØINTS

Fig.: (5.1)

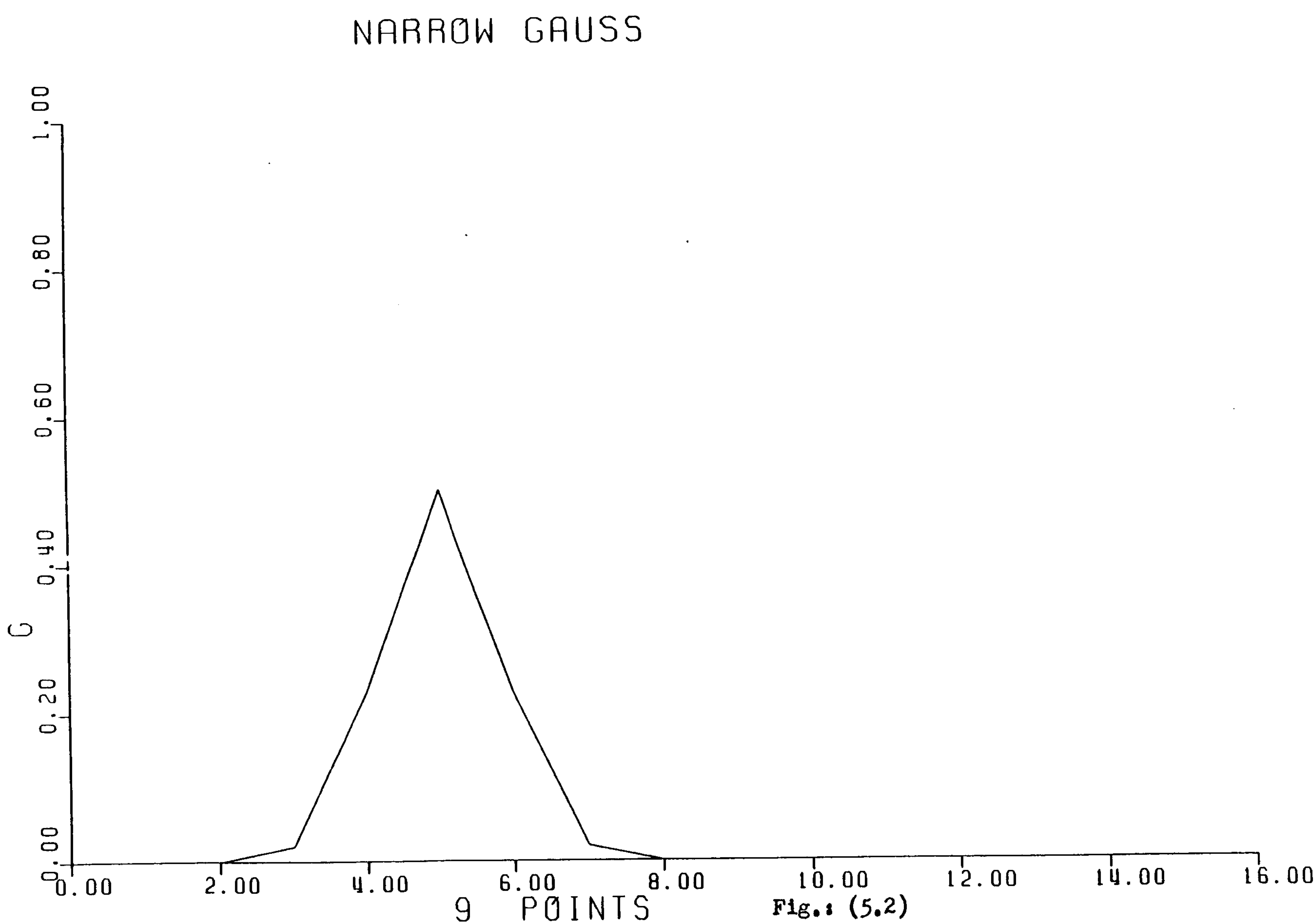

NARRØW GAUSS
G
0.00
0.20
0.40
0.60
0.80
1.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
9 PØINTS

Fig.: (5.2)

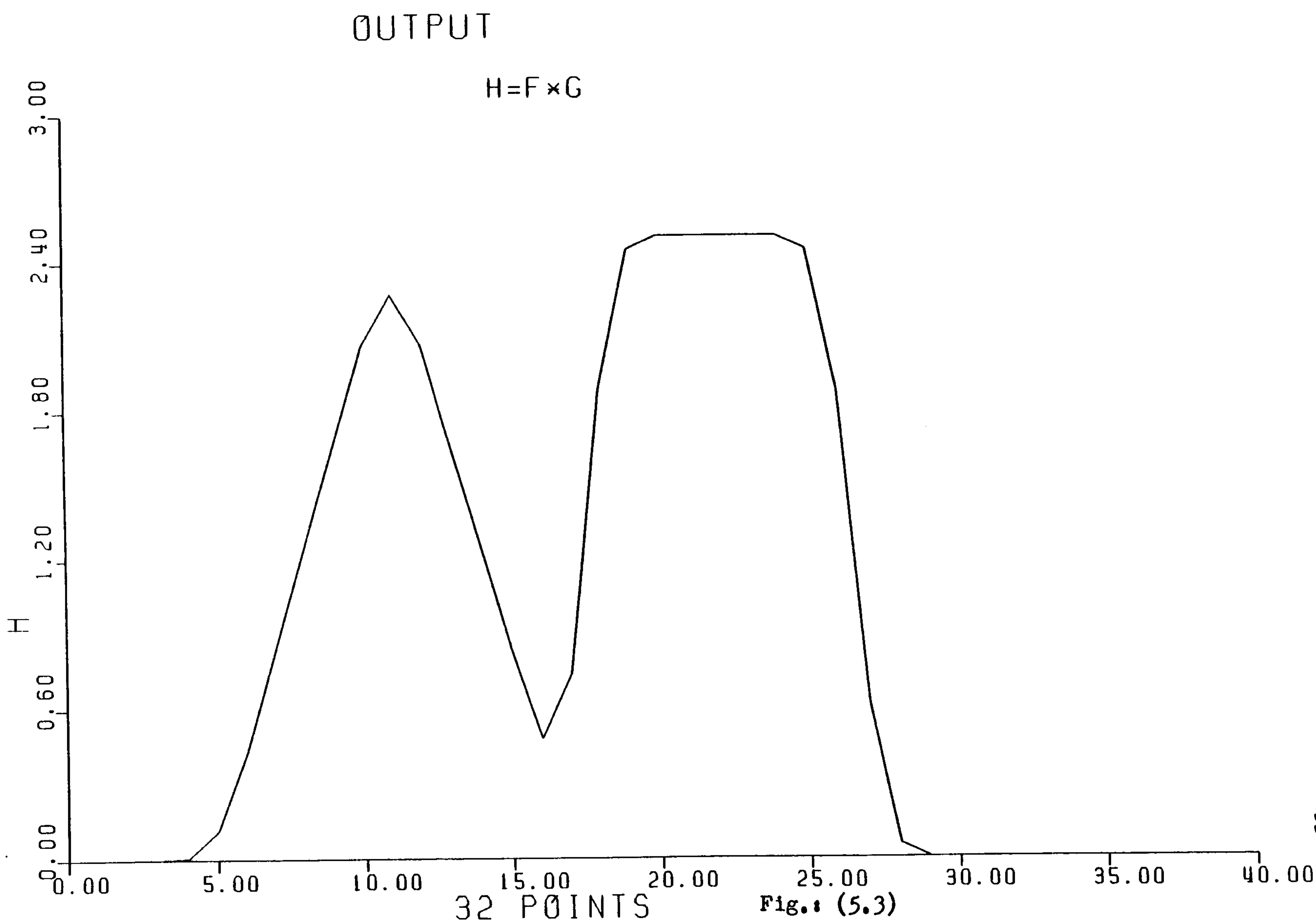
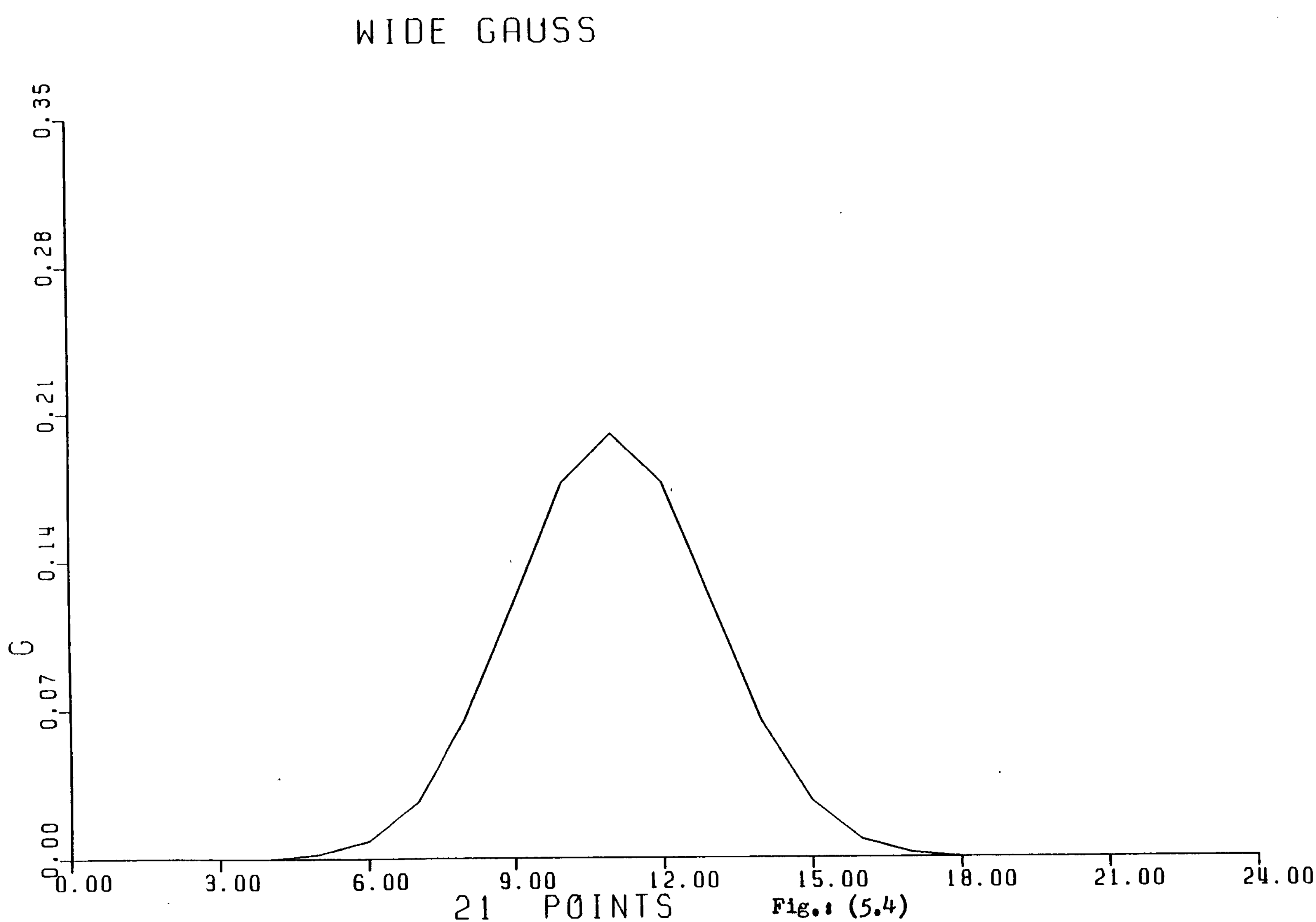

OUTPUT
H=F×G
H
3.00
2.40
1.80
1.20
0.60
0.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
32 PØINTS

Fig.: (5.3)



WIDE GAUSS
G
0.00
0.07
0.14
0.21
0.28
0.35
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
21 PØINTS

Fig.: (5.4)

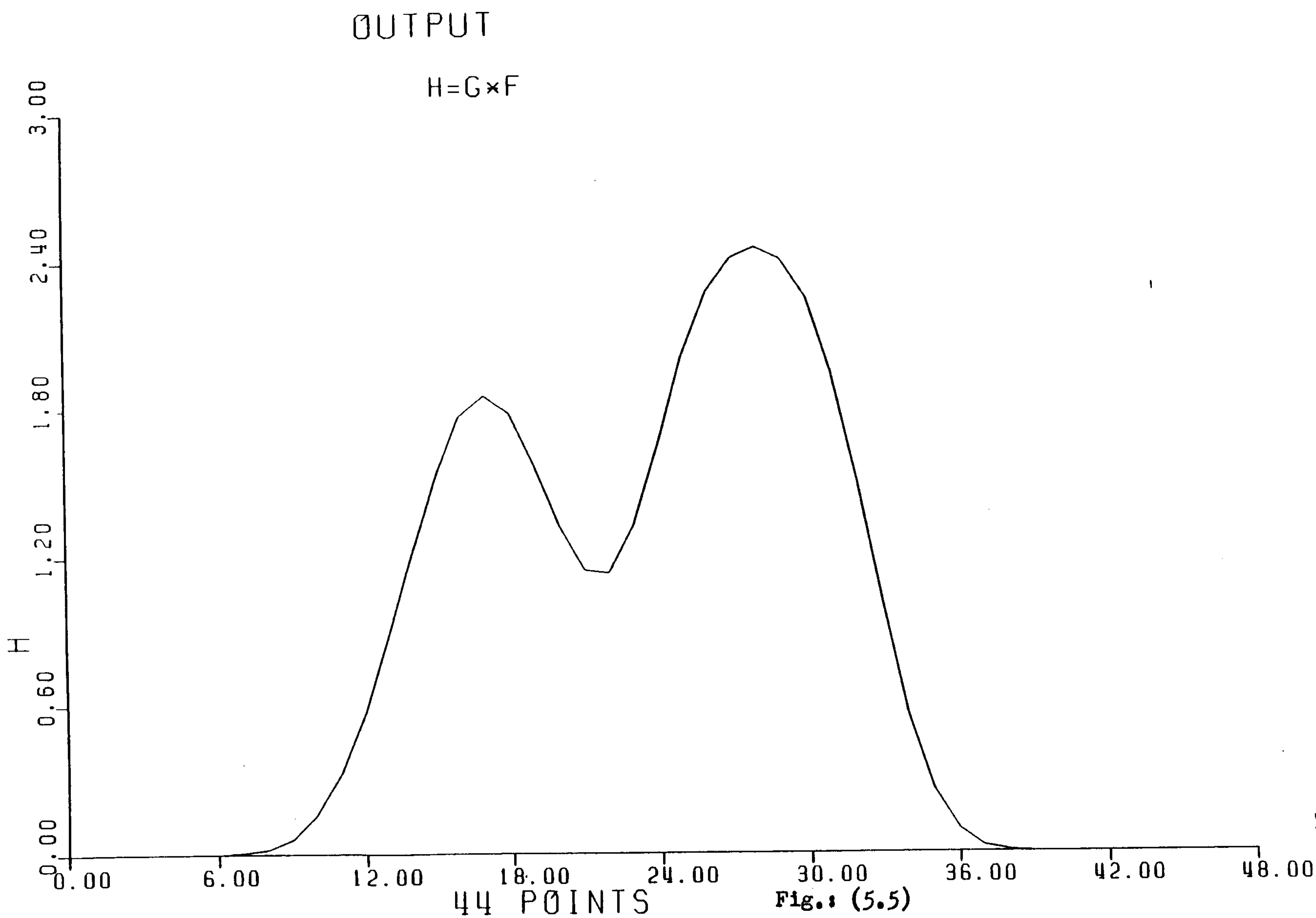

OUTPUT
H=G×F
H
0.00
0.60
1.20
1.80
2.40
3.00
0.00
6.00
12.00
18.00
24.00
30.00
36.00
42.00
48.00
44 POINTS

Fig.: (5.5)

TABLE (5.1)

SCALED NARROW ORDINAT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36258340E+00	2.56703777E+00	2.18037959E+00	3.99000000E+02
3.00000000E+00	3.14358191E+00	3.36858919E+00	2.91042387E+00	3.49000000E+02
4.00000000E+00	3.94490345E+00	4.23985276E+00	3.62263843E+00	3.57000000E+02
5.00000000E+00	4.82867725E+00	5.27650268E+00	4.46220519E+00	3.53000000E+02
7.50000000E+00	7.42870853E+00	8.11945282E+00	6.88343436E+00	3.58000000E+02
1.00000000E+01	9.86766076E+00	1.05756122E+01	9.17682864E+00	3.62000000E+02
1.50000000E+01	1.51777312E+01	1.67703058E+01	1.38689688E+01	3.27000000E+02
2.00000000E+01	1.93612023E+01	2.10230427E+01	1.77395948E+01	3.75000000E+02
2.50000000E+01	2.54713673E+01	2.78008279E+01	2.37453818E+01	3.72000000E+02
3.50000000E+01	3.49397876E+01	3.76998752E+01	3.22674728E+01	3.22000000E+02
5.00000000E+01	5.03170516E+01	5.40962637E+01	4.68674210E+01	4.12000000E+02
7.50000000E+01	7.50853180E+01	8.24997091E+01	6.87960513E+01	3.36000000E+02
1.00000000E+02	1.00476079E+02	1.08352561E+02	9.23643071E+01	3.98000000E+02
1.50000000E+02	1.45435095E+02	1.57608786E+02	1.34013517E+02	3.74000000E+02
2.00000000E+02	2.02956372E+02	2.21950432E+02	1.81066606E+02	3.17000000E+02
3.00000000E+02	2.96842155E+02	3.22487834E+02	2.73420196E+02	3.31000000E+02
4.00000000E+02	4.05393678E+02	4.43115150E+02	3.74198256E+02	3.60000000E+02
5.00000000E+02	4.91303170E+02	5.35148544E+02	4.50731972E+02	3.68000000E+02
7.50000000E+02	7.55217434E+02	8.12373370E+02	6.97852994E+02	3.80000000E+02
1.00000000E+03	1.00013444E+03	1.08080587E+03	9.30717075E+02	3.59000000E+02

TABLE (5.2)

SCALED NARROW ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36258340E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14358191E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.94490345E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.82867725E+00	1.04000000E+00	1.95959179E-01	1.00000000E+00	0.00000000E+00
7.42870853E+00	1.25000000E+00	4.33012702E-01	1.06000000E+00	2.37486842E-01
9.86766076E+00	1.56000000E+00	6.52993109E-01	1.27000000E+00	4.43959458E-01
1.51777312E+01	2.25000000E+00	8.87411967E-01	1.85000000E+00	4.55521679E-01
1.93612023E+01	2.68000000E+00	9.88736568E-01	2.21000000E+00	4.95883051E-01
2.54713673E+01	3.09000000E+00	1.12334322E+00	2.69000000E+00	6.88403951E-01
3.49397876E+01	4.87000000E+00	4.02654939E+00	3.77000000E+00	1.05692952E+00
5.03170516E+01	7.23000000E+00	4.85768463E+00	5.59000000E+00	1.87667259E+00
7.50853180E+01	1.01600000E+01	7.81245160E+00	8.27000000E+00	4.34477848E+00
1.00476079E+02	1.52500000E+01	9.61808193E+00	1.24700000E+01	6.39289449E+00
1.45435095E+02	1.92300000E+01	1.00208333E+01	1.60000000E+01	6.12698947E+00
2.02956372E+02	2.47100000E+01	1.01973477E+01	2.11900000E+01	7.85836497E+00
2.96842155E+02	2.95700000E+01	9.25662465E+00	2.62500000E+01	7.12372796E+00
4.05393678E+02	3.29000000E+01	8.91795941E+00	3.02700000E+01	7.41600297E+00
4.91303170E+02	3.35400000E+01	7.68169252E+00	3.13500000E+01	7.07442577E+00
7.55217434E+02	3.57800000E+01	7.30147930E+00	3.31000000E+01	6.72086304E+00
1.00013444E+03	3.62900000E+01	6.35813652E+00	3.48000000E+01	5.34415569E+00

TABLE(5.3)

SCALED NARROW ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.25000000E+00	1.00000000E+00	2.00000000E+00	1.06000000E+00	1.00000000E+00	2.00000000E+00
1.56000000E+00	1.00000000E+00	5.00000000E+00	1.27000000E+00	1.00000000E+00	2.00000000E+00
2.25000000E+00	1.00000000E+00	6.00000000E+00	1.85000000E+00	1.00000000E+00	3.00000000E+00
2.68000000E+00	1.00000000E+00	7.00000000E+00	2.21000000E+00	1.00000000E+00	4.00000000E+00
3.09000000E+00	2.00000000E+00	8.00000000E+00	2.69000000E+00	2.00000000E+00	4.00000000E+00
4.87000000E+00	2.00000000E+00	3.80000000E+01	3.77000000E+00	2.00000000E+00	7.00000000E+00
7.23000000E+00	3.00000000E+00	3.10000000E+01	5.59000000E+00	3.00000000E+00	1.50000000E+01
1.01600000E+01	3.00000000E+00	3.90000000E+01	8.27000000E+00	4.00000000E+00	3.20000000E+01
1.52500000E+01	4.00000000E+00	4.60000000E+01	1.24700000E+01	5.00000000E+00	3.30000000E+01
1.92300000E+01	5.00000000E+00	4.30000000E+01	1.60000000E+01	7.00000000E+00	3.20000000E+01
2.47100000E+01	9.00000000E+00	4.40000000E+01	2.11900000E+01	1.00000000E+01	4.10000000E+01
2.95700000E+01	1.30000000E+01	4.70000000E+01	2.62500000E+01	1.20000000E+01	4.10000000E+01
3.29000000E+01	1.60000000E+01	4.70000000E+01	3.02700000E+01	1.80000000E+01	4.50000000E+01
3.35400000E+01	1.80000000E+01	4.50000000E+01	3.13500000E+01	1.80000000E+01	4.50000000E+01
3.57800000E+01	2.10000000E+01	4.80000000E+01	3.31000000E+01	2.00000000E+01	4.80000000E+01
3.62900000E+01	2.20000000E+01	4.90000000E+01	3.48000000E+01	2.10000000E+01	4.70000000E+01

TABLE (5.4)

SCALED NARROW ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36258340E+00	6.48435075E-01	9.85583789E-02	6.17719057E-01	9.20716836E-02
3.14358191E+00	6.38058528E-01	9.97883048E-02	5.97672738E-01	9.03616932E-02
3.94490345E+00	6.56778043E-01	9.41789672E-02	6.23142530E-01	8.55357673E-02
4.82867725E+00	6.61455900E-01	9.31934778E-02	6.22863033E-01	8.50062628E-02
7.42870853E+00	6.93838296E-01	1.04833341E-01	6.55267494E-01	9.48784705E-02
9.86766076E+00	7.24726272E-01	1.11684464E-01	6.90656392E-01	1.01087641E-01
1.51777312E+01	7.80451236E-01	9.49107269E-02	7.49918451E-01	9.10927845E-02
1.93612023E+01	7.89491641E-01	1.01846244E-01	7.68066315E-01	9.20432853E-02
2.54713673E+01	8.15128948E-01	8.81197531E-02	7.95031421E-01	8.25556024E-02
3.49397876E+01	8.73055100E-01	8.57180826E-02	8.50846963E-01	7.98841162E-02
5.03170516E+01	9.00683123E-01	7.95038891E-02	8.87029555E-01	7.22713423E-02
7.50853180E+01	9.31991293E-01	6.81644211E-02	9.13452008E-01	6.95662606E-02
1.00476079E+02	9.58831188E-01	4.65718617E-02	9.48834544E-01	4.27363491E-02
1.45435095E+02	9.69796918E-01	4.26602721E-02	9.63850882E-01	3.93118092E-02
2.02956372E+02	9.83064430E-01	3.29585223E-02	9.75507605E-01	2.92396978E-02
2.96842155E+02	9.88833526E-01	3.06900249E-02	9.83908300E-01	3.37775528E-02
4.05393678E+02	9.97458109E-01	2.35702820E-02	9.89444745E-01	2.59738892E-02
4.91303170E+02	9.98558889E-01	2.54998193E-02	9.89154231E-01	2.82047808E-02
7.55217434E+02	1.00297939E+00	2.57954786E-02	9.88535191E-01	2.93573548E-02
1.00013444E+03	1.00554888E+00	3.20526946E-02	9.93116767E-01	3.73357470E-02

TABLE (5.5)

SCALED NARROW ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
6.48435075E-01	4.02004635E-01	8.68977670E-01	6.17719057E-01	3.71611211E-01	8.24138474E-01
6.38058528E-01	4.44672139E-01	8.37646149E-01	5.97672738E-01	3.96790936E-01	7.99140390E-01
6.56778043E-01	4.56294976E-01	8.66903454E-01	6.23142530E-01	3.93212378E-01	7.98804289E-01
6.61455900E-01	4.40920490E-01	9.08345208E-01	6.22863033E-01	4.34216635E-01	8.30902270E-01
6.93838296E-01	4.58345808E-01	9.12660485E-01	6.55267494E-01	4.36256671E-01	8.42330115E-01
7.24726272E-01	5.05951804E-01	9.59898313E-01	6.90656392E-01	4.47705434E-01	9.09306895E-01
7.80451236E-01	5.80330089E-01	9.67923080E-01	7.49918451E-01	5.69085743E-01	9.60562409E-01
7.89491641E-01	4.86322549E-01	9.70840742E-01	7.68066315E-01	4.94425345E-01	9.45956233E-01
8.15128948E-01	6.04004551E-01	1.00016036E+00	7.95031421E-01	5.82367528E-01	9.50966820E-01
8.73055100E-01	5.49468359E-01	1.00109952E+00	8.50846963E-01	5.39664388E-01	9.69390005E-01
9.00683123E-01	6.33704969E-01	1.01719886E+00	8.87029555E-01	6.48111628E-01	9.95503368E-01
9.31991293E-01	6.46924190E-01	1.03209013E+00	9.13452008E-01	6.30774128E-01	1.00135774E+00
9.58831188E-01	8.17891645E-01	1.01113827E+00	9.48834544E-01	8.20889998E-01	1.00168588E+00
9.69796918E-01	8.42898060E-01	1.01720845E+00	9.63850882E-01	8.25952765E-01	1.00328845E+00
9.83064430E-01	8.34129590E-01	1.04289171E+00	9.75507605E-01	8.80146939E-01	1.00445006E+00
9.88833526E-01	8.31455687E-01	1.01696000E+00	9.83908300E-01	7.99056768E-01	1.00655774E+00
9.97458109E-01	8.55492826E-01	1.01721736E+00	9.89444745E-01	8.93897321E-01	1.01089159E+00
9.98558889E-01	8.55241041E-01	1.02474302E+00	9.89154231E-01	8.91841234E-01	1.01363335E+00
1.00297939E+00	9.14954023E-01	1.07454343E+00	9.88535191E-01	8.93729998E-01	1.01608866E+00
1.00554888E+00	8.32422488E-01	1.03756558E+00	9.93116767E-01	7.57607489E-01	1.02089123E+00

TABLE (5.6)

SCALED NARROW CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.23024575E+00	2.38621271E+00	2.09679916E+00	3.86000000E+02
3.00000000E+00	3.14335954E+00	3.35897406E+00	2.91977809E+00	3.34000000E+02
4.00000000E+00	4.11323178E+00	4.33639361E+00	3.86745062E+00	3.50000000E+02
5.00000000E+00	5.03484071E+00	5.40346845E+00	4.77243965E+00	3.43000000E+02
7.50000000E+00	7.71418082E+00	8.26683028E+00	7.26938047E+00	3.48000000E+02
1.00000000E+01	1.01754590E+01	1.08254892E+01	9.60509326E+00	3.63000000E+02
1.50000000E+01	1.54093560E+01	1.63997433E+01	1.44417537E+01	3.78000000E+02
2.00000000E+01	2.01180204E+01	2.13376084E+01	1.87386813E+01	3.34000000E+02
2.50000000E+01	2.59659051E+01	2.74694257E+01	2.43412880E+01	3.76000000E+02
3.50000000E+01	3.50728506E+01	3.74770562E+01	3.30452773E+01	3.38000000E+02
5.00000000E+01	5.13631005E+01	5.45799338E+01	4.84832118E+01	3.65000000E+02
7.50000000E+01	7.39518697E+01	7.93018385E+01	6.94914662E+01	3.52000000E+02
1.00000000E+02	9.95079962E+01	1.06203813E+02	9.34674079E+01	3.65000000E+02
1.50000000E+02	1.50376137E+02	1.59570265E+02	1.40763020E+02	3.37000000E+02
2.00000000E+02	2.01464171E+02	2.12634123E+02	1.90081278E+02	3.80000000E+02
3.00000000E+02	3.04656202E+02	3.23046258E+02	2.86549482E+02	3.60000000E+02
4.00000000E+02	4.02653155E+02	4.29266901E+02	3.76326096E+02	3.58000000E+02
5.00000000E+02	5.09645109E+02	5.46508814E+02	4.74512065E+02	3.42000000E+02
7.50000000E+02	7.67146619E+02	8.15225229E+02	7.25147741E+02	3.68000000E+02
1.00000000E+03	1.02475298E+03	1.09361346E+03	9.62524660E+02	3.65000000E+02

TABLE(5.7)

SCALED NARROW CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.23024575E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14335954E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.11323178E+00	1.04000000E+00	1.95959179E-01	1.00000000E+00	0.00000000E+00
5.03484071E+00	1.06000000E+00	2.37486842E-01	1.00000000E+00	0.00000000E+00
7.71418082E+00	1.35000000E+00	4.76969601E-01	1.30000000E+00	4.58257569E-01
1.01754590E+01	1.71000000E+00	6.97065277E-01	1.58000000E+00	4.93558507E-01
1.54093560E+01	2.26000000E+00	5.58927544E-01	2.12000000E+00	3.81575681E-01
2.01180204E+01	2.69000000E+00	9.13181253E-01	2.46000000E+00	5.37028863E-01
2.59659051E+01	3.08000000E+00	1.25443214E+00	2.93000000E+00	8.27707678E-01
3.50728506E+01	4.83000000E+00	4.50789308E+00	3.74000000E+00	1.05470375E+00
5.13631005E+01	6.46000000E+00	5.16414562E+00	5.79000000E+00	1.80163814E+00
7.39518697E+01	8.74000000E+00	6.23477345E+00	8.81000000E+00	4.04646760E+00
9.95079962E+01	1.24000000E+01	7.91833316E+00	1.25000000E+01	5.82837885E+00
1.50376137E+02	1.76400000E+01	8.46583723E+00	1.81700000E+01	7.01862522E+00
2.01464171E+02	2.30800000E+01	8.68525187E+00	2.29100000E+01	7.40553172E+00
3.04656202E+02	2.55900000E+01	8.18913304E+00	2.72100000E+01	6.67876486E+00
4.02653155E+02	3.04900000E+01	8.60638716E+00	3.12700000E+01	6.62095915E+00
5.09645109E+02	3.05600000E+01	6.86049561E+00	3.16700000E+01	6.40789357E+00
7.67146619E+02	3.29400000E+01	6.95675212E+00	3.36400000E+01	6.06715749E+00
1.02475298E+03	3.43400000E+01	5.82789842E+00	3.58200000E+01	5.10955967E+00

TABLE (5.8)

SCALED NARROW CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.06000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.35000000E+00	1.00000000E+00	2.00000000E+00	1.30000000E+00	1.00000000E+00	2.00000000E+00
1.71000000E+00	1.00000000E+00	5.00000000E+00	1.58000000E+00	1.00000000E+00	2.00000000E+00
2.26000000E+00	1.00000000E+00	5.00000000E+00	2.12000000E+00	1.00000000E+00	3.00000000E+00
2.69000000E+00	1.00000000E+00	6.00000000E+00	2.46000000E+00	2.00000000E+00	4.00000000E+00
3.08000000E+00	2.00000000E+00	9.00000000E+00	2.93000000E+00	2.00000000E+00	5.00000000E+00
4.83000000E+00	2.00000000E+00	3.50000000E+01	3.74000000E+00	2.00000000E+00	7.00000000E+00
6.46000000E+00	3.00000000E+00	3.50000000E+01	5.79000000E+00	3.00000000E+00	1.20000000E+01
8.74000000E+00	3.00000000E+00	3.90000000E+01	8.81000000E+00	4.00000000E+00	2.50000000E+01
1.24000000E+01	4.00000000E+00	4.00000000E+01	1.25000000E+01	5.00000000E+00	3.50000000E+01
1.76400000E+01	4.00000000E+00	3.90000000E+01	1.81700000E+01	7.00000000E+00	3.70000000E+01
2.30800000E+01	9.00000000E+00	4.30000000E+01	2.29100000E+01	1.30000000E+01	4.10000000E+01
2.55900000E+01	1.30000000E+01	4.50000000E+01	2.72100000E+01	1.50000000E+01	4.30000000E+01
3.04900000E+01	1.40000000E+01	4.60000000E+01	3.12700000E+01	1.50000000E+01	4.30000000E+01
3.05600000E+01	1.60000000E+01	4.50000000E+01	3.16700000E+01	1.90000000E+01	4.50000000E+01
3.29400000E+01	2.00000000E+01	4.80000000E+01	3.36400000E+01	2.10000000E+01	4.80000000E+01
3.43400000E+01	2.10000000E+01	4.80000000E+01	3.58200000E+01	2.30000000E+01	4.60000000E+01

TABLE (5.9)

SCALED NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.23024575E+00	7.58474965E-01	6.44554689E-02	7.19748547E-01	5.69264646E-02
3.14335954E+00	7.37248223E-01	7.21155910E-02	7.07372573E-01	6.47200772E-02
4.11323178E+00	7.35409622E-01	7.35089531E-02	7.10248377E-01	6.64098983E-02
5.03484071E+00	7.46664942E-01	7.37153486E-02	7.16475590E-01	6.48706889E-02
7.71418082E+00	7.71740615E-01	8.76457525E-02	7.41321917E-01	7.98498024E-02
1.01754590E+01	7.93205166E-01	7.28851422E-02	7.68911865E-01	6.68154540E-02
1.54093560E+01	8.18258470E-01	7.17756556E-02	8.04213584E-01	7.10894128E-02
2.01180204E+01	8.27310431E-01	8.40750215E-02	8.20619336E-01	7.25058761E-02
2.59659051E+01	8.47303572E-01	7.11318478E-02	8.41025537E-01	6.26681393E-02
3.50728506E+01	8.79990511E-01	7.35795571E-02	8.77708357E-01	5.98826764E-02
5.13631005E+01	9.13909023E-01	6.20900938E-02	9.12799328E-01	5.27091442E-02
7.39518697E+01	9.31531641E-01	6.00836429E-02	9.35902656E-01	5.41320614E-02
9.95079962E+01	9.61821066E-01	4.78701631E-02	9.62676226E-01	3.60891215E-02
1.50376137E+02	9.73076776E-01	3.69702273E-02	9.76273538E-01	2.84189641E-02
2.01464171E+02	9.83879445E-01	2.72350836E-02	9.87011583E-01	1.91236216E-02
3.04656202E+02	9.83222928E-01	3.24984311E-02	9.90622729E-01	2.00654673E-02
4.02653155E+02	9.92757195E-01	2.51113104E-02	9.95320179E-01	1.85364156E-02
5.09645109E+02	9.92913795E-01	2.60808170E-02	9.92514433E-01	2.20456768E-02
7.67146619E+02	9.88358267E-01	3.62381806E-02	9.91690458E-01	2.80043480E-02
1.02475298E+03	9.93692859E-01	3.26731945E-02	9.97884559E-01	2.76726842E-02

TABLE (5.10)

SCALED NARROW CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
7.58474965E-01	5.71290537E-01	8.84296246E-01	7.19748547E-01	5.64783723E-01	8.36933080E-01
7.37248223E-01	5.81248563E-01	8.86152723E-01	7.07372573E-01	5.52922399E-01	8.49538718E-01
7.35409622E-01	5.29466788E-01	9.10080022E-01	7.10248377E-01	5.22759161E-01	8.62443117E-01
7.46664942E-01	5.15873688E-01	8.97973900E-01	7.16475590E-01	5.28814698E-01	8.52532527E-01
7.71740615E-01	4.47791341E-01	9.34025714E-01	7.41321917E-01	4.66211015E-01	9.00545979E-01
7.93205166E-01	6.29472614E-01	9.55593105E-01	7.68911865E-01	6.22076780E-01	9.06547210E-01
8.18258470E-01	6.34494084E-01	9.40062303E-01	8.04213584E-01	6.19763740E-01	9.30234973E-01
8.27310431E-01	6.01083347E-01	9.81476510E-01	8.20619336E-01	5.78079590E-01	9.38355744E-01
8.47303572E-01	6.76362569E-01	9.83787274E-01	8.41025537E-01	6.70575614E-01	9.83467952E-01
8.79990511E-01	6.52325851E-01	1.00297627E+00	8.77708357E-01	7.13568416E-01	9.80870731E-01
9.13909023E-01	7.23472986E-01	1.00442931E+00	9.12799328E-01	7.77333289E-01	9.97431633E-01
9.31531641E-01	7.20637983E-01	1.02249663E+00	9.35902656E-01	6.92745836E-01	1.00917306E+00
9.61821066E-01	7.80136022E-01	1.12916262E+00	9.62676226E-01	8.33188968E-01	1.00161465E+00
9.73076776E-01	8.51405883E-01	1.07897695E+00	9.76273538E-01	8.73291025E-01	1.00365622E+00
9.83879445E-01	8.84565836E-01	1.01199342E+00	9.87011583E-01	9.20401139E-01	1.00519993E+00
9.83222928E-01	8.33928285E-01	1.01310101E+00	9.90622729E-01	9.03491028E-01	1.00655502E+00
9.92757195E-01	8.85491176E-01	1.01672591E+00	9.95320179E-01	8.99509231E-01	1.01072672E+00
9.92913795E-01	8.98236735E-01	1.02354426E+00	9.92514433E-01	9.00509201E-01	1.01138595E+00
9.88358267E-01	8.71885374E-01	1.04416135E+00	9.91690458E-01	8.75193932E-01	1.01568981E+00
9.93692859E-01	8.35502073E-01	1.03683033E+00	9.97884559E-01	8.09957747E-01	1.02009228E+00

TABLE (5.11)

SCALED WIDE ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36816210E+00	2.55548233E+00	2.17664375E+00	3.59000000E+02
3.00000000E+00	3.40120509E+00	3.65578767E+00	3.12070721E+00	3.65000000E+02
4.00000000E+00	4.20129683E+00	4.57414145E+00	3.92109555E+00	3.57000000E+02
5.00000000E+00	4.99396969E+00	5.40408912E+00	4.61384589E+00	3.36000000E+02
7.50000000E+00	7.50600566E+00	8.12727844E+00	6.96049297E+00	4.02000000E+02
1.00000000E+01	1.00642901E+01	1.08717192E+01	9.36312891E+00	3.60000000E+02
1.50000000E+01	1.44404671E+01	1.55358730E+01	1.34116711E+01	3.62000000E+02
2.00000000E+01	1.99548473E+01	2.16461190E+01	1.84673158E+01	3.54000000E+02
2.50000000E+01	2.52146238E+01	2.70240758E+01	2.33507443E+01	3.99000000E+02
3.50000000E+01	3.45358206E+01	3.72069663E+01	3.22789637E+01	3.44000000E+02
5.00000000E+01	5.08967916E+01	5.47343209E+01	4.70868409E+01	3.52000000E+02
7.50000000E+01	7.50989242E+01	8.22860731E+01	6.98302754E+01	3.62000000E+02
1.00000000E+02	9.93161409E+01	1.06231711E+02	9.25023438E+01	3.89000000E+02
1.50000000E+02	1.47331352E+02	1.57088445E+02	1.36887592E+02	3.47000000E+02
2.00000000E+02	2.03204024E+02	2.19569976E+02	1.88050981E+02	3.74000000E+02
3.00000000E+02	3.02238573E+02	3.24358283E+02	2.82326366E+02	3.79000000E+02
4.00000000E+02	3.83989189E+02	4.11103255E+02	3.55186537E+02	3.37000000E+02
5.00000000E+02	4.98222025E+02	5.43019516E+02	4.62979844E+02	3.25000000E+02
7.50000000E+02	7.32878476E+02	8.01353262E+02	6.76216663E+02	3.21000000E+02
1.00000000E+03	9.92074905E+02	1.07606525E+03	9.25104783E+02	3.70000000E+02

TABLE(5.12)

SCALED WIDE ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36816210E+00	1.21000000E+00	6.37102817E-01	1.02000000E+00	1.40000000E-01
3.40120509E+00	1.53000000E+00	6.55057249E-01	1.31000000E+00	5.60267793E-01
4.20129683E+00	1.84000000E+00	8.56971411E-01	1.43000000E+00	6.20564259E-01
4.99396969E+00	2.15000000E+00	1.22780292E+00	1.77000000E+00	7.72722460E-01
7.50600566E+00	2.78000000E+00	1.17115328E+00	2.38000000E+00	8.34026378E-01
1.00642901E+01	3.06000000E+00	1.05659832E+00	2.87000000E+00	9.34398202E-01
1.44404671E+01	4.23000000E+00	2.24434846E+00	3.62000000E+00	1.38405202E+00
1.99548473E+01	4.52000000E+00	1.85191792E+00	4.15000000E+00	1.63324830E+00
2.52146238E+01	5.48000000E+00	2.71470072E+00	5.06000000E+00	2.17632718E+00
3.45358206E+01	8.64000000E+00	4.83015528E+00	7.57000000E+00	3.71552150E+00
5.08967916E+01	1.29200000E+01	6.62371497E+00	1.20900000E+01	5.42235189E+00
7.50989242E+01	1.72600000E+01	8.79502132E+00	1.57500000E+01	5.88960949E+00
9.93161409E+01	2.07400000E+01	9.50433585E+00	1.82000000E+01	6.08440630E+00
1.47331352E+02	2.64800000E+01	9.97845679E+00	2.42400000E+01	8.03756182E+00
2.03204024E+02	3.07400000E+01	1.07225184E+01	2.79200000E+01	9.01518719E+00
3.02238573E+02	3.74300000E+01	1.01992696E+01	3.47700000E+01	8.92396212E+00
3.83989189E+02	3.82000000E+01	9.58644877E+00	3.53900000E+01	8.78054099E+00
4.98222025E+02	4.33100000E+01	8.90134260E+00	4.11700000E+01	8.73390520E+00
7.32878476E+02	4.69000000E+01	8.52818855E+00	4.57600000E+01	8.45472649E+00
9.92074905E+02	4.84800000E+01	7.78136235E+00	4.80400000E+01	8.10298710E+00

TABLE(5.13)

SCALED WIDE ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.21000000E+00	1.00000000E+00	6.00000000E+00	1.02000000E+00	1.00000000E+00	2.00000000E+00
1.53000000E+00	1.00000000E+00	4.00000000E+00	1.31000000E+00	1.00000000E+00	3.00000000E+00
1.84000000E+00	1.00000000E+00	5.00000000E+00	1.43000000E+00	1.00000000E+00	3.00000000E+00
2.15000000E+00	1.00000000E+00	1.10000000E+01	1.77000000E+00	1.00000000E+00	5.00000000E+00
2.78000000E+00	1.00000000E+00	9.00000000E+00	2.38000000E+00	1.00000000E+00	5.00000000E+00
3.06000000E+00	2.00000000E+00	7.00000000E+00	2.87000000E+00	1.00000000E+00	6.00000000E+00
4.23000000E+00	2.00000000E+00	1.70000000E+01	3.62000000E+00	2.00000000E+00	9.00000000E+00
4.52000000E+00	2.00000000E+00	1.60000000E+01	4.15000000E+00	2.00000000E+00	1.30000000E+01
5.48000000E+00	2.00000000E+00	1.90000000E+01	5.06000000E+00	2.00000000E+00	1.40000000E+01
8.64000000E+00	3.00000000E+00	3.30000000E+01	7.57000000E+00	3.00000000E+00	1.90000000E+01
1.29200000E+01	4.00000000E+00	3.40000000E+01	1.20900000E+01	4.00000000E+00	2.70000000E+01
1.72600000E+01	5.00000000E+00	4.70000000E+01	1.57500000E+01	5.00000000E+00	3.10000000E+01
2.07400000E+01	6.00000000E+00	5.30000000E+01	1.82000000E+01	7.00000000E+00	3.10000000E+01
2.64800000E+01	1.00000000E+01	5.20000000E+01	2.42400000E+01	9.00000000E+00	4.50000000E+01
3.07400000E+01	1.30000000E+01	6.20000000E+01	2.79200000E+01	1.30000000E+01	4.60000000E+01
3.74300000E+01	1.50000000E+01	5.70000000E+01	3.47700000E+01	1.90000000E+01	5.50000000E+01
3.82000000E+01	1.60000000E+01	5.90000000E+01	3.53900000E+01	1.70000000E+01	5.50000000E+01
4.33100000E+01	2.20000000E+01	5.70000000E+01	4.11700000E+01	2.40000000E+01	5.60000000E+01
4.69000000E+01	2.80000000E+01	6.60000000E+01	4.57600000E+01	2.70000000E+01	6.40000000E+01
4.84800000E+01	2.90000000E+01	6.30000000E+01	4.80400000E+01	3.10000000E+01	6.80000000E+01

TABLE(5.14)

SCALED WIDE ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36816210E+00	5.19820020E-01	1.22818919E-01	4.30905827E-01	9.70108053E-02
3.40120509E+00	4.55120945E-01	1.09651898E-01	4.03661133E-01	9.88310458E-02
4.20129683E+00	4.99796707E-01	1.19400147E-01	4.48713388E-01	1.09256792E-01
4.99396969E+00	4.65921333E-01	1.13338006E-01	4.23835146E-01	1.03895261E-01
7.50600566E+00	4.88468153E-01	1.23343208E-01	4.60558039E-01	1.11899403E-01
1.00642901E+01	5.10178337E-01	1.28626506E-01	4.77897284E-01	1.19326169E-01
1.44404671E+01	5.53269434E-01	1.34239498E-01	5.17988687E-01	1.24724182E-01
1.99548473E+01	5.49957236E-01	1.22259891E-01	5.15861916E-01	1.21137191E-01
2.52146238E+01	5.65930099E-01	1.25527836E-01	5.37169849E-01	1.14380846E-01
3.45358206E+01	5.63857635E-01	1.24724539E-01	5.36731433E-01	1.17603420E-01
5.08967916E+01	6.06012834E-01	1.21430908E-01	5.75644636E-01	1.15754964E-01
7.50989242E+01	6.41468003E-01	9.44184624E-02	6.08838941E-01	9.75475890E-02
9.93161409E+01	6.21520275E-01	1.21239866E-01	5.85389962E-01	1.11521748E-01
1.47331352E+02	6.56641748E-01	1.13446795E-01	6.20987089E-01	1.12768611E-01
2.03204024E+02	6.45820069E-01	1.20680602E-01	6.09438560E-01	1.21203565E-01
3.02238573E+02	6.97564311E-01	1.13442654E-01	6.55726151E-01	1.07717421E-01
3.83989189E+02	6.84478684E-01	1.25725261E-01	6.36588139E-01	1.19070240E-01
4.98222025E+02	7.15527056E-01	1.13440157E-01	6.71650156E-01	1.03343844E-01
7.32878476E+02	7.28374961E-01	1.05925764E-01	6.62870686E-01	9.59904619E-02
9.92074905E+02	7.71161062E-01	1.04923322E-01	7.05081389E-01	9.73038058E-02

TABLE (5.15)

SCALED WIDE ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
5.19820020E-01	2.60720293E-01	8.43814608E-01	4.30905827E-01	2.17935702E-01	7.09156062E-01
4.55120945E-01	2.33142719E-01	6.95300970E-01	4.03661133E-01	2.05571290E-01	6.40439618E-01
4.99796707E-01	1.93117296E-01	7.55169540E-01	4.48713388E-01	1.99902612E-01	6.99979866E-01
4.65921333E-01	2.31028668E-01	8.31397771E-01	4.23835146E-01	1.98441106E-01	7.54390668E-01
4.88468153E-01	2.52849169E-01	8.22219453E-01	4.60558039E-01	2.54945882E-01	7.43795525E-01
5.10178337E-01	2.14986819E-01	8.13630973E-01	4.77897284E-01	1.78787949E-01	7.92578494E-01
5.53269434E-01	2.51354605E-01	8.89533736E-01	5.17988687E-01	2.41160313E-01	8.31403364E-01
5.49957236E-01	3.01812410E-01	8.77880999E-01	5.15861916E-01	2.75462259E-01	8.66653133E-01
5.65930099E-01	2.88775951E-01	8.87028063E-01	5.37169849E-01	2.44359375E-01	7.76753853E-01
5.63857635E-01	2.81012035E-01	8.76675706E-01	5.36731433E-01	2.78510075E-01	8.40167827E-01
6.06012834E-01	2.90426140E-01	8.50516364E-01	5.75644636E-01	2.62394255E-01	8.51510721E-01
6.41468003E-01	4.02795057E-01	8.76327028E-01	6.08838941E-01	3.82687211E-01	8.71123838E-01
6.21520275E-01	3.37686347E-01	8.97933573E-01	5.85389962E-01	3.44601722E-01	9.08408225E-01
6.56641748E-01	3.52104058E-01	9.10554064E-01	6.20987089E-01	3.55380684E-01	8.53500183E-01
6.45820069E-01	3.87319469E-01	9.12793613E-01	6.09438560E-01	3.40933172E-01	8.30631642E-01
6.97564311E-01	3.99360012E-01	9.51792075E-01	6.55726151E-01	3.78968410E-01	9.25721547E-01
6.84478684E-01	3.69666579E-01	9.79728584E-01	6.36588139E-01	3.10462693E-01	8.78693432E-01
7.15527056E-01	3.27739717E-01	9.31350946E-01	6.71650156E-01	3.02763562E-01	9.03946302E-01
7.28374961E-01	4.83924351E-01	9.43137363E-01	6.62870686E-01	4.46415879E-01	8.48479821E-01
7.71161062E-01	5.46530982E-01	1.01462145E+00	7.05081389E-01	4.64253424E-01	9.13080820E-01

TABLE (5.16)

SCALED WIDE CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.13206184E+00	2.23381742E+00	2.02987960E+00	3.86000000E+02
3.00000000E+00	3.18414895E+00	3.35848772E+00	2.99941042E+00	3.31000000E+02
4.00000000E+00	4.18061047E+00	4.41853821E+00	3.98675333E+00	3.79000000E+02
5.00000000E+00	5.19808473E+00	5.47874324E+00	4.93218893E+00	3.44000000E+02
7.50000000E+00	7.88891595E+00	8.33965056E+00	7.44772209E+00	3.82000000E+02
1.00000000E+01	1.04449311E+01	1.09752614E+01	9.90095041E+00	3.67000000E+02
1.50000000E+01	1.51252135E+01	1.59666238E+01	1.44384688E+01	3.86000000E+02
2.00000000E+01	2.04064658E+01	2.15495765E+01	1.92478999E+01	3.67000000E+02
2.50000000E+01	2.55213832E+01	2.69256677E+01	2.42946164E+01	3.84000000E+02
3.50000000E+01	3.55528490E+01	3.74934166E+01	3.37254828E+01	3.41000000E+02
5.00000000E+01	5.08628546E+01	5.45141163E+01	4.81127301E+01	3.30000000E+02
7.50000000E+01	7.87435472E+01	8.35115546E+01	7.40958022E+01	3.43000000E+02
1.00000000E+02	1.02412893E+02	1.07688572E+02	9.77445158E+01	3.83000000E+02
1.50000000E+02	1.51128607E+02	1.58877706E+02	1.44270204E+02	3.82000000E+02
2.00000000E+02	2.04487333E+02	2.16933267E+02	1.95123357E+02	3.31000000E+02
3.00000000E+02	3.04848153E+02	3.21204570E+02	2.89570788E+02	3.82000000E+02
4.00000000E+02	3.98841395E+02	4.16446140E+02	3.81000147E+02	4.18000000E+02
5.00000000E+02	5.08989533E+02	5.36431751E+02	4.82279616E+02	3.35000000E+02
7.50000000E+02	7.42167118E+02	7.80436775E+02	7.07169063E+02	3.51000000E+02
1.00000000E+03	9.97471430E+02	1.04177808E+03	9.50764663E+02	4.35000000E+02

TABLE(5.17)

SCALED WIDE CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.13206184E+00	1.03000000E+00	2.21585198E-01	1.00000000E+00	0.00000000E+00
3.18414895E+00	1.63000000E+00	8.08146026E-01	1.22000000E+00	4.37721373E-01
4.18061047E+00	1.92000000E+00	8.68101377E-01	1.67000000E+00	5.30188646E-01
5.19808473E+00	2.41000000E+00	1.07791465E+00	2.04000000E+00	5.81721583E-01
7.88891595E+00	3.21000000E+00	1.91465402E+00	2.58000000E+00	6.66033032E-01
1.04449311E+01	3.51000000E+00	1.24494980E+00	2.99000000E+00	7.80960947E-01
1.51252135E+01	4.02000000E+00	2.28901726E+00	3.41000000E+00	1.12334322E+00
2.04064658E+01	5.27000000E+00	2.97272602E+00	4.28000000E+00	1.53674982E+00
2.55213832E+01	6.01000000E+00	3.70808576E+00	5.23000000E+00	2.18565780E+00
3.55528490E+01	8.33000000E+00	4.87248397E+00	7.59000000E+00	3.46726117E+00
5.08628546E+01	1.16100000E+01	5.79809451E+00	1.13900000E+01	4.23295405E+00
7.87435472E+01	1.57800000E+01	6.42585403E+00	1.53200000E+01	5.22088115E+00
1.02412893E+02	1.91400000E+01	6.56356610E+00	1.85500000E+01	4.85875498E+00
1.51128607E+02	2.57900000E+01	9.63980809E+00	2.48700000E+01	6.64477991E+00
2.04487333E+02	2.91500000E+01	8.30346313E+00	2.75000000E+01	6.40078120E+00
3.04848153E+02	3.46400000E+01	7.82370756E+00	3.49500000E+01	7.18383602E+00
3.98841395E+02	3.68900000E+01	8.33534042E+00	3.68100000E+01	7.51757275E+00
5.08989533E+02	4.14900000E+01	7.14212153E+00	4.19700000E+01	7.40871784E+00
7.42167118E+02	4.41900000E+01	8.04946582E+00	4.48900000E+01	6.84528305E+00
9.97471430E+02	4.78800000E+01	6.97463978E+00	4.87500000E+01	6.51363954E+00

TABLE(5.18)

SCALED WIDE CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.03000000E+00	1.00000000E+00	3.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.63000000E+00	1.00000000E+00	5.00000000E+00	1.22000000E+00	1.00000000E+00	3.00000000E+00
1.92000000E+00	1.00000000E+00	5.00000000E+00	1.67000000E+00	1.00000000E+00	3.00000000E+00
2.41000000E+00	1.00000000E+00	9.00000000E+00	2.04000000E+00	1.00000000E+00	4.00000000E+00
3.21000000E+00	2.00000000E+00	1.80000000E+01	2.58000000E+00	2.00000000E+00	5.00000000E+00
3.51000000E+00	2.00000000E+00	7.00000000E+00	2.99000000E+00	2.00000000E+00	5.00000000E+00
4.02000000E+00	2.00000000E+00	1.50000000E+01	3.41000000E+00	2.00000000E+00	9.00000000E+00
5.27000000E+00	2.00000000E+00	1.80000000E+01	4.28000000E+00	2.00000000E+00	1.10000000E+01
6.01000000E+00	3.00000000E+00	2.30000000E+01	5.23000000E+00	3.00000000E+00	1.30000000E+01
8.33000000E+00	3.00000000E+00	2.90000000E+01	7.59000000E+00	3.00000000E+00	1.80000000E+01
1.16100000E+01	4.00000000E+00	3.20000000E+01	1.13900000E+01	4.00000000E+00	2.20000000E+01
1.57800000E+01	4.00000000E+00	3.50000000E+01	1.53200000E+01	5.00000000E+00	2.80000000E+01
1.91400000E+01	7.00000000E+00	3.40000000E+01	1.85500000E+01	8.00000000E+00	3.10000000E+01
2.57900000E+01	1.20000000E+01	5.30000000E+01	2.48700000E+01	1.40000000E+01	4.20000000E+01
2.91500000E+01	1.30000000E+01	5.10000000E+01	2.75000000E+01	1.60000000E+01	4.40000000E+01
3.46400000E+01	1.70000000E+01	5.30000000E+01	3.49500000E+01	1.90000000E+01	5.00000000E+01
3.68900000E+01	2.00000000E+01	5.60000000E+01	3.68100000E+01	2.10000000E+01	5.10000000E+01
4.14900000E+01	2.70000000E+01	5.80000000E+01	4.19700000E+01	2.70000000E+01	5.50000000E+01
4.41900000E+01	2.50000000E+01	6.20000000E+01	4.48900000E+01	2.90000000E+01	6.20000000E+01
4.78800000E+01	3.30000000E+01	6.10000000E+01	4.87500000E+01	3.50000000E+01	6.20000000E+01

TABLE(5.19)

SCALED WIDE CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.13206184E+00	6.98751647E-01	5.99815591E-02	6.47762949E-01	5.44761713E-02
3.18414895E+00	6.79395877E-01	7.19145159E-02	6.34580965E-01	5.81105794E-02
4.18061047E+00	7.01493420E-01	7.15378841E-02	6.46360742E-01	6.11609088E-02
5.19808473E+00	6.70713274E-01	7.88165465E-02	6.26677280E-01	6.73282291E-02
7.88891595E+00	6.77409029E-01	7.92314943E-02	6.37512397E-01	6.85029629E-02
1.04449311E+01	6.83105587E-01	8.10673163E-02	6.43811566E-01	6.62272771E-02
1.51252135E+01	6.74160266E-01	9.04582611E-02	6.39940250E-01	8.38108023E-02
2.04064658E+01	6.78937483E-01	8.84491373E-02	6.42591896E-01	7.91543814E-02
2.55213832E+01	6.89491173E-01	8.19022366E-02	6.59234417E-01	7.27887163E-02
3.55528490E+01	6.85265140E-01	8.07276691E-02	6.60350854E-01	7.16256076E-02
5.08628546E+01	6.97616257E-01	7.97104580E-02	6.78644524E-01	7.28990449E-02
7.87435472E+01	7.15522304E-01	7.86213515E-02	6.87277519E-01	7.42604315E-02
1.02412893E+02	7.20929573E-01	8.01559964E-02	6.97729541E-01	6.96241455E-02
1.51128607E+02	7.23013568E-01	7.59110239E-02	6.97667391E-01	6.84177031E-02
2.04487333E+02	7.39749238E-01	7.79000723E-02	7.16999911E-01	6.83230500E-02
3.04848153E+02	7.49986570E-01	7.99727709E-02	7.22697802E-01	7.22387118E-02
3.98841395E+02	7.34404074E-01	7.59610397E-02	7.16420914E-01	6.69613086E-02
5.08989533E+02	7.43853674E-01	8.39830728E-02	7.25201274E-01	7.76288800E-02
7.42167118E+02	7.58998996E-01	7.64411186E-02	7.36913761E-01	6.75924842E-02
9.97471430E+02	7.85635261E-01	7.60796395E-02	7.61227297E-01	6.78418180E-02

TABLE(5.20)

SCALED WIDE CONSTAT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
6.98751647E-01	5.34751997E-01	8.49845480E-01	6.47762949E-01	4.99990264E-01	7.82622787E-01
6.79395877E-01	4.80106301E-01	8.01658880E-01	6.34580965E-01	4.46477374E-01	7.48462004E-01
7.01493420E-01	5.10211188E-01	8.72518749E-01	6.46360742E-01	5.24927931E-01	7.87624342E-01
6.70713274E-01	5.07993231E-01	8.36501574E-01	6.26677280E-01	4.79732365E-01	7.77146941E-01
6.77409029E-01	4.42785479E-01	8.58246758E-01	6.37512397E-01	4.42975658E-01	8.05626013E-01
6.83105587E-01	4.55018153E-01	8.73897819E-01	6.43811566E-01	4.22917078E-01	7.58075400E-01
6.74160266E-01	4.64643199E-01	8.92393499E-01	6.39940250E-01	4.41951767E-01	8.31741095E-01
6.78937483E-01	4.85904603E-01	8.57240539E-01	6.42591896E-01	4.74718205E-01	8.07927926E-01
6.89491173E-01	5.05149508E-01	8.99530555E-01	6.59234417E-01	4.49815795E-01	8.09165283E-01
6.85265140E-01	4.79697071E-01	9.06559604E-01	6.60350854E-01	4.56348935E-01	8.41671205E-01
6.97616257E-01	5.15772636E-01	8.77530326E-01	6.78644524E-01	5.19798460E-01	8.37428233E-01
7.15522304E-01	5.12966829E-01	9.32041052E-01	6.87277519E-01	4.84708628E-01	8.67893276E-01
7.20929573E-01	4.52280739E-01	9.15957919E-01	6.97729541E-01	4.98810556E-01	8.99002085E-01
7.23013568E-01	5.47128273E-01	9.41739603E-01	6.97667391E-01	5.36946655E-01	8.78914402E-01
7.39749238E-01	5.59385828E-01	9.47621371E-01	7.16999911E-01	5.46192750E-01	8.91838038E-01
7.49986570E-01	5.60293758E-01	9.28031088E-01	7.22697802E-01	5.72974244E-01	8.76268044E-01
7.34404074E-01	5.49300608E-01	8.93610769E-01	7.16420914E-01	5.65101396E-01	8.53673673E-01
7.43853674E-01	4.89563226E-01	9.26497440E-01	7.25201274E-01	5.10102157E-01	8.79246578E-01
7.58998996E-01	5.98297599E-01	9.38686276E-01	7.36913761E-01	5.75204990E-01	9.17446230E-01
7.85635261E-01	5.47202838E-01	9.32476759E-01	7.61227297E-01	5.88389958E-01	9.17803752E-01

TABLE(5.21)

SCALED NARROW ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.35942211E+00	2.55195542E+00	2.18037959E+00	2.56000000E+02
3.00000000E+00	3.14827899E+00	3.47611340E+00	2.87774158E+00	2.22000000E+02
4.00000000E+00	4.08657539E+00	4.32811417E+00	3.80287794E+00	2.23000000E+02
5.00000000E+00	4.92746837E+00	5.34327151E+00	4.48717704E+00	2.23000000E+02
7.50000000E+00	7.40686467E+00	8.02510444E+00	6.80834360E+00	2.20000000E+02
1.00000000E+01	9.63337117E+00	1.05093549E+01	8.96260791E+00	2.21000000E+02
1.50000000E+01	1.48674299E+01	1.63503898E+01	1.37781917E+01	2.38000000E+02
2.00000000E+01	1.97761245E+01	2.10675408E+01	1.81297614E+01	2.30000000E+02
2.50000000E+01	2.48138517E+01	2.68418722E+01	2.32734156E+01	2.34000000E+02
3.50000000E+01	3.53601890E+01	3.84241460E+01	3.25049136E+01	2.24000000E+02
5.00000000E+01	5.07320989E+01	5.53803798E+01	4.69246785E+01	2.23000000E+02
7.50000000E+01	7.26365062E+01	7.82292572E+01	6.64555517E+01	2.45000000E+02
1.00000000E+02	9.86421578E+01	1.06633050E+02	9.21968607E+01	2.44000000E+02
1.50000000E+02	1.56705875E+02	1.71423250E+02	1.44775868E+02	2.39000000E+02
2.00000000E+02	2.00731091E+02	2.13774947E+02	1.84496383E+02	2.16000000E+02
3.00000000E+02	3.00277694E+02	3.23188020E+02	2.78255157E+02	2.28000000E+02
4.00000000E+02	4.02015113E+02	4.37287636E+02	3.73261107E+02	2.17000000E+02
5.00000000E+02	4.86793022E+02	5.44315271E+02	4.55314732E+02	2.17000000E+02
7.50000000E+02	7.76887744E+02	8.53703904E+02	7.11141725E+02	2.44000000E+02
1.00000000E+03	1.02392829E+03	1.12064421E+03	9.53403268E+02	2.45000000E+02

TABLE(5.22)

SCALED NARROW ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.35942211E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14827899E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.08657539E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.92746837E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.40686467E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
9.63337117E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.48674299E+01	1.04000000E+00	1.95959179E-01	1.20000000E+00	4.00000000E-01
1.97761245E+01	1.20000000E+00	4.89897949E-01	1.76000000E+00	4.71593045E-01
2.48138517E+01	1.40000000E+00	6.63324958E-01	2.24000000E+00	5.85149554E-01
3.53601890E+01	1.84000000E+00	9.87117014E-01	3.08000000E+00	7.70454411E-01
5.07320989E+01	3.64000000E+00	3.14807878E+00	4.78000000E+00	2.22970850E+00
7.26365062E+01	6.34000000E+00	3.99804952E+00	7.72000000E+00	3.08570899E+00
9.86421578E+01	1.12000000E+01	7.98999374E+00	1.18000000E+01	6.79411510E+00
1.56705875E+02	2.50000000E+01	1.36718689E+01	2.11200000E+01	1.12705634E+01
2.00731091E+02	2.85000000E+01	1.44003472E+01	2.63800000E+01	1.33174923E+01
3.00277694E+02	3.55800000E+01	1.57188931E+01	3.47400000E+01	1.54554974E+01
4.02015113E+02	3.98800000E+01	1.52021577E+01	3.96000000E+01	1.55473470E+01
4.86793022E+02	4.18800000E+01	1.43647346E+01	3.98400000E+01	1.56248008E+01
7.76887744E+02	4.69000000E+01	1.39688940E+01	4.59800000E+01	1.50897184E+01
1.02392829E+03	4.84600000E+01	1.28720006E+01	4.67400000E+01	1.32752552E+01

TABLE(5.23)

SCALED NARROW ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.20000000E+00	1.00000000E+00	2.00000000E+00
1.20000000E+00	1.00000000E+00	3.00000000E+00	1.76000000E+00	1.00000000E+00	3.00000000E+00
1.40000000E+00	1.00000000E+00	4.00000000E+00	2.24000000E+00	2.00000000E+00	5.00000000E+00
1.84000000E+00	1.00000000E+00	5.00000000E+00	3.08000000E+00	2.00000000E+00	5.00000000E+00
3.64000000E+00	1.00000000E+00	1.80000000E+01	4.78000000E+00	3.00000000E+00	1.60000000E+01
6.34000000E+00	1.00000000E+00	2.30000000E+01	7.72000000E+00	4.00000000E+00	2.30000000E+01
1.12000000E+01	2.00000000E+00	4.30000000E+01	1.18000000E+01	6.00000000E+00	4.10000000E+01
2.50000000E+01	3.00000000E+00	6.00000000E+01	2.11200000E+01	9.00000000E+00	5.20000000E+01
2.85000000E+01	8.00000000E+00	5.60000000E+01	2.63800000E+01	1.10000000E+01	5.80000000E+01
3.55800000E+01	1.70000000E+01	6.30000000E+01	3.47400000E+01	1.60000000E+01	6.30000000E+01
3.98800000E+01	1.80000000E+01	6.60000000E+01	3.96000000E+01	1.80000000E+01	6.60000000E+01
4.18800000E+01	1.70000000E+01	6.60000000E+01	3.98400000E+01	1.80000000E+01	6.80000000E+01
4.69000000E+01	2.30000000E+01	6.80000000E+01	4.59800000E+01	2.30000000E+01	6.60000000E+01
4.84600000E+01	2.50000000E+01	6.60000000E+01	4.67400000E+01	2.50000000E+01	6.80000000E+01

TABLE(5.24)

SCALED NARROW ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.35942211E+00	2.23468949E-01	6.87074055E-02	2.27789001E-01	7.18022216E-02
3.14827899E+00	2.17166140E-01	5.49854986E-02	2.27476966E-01	5.22195997E-02
4.08657539E+00	2.08228109E-01	4.33866622E-02	2.17590458E-01	3.96499180E-02
4.92746837E+00	2.37782533E-01	6.16000216E-02	2.43798345E-01	6.23681277E-02
7.40686467E+00	2.53207590E-01	6.29716546E-02	2.65960918E-01	6.45311746E-02
9.63337117E+00	2.79910746E-01	7.34583125E-02	2.93567429E-01	6.86268774E-02
1.48674299E+01	3.15610476E-01	7.34131626E-02	3.54589450E-01	7.91802445E-02
1.97761245E+01	3.80331663E-01	1.11926201E-01	4.29040251E-01	1.19572410E-01
2.48138517E+01	4.62702906E-01	1.32093768E-01	5.26482023E-01	1.38269599E-01
3.53601890E+01	5.11202680E-01	1.16152343E-01	5.65108174E-01	1.28069206E-01
5.07320989E+01	6.26475141E-01	1.48441524E-01	6.54476763E-01	1.30729990E-01
7.26365062E+01	7.36619857E-01	1.47176241E-01	7.57693996E-01	1.37282098E-01
9.86421578E+01	8.35149379E-01	1.28322631E-01	8.32090714E-01	1.16669755E-01
1.56705875E+02	9.08200597E-01	1.19327359E-01	8.97287894E-01	1.17940811E-01
2.00731091E+02	9.19844442E-01	1.09300268E-01	9.22520016E-01	1.03478884E-01
3.00277694E+02	9.36474871E-01	8.96147927E-02	9.30441246E-01	9.60272142E-02
4.02015113E+02	9.54647613E-01	8.57533378E-02	9.45574068E-01	9.04235692E-02
4.86793022E+02	9.53205045E-01	9.55026522E-02	9.37757738E-01	1.02238393E-01
7.76887744E+02	9.61063761E-01	7.73005524E-02	9.44534062E-01	9.40024124E-02
1.02392829E+03	9.67949154E-01	7.77434252E-02	9.50681853E-01	9.31453424E-02

TABLE(5.25)

SCALED NARROW ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.23468949E-01	1.38754879E-01	5.25007748E-01	2.27789001E-01	1.45636195E-01	5.22305324E-01
2.17166140E-01	1.34317521E-01	4.52054886E-01	2.27476966E-01	1.49834228E-01	4.02410204E-01
2.08228109E-01	1.36712567E-01	3.12642772E-01	2.17590458E-01	1.55476242E-01	3.12268128E-01
2.37782533E-01	1.23747927E-01	4.25985337E-01	2.43798345E-01	1.39953832E-01	4.23917951E-01
2.53207590E-01	1.28159751E-01	4.68818732E-01	2.65960918E-01	1.35702024E-01	4.52808510E-01
2.79910746E-01	1.62186523E-01	4.99930137E-01	2.93567429E-01	1.62712992E-01	4.66587272E-01
3.15610476E-01	1.96184098E-01	5.43623960E-01	3.54589450E-01	2.06632259E-01	5.75020872E-01
3.80331663E-01	2.03972450E-01	7.75104939E-01	4.29040251E-01	2.18061677E-01	8.27537428E-01
4.62702906E-01	2.54742379E-01	8.60987562E-01	5.26482023E-01	3.04956232E-01	9.40850957E-01
5.11202680E-01	3.25442404E-01	8.38675797E-01	5.65108174E-01	3.37886125E-01	8.58087800E-01
6.26475141E-01	3.26000583E-01	9.70735360E-01	6.54476763E-01	3.81554680E-01	9.91231528E-01
7.36619857E-01	4.16853598E-01	1.16655418E+00	7.57693996E-01	4.50702614E-01	1.00469412E+00
8.35149379E-01	5.60629075E-01	1.08947030E+00	8.32090714E-01	5.36058527E-01	1.00465853E+00
9.08200597E-01	4.65603089E-01	1.02819613E+00	8.97287894E-01	4.73525593E-01	1.00662566E+00
9.19844442E-01	5.56464565E-01	1.00937700E+00	9.22520016E-01	5.68069197E-01	1.01164178E+00
9.36474871E-01	6.46237455E-01	1.03759729E+00	9.30441246E-01	6.14232498E-01	1.00588603E+00
9.54647613E-01	6.19575080E-01	1.00794377E+00	9.45574068E-01	6.36616561E-01	1.00597200E+00
9.53205045E-01	6.00891589E-01	1.01397783E+00	9.37757738E-01	5.99766792E-01	1.00909799E+00
9.61063761E-01	6.90441776E-01	1.01583982E+00	9.44534062E-01	6.42186430E-01	1.01040460E+00
9.67949154E-01	7.36486958E-01	1.02463724E+00	9.50681853E-01	6.29357599E-01	1.01738830E+00

TABLE(5.26)

SCALED NARROW CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.22506791E+00	2.38621271E+00	2.10729989E+00	2.38000000E+02
3.00000000E+00	3.16729419E+00	3.37307918E+00	2.94968406E+00	2.33000000E+02
4.00000000E+00	4.17633505E+00	4.39874406E+00	3.92267846E+00	2.28000000E+02
5.00000000E+00	5.04874786E+00	5.38479646E+00	4.76697059E+00	2.12000000E+02
7.50000000E+00	7.78913930E+00	8.35022371E+00	7.18744522E+00	2.08000000E+02
1.00000000E+01	9.94040217E+00	1.06081608E+01	9.40141229E+00	2.15000000E+02
1.50000000E+01	1.54917719E+01	1.64009805E+01	1.45667527E+01	2.53000000E+02
2.00000000E+01	2.03200407E+01	2.17322547E+01	1.91547921E+01	2.29000000E+02
2.50000000E+01	2.47933584E+01	2.62243374E+01	2.35747770E+01	2.27000000E+02
3.50000000E+01	3.54754203E+01	3.75725365E+01	3.31963981E+01	2.48000000E+02
5.00000000E+01	5.08791893E+01	5.38556248E+01	4.82263761E+01	2.61000000E+02
7.50000000E+01	7.49724836E+01	7.90093445E+01	6.98678281E+01	2.31000000E+02
1.00000000E+02	9.97131118E+01	1.05867797E+02	9.53332106E+01	2.65000000E+02
1.50000000E+02	1.55262568E+02	1.65115965E+02	1.45712055E+02	2.55000000E+02
2.00000000E+02	2.00982243E+02	2.13763231E+02	1.90580013E+02	2.48000000E+02
3.00000000E+02	3.08275840E+02	3.26353136E+02	2.91153732E+02	2.26000000E+02
4.00000000E+02	3.98087302E+02	4.30061312E+02	3.76841328E+02	2.16000000E+02
5.00000000E+02	5.08005721E+02	5.41432930E+02	4.77213917E+02	2.23000000E+02
7.50000000E+02	7.37176302E+02	7.81393909E+02	6.91401319E+02	2.28000000E+02
1.00000000E+03	1.00847931E+03	1.07368531E+03	9.50473132E+02	2.42000000E+02

TABLE(5.27)

SCALED NARROW CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.22506791E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.16729419E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.17633505E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.04874786E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.78913930E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
9.94040217E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.54917719E+01	1.08000000E+00	2.71293199E-01	1.48000000E+00	4.99599840E-01
2.03200407E+01	1.34000000E+00	5.14198405E-01	2.06000000E+00	3.69323706E-01
2.47933584E+01	1.42000000E+00	5.32541078E-01	2.18000000E+00	3.84187454E-01
3.54754203E+01	2.04000000E+00	7.98999374E-01	3.38000000E+00	8.45931439E-01
5.08791893E+01	3.04000000E+00	1.59949992E+00	5.32000000E+00	1.65456943E+00
7.49724836E+01	5.00000000E+00	2.52190404E+00	8.42000000E+00	4.75011579E+00
9.97131118E+01	1.37200000E+01	9.70781129E+00	1.38000000E+01	7.98498591E+00
1.55262568E+02	2.40600000E+01	1.23861374E+01	2.29400000E+01	1.03911693E+01
2.00982243E+02	2.78200000E+01	1.39279431E+01	2.85600000E+01	1.30754120E+01
3.08275840E+02	3.67600000E+01	1.59418443E+01	3.71000000E+01	1.52541798E+01
3.98087302E+02	4.20400000E+01	1.51577835E+01	4.40400000E+01	1.42323013E+01
5.08005721E+02	4.17200000E+01	1.62222563E+01	4.23600000E+01	1.59884458E+01
7.37176302E+02	4.31800000E+01	1.32494377E+01	4.40000000E+01	1.32090878E+01
1.00847931E+03	4.62600000E+01	1.17793209E+01	4.83600000E+01	1.15477444E+01

TABLE(5.28)

SCALED NARROW CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.08000000E+00	1.00000000E+00	2.00000000E+00	1.48000000E+00	1.00000000E+00	2.00000000E+00
1.34000000E+00	1.00000000E+00	3.00000000E+00	2.06000000E+00	1.00000000E+00	3.00000000E+00
1.42000000E+00	1.00000000E+00	3.00000000E+00	2.18000000E+00	2.00000000E+00	3.00000000E+00
2.04000000E+00	1.00000000E+00	4.00000000E+00	3.38000000E+00	2.00000000E+00	6.00000000E+00
3.04000000E+00	1.00000000E+00	7.00000000E+00	5.32000000E+00	4.00000000E+00	1.30000000E+01
5.00000000E+00	1.00000000E+00	1.00000000E+01	8.42000000E+00	5.00000000E+00	3.80000000E+01
1.37200000E+01	2.00000000E+00	4.70000000E+01	1.38000000E+01	6.00000000E+00	4.20000000E+01
2.40600000E+01	9.00000000E+00	5.40000000E+01	2.29400000E+01	1.10000000E+01	5.00000000E+01
2.78200000E+01	1.10000000E+01	6.10000000E+01	2.85600000E+01	1.10000000E+01	5.60000000E+01
3.67600000E+01	1.60000000E+01	6.40000000E+01	3.71000000E+01	1.50000000E+01	6.60000000E+01
4.20400000E+01	1.60000000E+01	6.40000000E+01	4.40400000E+01	1.50000000E+01	6.50000000E+01
4.17200000E+01	1.90000000E+01	6.60000000E+01	4.23600000E+01	1.80000000E+01	6.70000000E+01
4.31800000E+01	2.10000000E+01	6.70000000E+01	4.40000000E+01	2.10000000E+01	6.60000000E+01
4.62600000E+01	2.60000000E+01	6.80000000E+01	4.83600000E+01	2.60000000E+01	6.80000000E+01

TABLE(5.29)

SCALED NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.22506791E+00	2.61572336E-01	7.23569818E-02	2.59328327E-01	6.63261490E-02
3.16729419E+00	2.49007230E-01	5.19744477E-02	2.51859742E-01	4.81166957E-02
4.17633505E+00	2.50863394E-01	6.26549900E-02	2.49211010E-01	5.75519656E-02
5.04874786E+00	2.65531816E-01	5.50985339E-02	2.67386597E-01	5.43607843E-02
7.78913930E+00	3.00359020E-01	7.81617268E-02	3.06055654E-01	7.59105070E-02
9.94040217E+00	3.05965209E-01	6.80139094E-02	3.21719067E-01	7.34314982E-02
1.54917719E+01	3.66874332E-01	8.49501002E-02	4.10543588E-01	9.12842718E-02
2.03200407E+01	3.97951848E-01	7.37874386E-02	4.46430779E-01	8.02317408E-02
2.47933584E+01	4.33549462E-01	9.82789773E-02	4.98262187E-01	1.11882494E-01
3.54754203E+01	5.05592916E-01	9.87165572E-02	5.76158878E-01	1.19325183E-01
5.08791893E+01	6.34962484E-01	1.24142225E-01	6.87162509E-01	1.28377201E-01
7.49724836E+01	7.42710621E-01	1.49462180E-01	7.77266624E-01	1.36719424E-01
9.97131118E+01	8.29513326E-01	1.33219083E-01	8.56577866E-01	1.23258895E-01
1.55262568E+02	9.07462595E-01	1.19043018E-01	9.20735168E-01	1.07248527E-01
2.00982243E+02	9.33551078E-01	9.54164937E-02	9.40129803E-01	8.46018993E-02
3.08275840E+02	9.30908125E-01	1.05376976E-01	9.47157583E-01	8.96668895E-02
3.98087302E+02	9.57958434E-01	1.02753319E-01	9.63872464E-01	9.63319160E-02
5.08005721E+02	9.38374045E-01	1.07474235E-01	9.48141876E-01	9.48939432E-02
7.37176302E+02	9.36001071E-01	1.26631468E-01	9.38352196E-01	1.17515161E-01
1.00847931E+03	9.61668741E-01	9.00410303E-02	9.68952388E-01	7.92326772E-02

TABLE(5.30)

SCALED NARROW CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.61572336E-01	1.50658237E-01	5.19108668E-01	2.59328327E-01	1.60930794E-01	4.92956380E-01
2.49007230E-01	1.69445059E-01	4.08107502E-01	2.51859742E-01	1.55301538E-01	4.12501989E-01
2.50863394E-01	1.48285713E-01	4.40646295E-01	2.49211010E-01	1.68069996E-01	4.16581490E-01
2.65531816E-01	1.62348294E-01	3.86121987E-01	2.67386597E-01	1.53394497E-01	3.94422080E-01
3.00359020E-01	1.41029149E-01	5.42899873E-01	3.06055654E-01	1.46641279E-01	5.4039940 7E-01
3.05965209E-01	1.62216222E-01	4.78198191E-01	3.21719067E-01	1.62965007E-01	5.31140528E-01
3.66874332E-01	2.47319954E-01	5.97010131E-01	4.10543588E-01	2.66918427E-01	6.42767629E-01
3.97951848E-01	2.35099380E-01	5.58433818E-01	4.46430779E-01	2.51084571E-01	6.46312633E-01
4.33549462E-01	2.58326650E-01	7.49689437E-01	4.98262187E-01	2.61603358E-01	8.16225549E-01
5.05592916E-01	3.03615460E-01	7.28001119E-01	5.76158878E-01	3.25034615E-01	8.26863446E-01
6.34962484E-01	3.11088452E-01	9.06810283E-01	6.87162509E-01	3.82753311E-01	9.77924335E-01
7.42710621E-01	3.90326777E-01	1.09472232E+00	7.77266624E-01	4.11656070E-01	1.00466119E+00
8.29513326E-01	5.34417271E-01	1.00553859E+00	8.56577866E-01	5.71971012E-01	1.00498648E+00
9.07462595E-01	5.92852545E-01	1.01898145E+00	9.20735168E-01	6.23469306E-01	1.00777397E+00
9.33551078E-01	6.35880776E-01	1.00564730E+00	9.40129803E-01	6.62867217E-01	1.00574779E+00
9.30908125E-01	5.36787641E-01	1.00597980E+00	9.47157583E-01	5.77276473E-01	1.00559790E+00
9.57958434E-01	3.95139498E-01	1.01020941E+00	9.63872464E-01	4.35427215E-01	1.00608591E+00
9.38374045E-01	5.53511424E-01	1.00986948E+00	9.48141876E-01	6.04530118E-01	1.00671066E+00
9.36001071E-01	4.48914942E-01	1.01507782E+00	9.38352196E-01	5.01507861E-01	1.01336801E+00
9.61668741E-01	6.38392076E-01	1.02075515E+00	9.68952388E-01	6.61085436E-01	1.01691638E+00

TABLE(5.31)

SCALED WIDE CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.13617035E+00	2.23292494E+00	2.03430656E+00	2.43000000E+02
3.00000000E+00	3.06970987E+00	3.21422519E+00	2.91768161E+00	2.23000000E+02
4.00000000E+00	4.17820802E+00	4.36720471E+00	3.95343258E+00	2.52000000E+02
5.00000000E+00	5.19199279E+00	5.51821883E+00	4.95895577E+00	2.41000000E+02
7.50000000E+00	7.75653388E+00	8.19688903E+00	7.39199221E+00	2.33000000E+02
1.00000000E+01	1.02489895E+01	1.07574332E+01	9.69724038E+00	2.21000000E+02
1.50000000E+01	1.56627491E+01	1.65028142E+01	1.47471370E+01	2.45000000E+02
2.00000000E+01	2.07805204E+01	2.19570478E+01	1.96380037E+01	2.11000000E+02
2.50000000E+01	2.63070969E+01	2.75395581E+01	2.45881003E+01	2.40000000E+02
3.50000000E+01	3.54470501E+01	3.75805539E+01	3.37509663E+01	2.20000000E+02
5.00000000E+01	5.21702046E+01	5.47469646E+01	4.95191979E+01	2.43000000E+02
7.50000000E+01	7.57792113E+01	7.97732542E+01	7.18080556E+01	2.62000000E+02
1.00000000E+02	1.01793999E+02	1.06562079E+02	9.62485585E+01	2.26000000E+02
1.50000000E+02	1.51220447E+02	1.60335943E+02	1.43938243E+02	2.38000000E+02
2.00000000E+02	2.01899167E+02	2.11110661E+02	1.91443195E+02	2.33000000E+02
3.00000000E+02	3.09997495E+02	3.29111739E+02	2.95737508E+02	2.46000000E+02
4.00000000E+02	4.02217668E+02	4.24484456E+02	3.80854086E+02	2.22000000E+02
5.00000000E+02	5.20585346E+02	5.52692371E+02	4.91882292E+02	2.35000000E+02
7.50000000E+02	7.58035278E+02	7.95541398E+02	7.22598637E+02	2.68000000E+02
1.00000000E+03	1.00259084E+03	1.05152119E+03	9.54887188E+02	2.42000000E+02

TABLE(5.32)

SCALED WIDE CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.13617035E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.06970987E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.17820802E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.19199279E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.75653388E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.02489895E+01	1.04000000E+00	1.95959179E-01	1.08000000E+00	2.71293199E-01
1.56627491E+01	1.38000000E+00	4.85386444E-01	1.52000000E+00	4.99599840E-01
2.07805204E+01	1.80000000E+00	4.00000000E-01	1.92000000E+00	2.71293199E-01
2.63070969E+01	2.00000000E+00	0.00000000E+00	2.00000000E+00	0.00000000E+00
3.54470501E+01	2.00000000E+00	0.00000000E+00	2.00000000E+00	0.00000000E+00
5.21702046E+01	2.00000000E+00	0.00000000E+00	2.08000000E+00	3.91918359E-01
7.57792113E+01	2.00000000E+00	0.00000000E+00	2.68000000E+00	9.47417543E-01
1.01793999E+02	2.08000000E+00	3.91918359E-01	3.40000000E+00	1.24899960E+00
1.51220447E+02	2.42000000E+00	9.18477000E-01	4.52000000E+00	6.99714227E-01
2.01899167E+02	3.26000000E+00	1.26190332E+00	5.14000000E+00	1.57492857E+00
3.09997495E+02	4.50000000E+00	7.00000000E-01	5.14000000E+00	6.00333241E-01
4.02217668E+02	4.92000000E+00	2.71293199E-01	6.58000000E+00	2.85720143E+00
5.20585346E+02	5.34000000E+00	1.08830143E+00	8.62000000E+00	4.14675777E+00
7.58035278E+02	5.28000000E+00	8.25590698E-01	1.36200000E+01	4.99955998E+00
1.00259084E+03	5.66000000E+00	1.08830143E+00	1.63800000E+01	4.59952171E+00

TABLE(5.33)

SCALED WIDE CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.08000000E+00	1.00000000E+00	2.00000000E+00
1.38000000E+00	1.00000000E+00	2.00000000E+00	1.52000000E+00	1.00000000E+00	2.00000000E+00
1.80000000E+00	1.00000000E+00	2.00000000E+00	1.92000000E+00	1.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.08000000E+00	2.00000000E+00	4.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.68000000E+00	2.00000000E+00	4.00000000E+00
2.08000000E+00	2.00000000E+00	4.00000000E+00	3.40000000E+00	2.00000000E+00	5.00000000E+00
2.42000000E+00	2.00000000E+00	5.00000000E+00	4.52000000E+00	2.00000000E+00	5.00000000E+00
3.26000000E+00	2.00000000E+00	5.00000000E+00	5.14000000E+00	4.00000000E+00	1.50000000E+01
4.50000000E+00	2.00000000E+00	5.00000000E+00	5.14000000E+00	5.00000000E+00	9.00000000E+00
4.92000000E+00	4.00000000E+00	5.00000000E+00	6.58000000E+00	5.00000000E+00	1.50000000E+01
5.34000000E+00	5.00000000E+00	9.00000000E+00	8.62000000E+00	5.00000000E+00	2.30000000E+01
5.28000000E+00	5.00000000E+00	9.00000000E+00	1.36200000E+01	5.00000000E+00	2.20000000E+01
5.66000000E+00	5.00000000E+00	9.00000000E+00	1.63800000E+01	6.00000000E+00	2.40000000E+01

TABLE(5.34)

SCALED NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.13617035E+00	2.55274907E-06	8.91097605E-07	2.63199229E-06	8.46186353E-07
3.06970987E+00	3.08100412E-06	1.26018437E-06	3.20586223E-06	1.26079100E-06
4.17820802E+00	3.09443233E-06	1.27162815E-06	3.20729054E-06	1.27859835E-06
5.19199279E+00	3.01467737E-06	1.16545958E-06	3.15777468E-06	1.16595701E-06
7.75653388E+00	3.31089788E-06	1.16445872E-06	3.63496474E-06	1.25944657E-06
1.02489895E+01	3.91267913E-06	1.52702307E-06	4.30261515E-06	1.49844881E-06
1.56627491E+01	5.82387483E-06	2.50936156E-06	6.91299835E-06	2.97135177E-06
2.07805204E+01	6.19526147E-06	2.65322002E-06	7.50349936E-06	2.86566296E-06
2.63070969E+01	7.77212415E-06	3.13907322E-06	9.64235309E-06	3.88808332E-06
3.54470501E+01	9.63891571E-06	4.05453001E-06	1.25606394E-05	5.02129435E-06
5.21702046E+01	1.26930186E-05	4.74050452E-06	1.72343805E-05	6.02449563E-06
7.57792113E+01	1.51482288E-05	5.84919597E-06	2.12340603E-05	7.64595364E-06
1.01793999E+02	2.23613062E-05	7.11881523E-06	3.04854085E-05	9.29565705E-06
1.51220447E+02	3.51175627E-05	1.26660769E-05	4.72917838E-05	1.69712821E-05
2.01899167E+02	4.21521380E-05	1.90160143E-05	5.67474880E-05	2.32895296E-05
3.09997495E+02	5.52840681E-05	2.47661008E-05	7.98479378E-05	3.41643808E-05
4.02217668E+02	7.21028457E-05	2.87482844E-05	1.04107975E-04	4.30287789E-05
5.20585346E+02	9.01286923E-05	4.38143711E-05	1.29228669E-04	5.61780088E-05
7.58035278E+02	1.55979269E-04	7.78166825E-05	2.13562212E-04	9.79267015E-05
1.00259084E+03	1.68881681E-04	5.92315843E-05	2.29340748E-04	8.12142427E-05

TABLE(5.35)

SCALED WIDE CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.55274907E-06	1.27580468E-06	5.18414724E-06	2.63199229E-06	1.45891928E-06	4.96674590E-06
3.08100412E-06	1.44703416E-06	7.31695958E-06	3.20586223E-06	1.27006188E-06	6.89703454E-06
3.09443233E-06	1.08943841E-06	7.54225073E-06	3.20729054E-06	1.32456045E-06	8.12315151E-06
3.01467737E-06	1.31589511E-06	7.40158191E-06	3.15777468E-06	1.22569555E-06	6.54498668E-06
3.31089788E-06	1.54718835E-06	6.40355856E-06	3.63496474E-06	1.68419850E-06	6.89402766E-06
3.91267913E-06	1.82130703E-06	1.00823278E-05	4.30261515E-06	2.18392764E-06	9.63825589E-06
5.82387483E-06	2.20035755E-06	1.33780117E-05	6.91299835E-06	2.70652467E-06	1.45367273E-05
6.19526147E-06	2.83800950E-06	1.57697184E-05	7.50349936E-06	3.39720878E-06	1.88127765E-05
7.77212415E-06	3.12293617E-06	1.80943394E-05	9.64235309E-06	3.97896936E-06	2.38430534E-05
9.63891571E-06	2.74966686E-06	2.45647160E-05	1.25606394E-05	3.88065522E-06	2.90029371E-05
1.26930186E-05	5.22801773E-06	3.07250148E-05	1.72343805E-05	7.38879109E-06	3.76434757E-05
1.51482288E-05	6.76302171E-06	3.45884327E-05	2.12340603E-05	9.31426496E-06	4.66161582E-05
2.23613062E-05	8.73179905E-06	4.43393591E-05	3.04854085E-05	1.29983281E-05	5.38092378E-05
3.51175627E-05	1.65044357E-05	7.17960172E-05	4.72917838E-05	2.02765812E-05	1.01214056E-04
4.21521380E-05	1.85020852E-05	1.20290523E-04	5.67474880E-05	2.55958379E-05	1.28337894E-04
5.52840681E-05	2.16190681E-05	1.42141663E-04	7.98479378E-05	3.45456314E-05	2.08314303E-04
7.21028457E-05	3.50239774E-05	1.98813023E-04	1.04107975E-04	5.49144270E-05	3.06733030E-04
9.01286923E-05	4.29397955E-05	2.48106264E-04	1.29228669E-04	6.92417507E-05	3.30785081E-04
1.55979269E-04	4.91749964E-05	4.63158350E-04	2.13562212E-04	6.88080808E-05	5.33258872E-04
1.68881681E-04	6.86871087E-05	3.46321583E-04	2.29340748E-04	1.06885484E-04	4.85509280E-04

TABLE(5.36)

SCALED WIDE ORDINATE

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.36908554E+00	2.54620199E+00	2.17664375E+00	2.22000000E+02
3.00000000E+00	3.32565146E+00	3.53831957E+00	3.08710114E+00	2.24000000E+02
4.00000000E+00	4.16380394E+00	4.47283206E+00	3.88946030E+00	2.43000000E+02
5.00000000E+00	5.08401014E+00	5.50212886E+00	4.75998712E+00	2.56000000E+02
7.50000000E+00	7.57849147E+00	8.18519121E+00	7.07193687E+00	2.32000000E+02
1.00000000E+01	1.00019454E+01	1.06249218E+01	9.26366316E+00	2.34000000E+02
1.50000000E+01	1.48934502E+01	1.59908596E+01	1.38295456E+01	2.83000000E+02
2.00000000E+01	2.04109869E+01	2.22254802E+01	1.90220312E+01	2.16000000E+02
2.50000000E+01	2.54015082E+01	2.72926435E+01	2.37011939E+01	2.27000000E+02
3.50000000E+01	3.37608023E+01	3.63190231E+01	3.14019744E+01	2.10000000E+02
5.00000000E+01	4.97626754E+01	5.39967218E+01	4.66571775E+01	2.62000000E+02
7.50000000E+01	7.59405244E+01	8.21798903E+01	7.03716889E+01	2.31000000E+02
1.00000000E+02	1.02569749E+02	1.08799422E+02	9.42931976E+01	2.36000000E+02
1.50000000E+02	1.50024130E+02	1.62124363E+02	1.39140584E+02	2.15000000E+02
2.00000000E+02	1.96266799E+02	2.11735317E+02	1.83233642E+02	2.15000000E+02
3.00000000E+02	3.05491923E+02	3.34209066E+02	2.81305641E+02	2.01000000E+02
4.00000000E+02	3.95705930E+02	4.24479080E+02	3.68538438E+02	2.40000000E+02
5.00000000E+02	5.04784947E+02	5.44022810E+02	4.73036394E+02	2.66000000E+02
7.50000000E+02	7.43756006E+02	7.96960459E+02	6.88875302E+02	2.18000000E+02
1.00000000E+03	1.00215917E+03	1.07810416E+03	9.23955828E+02	2.44000000E+02

TABLE(5.37)

SCALED WIDE ORDINATE

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.36908554E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.32565146E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.16380394E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
5.08401014E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
7.57849147E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
1.00019454E+01	1.04000000E+00	1.95959179E-01	1.02000000E+00	1.40000000E-01
1.48934502E+01	1.26000000E+00	4.38634244E-01	1.26000000E+00	4.38634244E-01
2.04109869E+01	1.82000000E+00	3.84187454E-01	1.84000000E+00	3.66606056E-01
2.54015082E+01	2.00000000E+00	0.00000000E+00	2.08000000E+00	2.71293199E-01
3.37608023E+01	2.20000000E+00	4.00000000E-01	2.46000000E+00	4.98397432E-01
4.97626754E+01	2.78000000E+00	7.01141926E-01	3.36000000E+00	7.41889480E-01
7.59405244E+01	3.64000000E+00	9.11262860E-01	4.38000000E+00	1.19816526E+00
1.02569749E+02	4.38000000E+00	9.14111591E-01	5.46000000E+00	1.44512975E+00
1.50024130E+02	5.72000000E+00	1.29676521E+00	7.80000000E+00	2.15406592E+00
1.96266799E+02	6.82000000E+00	1.33701159E+00	9.58000000E+00	2.09847564E+00
3.05491923E+02	8.48000000E+00	1.00478853E+00	1.25200000E+01	2.95458965E+00
3.95705930E+02	8.80000000E+00	7.21110255E-01	1.34600000E+01	2.66240493E+00
5.04784947E+02	8.92000000E+00	4.40000000E-01	1.36000000E+01	1.70880075E+00
7.43756006E+02	9.00000000E+00	0.00000000E+00	1.44600000E+01	4.98397432E-01
1.00215917E+03	9.00000000E+00	0.00000000E+00	1.45400000E+01	5.37028863E-01

TABLE(5.38)

SCALED WIDE ORDINATE

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.02000000E+00	1.00000000E+00	2.00000000E+00
1.26000000E+00	1.00000000E+00	2.00000000E+00	1.26000000E+00	1.00000000E+00	2.00000000E+00
1.82000000E+00	1.00000000E+00	2.00000000E+00	1.84000000E+00	1.00000000E+00	2.00000000E+00
2.00000000E+00	2.00000000E+00	2.00000000E+00	2.08000000E+00	2.00000000E+00	3.00000000E+00
2.20000000E+00	2.00000000E+00	3.00000000E+00	2.46000000E+00	2.00000000E+00	3.00000000E+00
2.78000000E+00	2.00000000E+00	5.00000000E+00	3.36000000E+00	2.00000000E+00	5.00000000E+00
3.64000000E+00	2.00000000E+00	6.00000000E+00	4.38000000E+00	3.00000000E+00	9.00000000E+00
4.38000000E+00	3.00000000E+00	6.00000000E+00	5.46000000E+00	4.00000000E+00	9.00000000E+00
5.72000000E+00	3.00000000E+00	9.00000000E+00	7.80000000E+00	5.00000000E+00	1.50000000E+01
6.82000000E+00	4.00000000E+00	9.00000000E+00	9.58000000E+00	6.00000000E+00	1.40000000E+01
8.48000000E+00	6.00000000E+00	9.00000000E+00	1.25200000E+01	8.00000000E+00	2.50000000E+01
8.80000000E+00	6.00000000E+00	9.00000000E+00	1.34600000E+01	9.00000000E+00	2.60000000E+01
8.92000000E+00	6.00000000E+00	9.00000000E+00	1.36000000E+01	9.00000000E+00	1.50000000E+01
9.00000000E+00	9.00000000E+00	9.00000000E+00	1.44600000E+01	1.40000000E+01	1.50000000E+01
9.00000000E+00	9.00000000E+00	9.00000000E+00	1.45400000E+01	1.40000000E+01	1.60000000E+01

TABLE(5.39)

SCALED WIDE ORDINATE

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.36908554E+00	2.11639992E-06	1.19975321E-06	2.44505988E-06	1.40462588E-06
3.32565146E+00	2.46923855E-06	1.47350924E-06	2.97062133E-06	1.82671409E-06
4.16380394E+00	2.40480791E-06	1.18020878E-06	2.68063378E-06	1.24169482E-06
5.08401014E+00	2.55498294E-06	1.21432329E-06	2.94704122E-06	1.41936396E-06
7.57849147E+00	2.81539665E-06	1.41255170E-06	3.21232481E-06	1.59670445E-06
1.00019454E+01	3.58360770E-06	1.87824377E-06	3.98924500E-06	1.96117611E-06
1.48934502E+01	5.86120222E-06	2.65052866E-06	6.93165505E-06	3.16450038E-06
2.04109869E+01	6.17462195E-06	3.03595230E-06	7.52454942E-06	3.66809238E-06
2.54015082E+01	8.75454378E-06	5.06172853E-06	1.05737681E-05	6.24725221E-06
3.37608023E+01	9.50871465E-06	5.26433795E-06	1.17854260E-05	6.40762966E-06
4.97626754E+01	1.19493352E-05	6.29592130E-06	1.44621506E-05	7.02417165E-06
7.59405244E+01	1.92408168E-05	1.13098582E-05	2.39623842E-05	1.29446754E-05
1.02569749E+02	2.56385617E-05	1.26101101E-05	3.20450133E-05	1.50978917E-05
1.50024130E+02	3.26249752E-05	1.60900532E-05	4.18434122E-05	2.07729148E-05
1.96266799E+02	4.33200293E-05	2.74974331E-05	5.55957950E-05	3.60326766E-05
3.05491923E+02	6.40072370E-05	4.93832098E-05	8.53231463E-05	6.19902018E-05
3.95705930E+02	7.88187190E-05	4.16975088E-05	1.00940016E-04	4.82913705E-05
5.04784947E+02	8.18063811E-05	3.24922838E-05	1.10475614E-04	3.96599510E-05
7.43756006E+02	1.36642104E-04	7.10835878E-05	1.84673154E-04	9.25298870E-05
1.00215917E+03	1.66715451E-04	9.64799296E-05	2.18426565E-04	1.19682150E-04

TABLE(5.40)

SCALED WIDE ORDINATE

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
2.11639992E-06	1.01487421E-06	9.53482089E-06	2.44505988E-06	1.16976161E-06	1.10172387E-05
2.46923855E-06	6.88324959E-07	7.58180823E-06	2.97062133E-06	9.53849744E-07	9.31537404E-06
2.40480791E-06	8.48636661E-07	6.06361008E-06	2.68063378E-06	9.77254816E-07	6.47192401E-06
2.55498294E-06	9.36602995E-07	6.81098588E-06	2.94704122E-06	1.17189737E-06	7.80442366E-06
2.81539665E-06	1.19291562E-06	7.50869711E-06	3.21232481E-06	1.41433695E-06	8.70677551E-06
3.58360770E-06	1.40039678E-06	9.60292496E-06	3.98924500E-06	1.82571841E-06	1.11435276E-05
5.86120222E-06	1.54717629E-06	1.36121320E-05	6.93165505E-06	1.98112685E-06	1.58127577E-05
6.17462195E-06	2.61866232E-06	1.95737464E-05	7.52454942E-06	3.16031892E-06	2.26689279E-05
8.75454378E-06	2.72110076E-06	2.73978771E-05	1.05737681E-05	3.67186431E-06	3.29658915E-05
9.50871465E-06	2.63142807E-06	3.05609325E-05	1.17854260E-05	3.39213911E-06	4.09514480E-05
1.19493352E-05	4.17257673E-06	3.22421043E-05	1.44621506E-05	6.23975317E-06	3.84490740E-05
1.92408168E-05	6.24233793E-06	6.41989699E-05	2.39623842E-05	8.86535533E-06	6.82833777E-05
2.56385617E-05	7.08858260E-06	5.47375806E-05	3.20450133E-05	1.07673111E-05	6.38644987E-05
3.26249752E-05	1.17346588E-05	9.49892863E-05	4.18434122E-05	1.67249706E-05	1.13325174E-04
4.33200293E-05	1.55537001E-05	1.85411196E-04	5.55957950E-05	2.06709525E-05	2.34357116E-04
6.40072370E-05	1.93155707E-05	3.14397639E-04	8.53231463E-05	2.36832993E-05	3.57224262E-04
7.88187190E-05	2.85708071E-05	1.89508760E-04	1.00940016E-04	3.90850395E-05	2.23834084E-04
8.18063811E-05	3.87312164E-05	1.85361052E-04	1.10475614E-04	5.53631161E-05	2.31410193E-04
1.36642104E-04	4.22888000E-05	4.23666508E-04	1.84673154E-04	5.66185807E-05	5.46626852E-04
1.66715451E-04	6.25820464E-05	6.74817744E-04	2.18426565E-04	8.19009010E-05	8.24089540E-04

TABLE(5.41)

SCALED NARROW CONSTANT

THEO. SNR	AVSNR2	MAXSNR	MINSNR	# NS ADD
2.00000000E+00	2.23024575E+00	2.38621271E+00	2.09679916E+00	3.86000000E+02
3.00000000E+00	3.14335954E+00	3.35897406E+00	2.91977809E+00	3.34000000E+02
4.00000000E+00	4.11323178E+00	4.33639361E+00	3.86745062E+00	3.50000000E+02
5.00000000E+00	5.03484071E+00	5.40346845E+00	4.77243965E+00	3.43000000E+02
7.50000000E+00	7.71418082E+00	8.26683028E+00	7.26938047E+00	3.48000000E+02
1.00000000E+01	1.01754590E+01	1.08254892E+01	9.60509326E+00	3.63000000E+02
1.50000000E+01	1.54093560E+01	1.63997433E+01	1.44417537E+01	3.78000000E+02
2.00000000E+01	2.01180204E+01	2.13376084E+01	1.87386813E+01	3.34000000E+02
2.50000000E+01	2.59659051E+01	2.74694257E+01	2.43412880E+01	3.76000000E+02
3.50000000E+01	3.50728506E+01	3.74770562E+01	3.30452773E+01	3.38000000E+02
5.00000000E+01	5.13631005E+01	5.45789338E+01	4.84832118E+01	3.65000000E+02
7.50000000E+01	7.39518697E+01	7.93018385E+01	6.94914662E+01	3.52000000E+02
1.00000000E+02	9.95079962E+01	1.06203813E+02	9.34674079E+01	3.65000000E+02
1.50000000E+02	1.50376137E+02	1.59570265E+02	1.40763020E+02	3.37000000E+02
2.00000000E+02	2.01464171E+02	2.12634123E+02	1.90081278E+02	3.80000000E+02
3.00000000E+02	3.04656202E+02	3.23046258E+02	2.86549482E+02	3.60000000E+02
4.00000000E+02	4.02653155E+02	4.29266901E+02	3.76326096E+02	3.58000000E+02
5.00000000E+02	5.09645109E+02	5.46508814E+02	4.74512065E+02	3.42000000E+02
7.50000000E+02	7.67146619E+02	8.15225229E+02	7.25147741E+02	3.68000000E+02
1.00000000E+03	1.02475298E+03	1.09361346E+03	9.62524660E+02	3.65000000E+02

TABLE(5.42)

SCALED NARROW CONSTANT

AVSNR2	ITERATION1#	IT1SD	ITERATION2#	IT2SD
2.23024575E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
3.14335954E+00	1.00000000E+00	0.00000000E+00	1.00000000E+00	0.00000000E+00
4.11323178E+00	1.04000000E+00	1.95959179E-01	1.00000000E+00	0.00000000E+00
5.03484071E+00	1.06000000E+00	2.37486842E-01	1.00000000E+00	0.00000000E+00
7.71418082E+00	1.35000000E+00	4.76969601E-01	1.30000000E+00	4.58257569E-01
1.01754590E+01	1.71000000E+00	6.97065277E-01	1.58000000E+00	4.93558507E-01
1.54093560E+01	2.26000000E+00	5.58927544E-01	2.12000000E+00	3.81575681E-01
2.01180204E+01	2.69000000E+00	9.13181253E-01	2.46000000E+00	5.37028863E-01
2.59659051E+01	3.08000000E+00	1.25443214E+00	2.93000000E+00	8.27707678E-01
3.50728506E+01	7.91000000E+00	3.29906335E+01	3.74000000E+00	1.05470375E+00
5.13631005E+01	1.27300000E+01	4.64148371E+01	5.79000000E+00	1.80163814E+00
7.39518697E+01	2.39600000E+01	7.06987864E+01	9.18000000E+00	5.44128661E+00
9.95079962E+01	4.32000000E+01	9.77539769E+01	3.09800000E+01	7.56372897E+01
1.50376137E+02	7.11200000E+01	1.20064506E+02	6.37000000E+01	1.11509148E+02
2.01464171E+02	9.77100000E+01	1.34873370E+02	1.06920000E+02	1.40784422E+02
3.04656202E+02	1.02600000E+02	1.34431618E+02	1.22890000E+02	1.39992349E+02
4.02653155E+02	1.62360000E+02	1.54784529E+02	1.67710000E+02	1.50011353E+02
5.09645109E+02	1.52690000E+02	1.48545461E+02	1.41800000E+02	1.44173021E+02
7.67146619E+02	1.39410000E+02	1.43966739E+02	1.54830000E+02	1.47587198E+02
1.02475298E+03	1.32230000E+02	1.37189202E+02	1.66180000E+02	1.45625642E+02

TABLE(5.43)

SCALED NARROW CONSTANT

AVE ITER #1	MIN ITER#1	MAX ITER#1	AVE ITER #2	MIN ITER#2	MAX ITER#2
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.04000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.06000000E+00	1.00000000E+00	2.00000000E+00	1.00000000E+00	1.00000000E+00	1.00000000E+00
1.35000000E+00	1.00000000E+00	2.00000000E+00	1.30000000E+00	1.00000000E+00	2.00000000E+00
1.71000000E+00	1.00000000E+00	5.00000000E+00	1.58000000E+00	1.00000000E+00	2.00000000E+00
2.26000000E+00	1.00000000E+00	5.00000000E+00	2.12000000E+00	1.00000000E+00	3.00000000E+00
2.69000000E+00	1.00000000E+00	6.00000000E+00	2.46000000E+00	2.00000000E+00	4.00000000E+00
3.08000000E+00	2.00000000E+00	9.00000000E+00	2.93000000E+00	2.00000000E+00	5.00000000E+00
7.91000000E+00	2.00000000E+00	3.34000000E+02	3.74000000E+00	2.00000000E+00	7.00000000E+00
1.27300000E+01	3.00000000E+00	3.37000000E+02	5.79000000E+00	3.00000000E+00	1.20000000E+01
2.39600000E+01	3.00000000E+00	3.42000000E+02	9.18000000E+00	4.00000000E+00	3.60000000E+01
4.32000000E+01	4.00000000E+00	3.42000000E+02	3.09800000E+01	5.00000000E+00	3.39000000E+02
7.11200000E+01	4.00000000E+00	3.46000000E+02	6.37000000E+01	7.00000000E+00	3.51000000E+02
9.77100000E+01	9.00000000E+00	3.57000000E+02	1.06920000E+02	1.30000000E+01	3.51000000E+02
1.02600000E+02	1.30000000E+01	3.59000000E+02	1.22890000E+02	1.50000000E+01	3.47000000E+02
1.62360000E+02	1.40000000E+01	3.64000000E+02	1.67710000E+02	1.50000000E+01	3.57000000E+02
1.52690000E+02	1.60000000E+01	3.62000000E+02	1.41800000E+02	1.90000000E+01	3.70000000E+02
1.39410000E+02	2.00000000E+01	3.58000000E+02	1.54830000E+02	2.10000000E+01	3.56000000E+02
1.32230000E+02	2.10000000E+01	3.66000000E+02	1.66180000E+02	2.30000000E+01	3.72000000E+02

TABLE(5.44)

SCALED NARROW CONSTANT

AVSNR2	ERROR #1	SD ERR1	ERROR #2	SD ERR2
2.23024575E+00	7.58474965E-01	6.44554689E-02	7.19748547E-01	5.69264646E-02
3.14335954E+00	7.37248223E-01	7.21155910E-02	7.07372573E-01	6.47200772E-02
4.11323178E+00	7.35409622E-01	7.35089531E-02	7.10248377E-01	6.64098983E-02
5.03484071E+00	7.46664942E-01	7.37153486E-02	7.16475590E-01	6.48706889E-02
7.71418082E+00	7.71740615E-01	8.76457525E-02	7.41321917E-01	7.98498024E-02
1.01754590E+01	7.93205166E-01	7.28851422E-02	7.68911865E-01	6.68154540E-02
1.54093560E+01	8.18258470E-01	7.17756556E-02	8.04213584E-01	7.10894128E-02
2.01180204E+01	8.27310431E-01	8.40750215E-02	8.20619336E-01	7.25058761E-02
2.59659051E+01	8.47303572E-01	7.11318478E-02	8.41025537E-01	6.26681393E-02
3.50728506E+01	8.79960420E-01	7.35298485E-02	8.77708357E-01	5.98826764E-02
5.13631005E+01	9.13881787E-01	6.20521216E-02	9.12799328E-01	5.27091442E-02
7.39518697E+01	9.31386534E-01	5.99120153E-02	9.35889933E-01	5.41170472E-02
9.95079962E+01	9.61500684E-01	4.77264485E-02	9.62579222E-01	3.59874038E-02
1.50376137E+02	9.72467638E-01	3.65044710E-02	9.75835457E-01	2.80319476E-02
2.01464171E+02	9.82325850E-01	2.61588507E-02	9.86071723E-01	1.83796811E-02
3.04656202E+02	9.81078050E-01	3.11466715E-02	9.88790422E-01	1.89276557E-02
4.02653155E+02	9.88308395E-01	2.26815848E-02	9.91941267E-01	1.67993175E-02
5.09645109E+02	9.87300592E-01	2.27511871E-02	9.88894415E-01	1.99228016E-02
7.67146619E+02	9.80963703E-01	3.16933527E-02	9.86058531E-01	2.46937811E-02
1.02475298E+03	9.84545431E-01	2.72679053E-02	9.89737446E-01	2.39521845E-02

TABLE(5.45)

SCALED NARROW CONSTANT

ERROR #1	MIN ERR1	MAX ERR1	ERROR #2	MIN ERR2	MAX ERR2
7.58474965E-01	5.71290537E-01	8.84296246E-01	7.19748547E-01	5.64783723E-01	8.36933080E-01
7.37248223E-01	5.81248563E-01	8.86152723E-01	7.07372573E-01	5.52922399E-01	8.49538718E-01
7.35409622E-01	5.29466788E-01	9.10080022E-01	7.10248377E-01	5.22759161E-01	8.62443117E-01
7.46664942E-01	5.15873688E-01	8.97973900E-01	7.16475590E-01	5.28814698E-01	8.52532527E-01
7.71740615E-01	4.47791341E-01	9.34025714E-01	7.41321917E-01	4.66211015E-01	9.00545979E-01
7.93205166E-01	6.29472614E-01	9.55593105E-01	7.68911865E-01	6.22076780E-01	9.06547210E-01
8.18258470E-01	6.34494084E-01	9.40062303E-01	8.04213584E-01	6.19763740E-01	9.30234973E-01
8.27310431E-01	6.01083347E-01	9.81476510E-01	8.20619336E-01	5.78079590E-01	9.38355744E-01
8.47303572E-01	6.76362569E-01	9.83787274E-01	8.41025537E-01	6.70575614E-01	9.83467952E-01
8.79960420E-01	6.52325851E-01	1.00100070E+00	8.77708357E-01	7.13568416E-01	9.80870731E-01
9.13881787E-01	7.23472986E-01	1.00442931E+00	9.12799328E-01	7.77333289E-01	9.97431633E-01
9.31386534E-01	7.20637983E-01	1.02249663E+00	9.35889933E-01	6.92745836E-01	1.00917306E+00
9.61500684E-01	7.80136022E-01	1.12916262E+00	9.62579222E-01	8.33188968E-01	1.00040602E+00
9.72467638E-01	8.51405883E-01	1.07897695E+00	9.75835457E-01	8.73291025E-01	1.00010202E+00
9.82325850E-01	8.84565836E-01	1.00950551E+00	9.86071723E-01	9.20401139E-01	1.00027273E+00
9.81078050E-01	8.33928285E-01	1.01310101E+00	9.88790422E-01	9.03491028E-01	1.00043471E+00
9.88308395E-01	8.85491176E-01	1.01672591E+00	9.91941267E-01	8.99509231E-01	1.00000000E+00
9.87300592E-01	8.98236735E-01	1.00437419E+00	9.88894415E-01	9.00509201E-01	1.00000000E+00
9.80963703E-01	8.71885374E-01	1.04416135E+00	9.86058531E-01	8.75193932E-01	1.00000000E+00
9.84545431E-01	8.35502073E-01	1.00000000E+00	9.89737446E-01	8.09957747E-01	1.00000000E+00

Chapter VI

Comparison Between Different Inputs

The purpose of this study is to see how different inputs affect the optimum iteration number as well as the error improvement. For the purpose of illustration, only the constant noise case and the L2 norm will be studied for Morrison's method for noise removal alone and for noise removal prior to deconvolution.

The term (old input) refers to the input used by Leclere (1984), and the (new input) refers to the input used in this thesis. One can refer to Leclere's thesis to see the exact values listed in his tables. In addition, one can refer to Figures (6.1)-(6.8) in this chapter where the new data and the old data are plotted to see a summary of his results and to understand the comparison.

Figure (6.1) shows the average iteration number versus the natural log of the average SNR for noise removal alone for the narrow case. Investigating this figure one can see that the new f has a smaller average iteration number than the old input. Also, the new average iteration number is smoother and has less fluctuation over the full AVSNR2 range. This is probably because the old input is more sensitive to the convergence value chosen.

Figure (6.2) shows the relation of the average error improvement to the natural log of the average SNR for the noise removal alone for the narrow case. In the low range of the AVSNR2 the new data have lower values and thus greater error improvements. However, at higher AVSNR2 the two inputs merge and both have nearly the same error improvements.

Figure (6.3) shows the average iteration number versus the natural log of the average SNR for the noise removal alone for the wide case. Studying Figure (6.3), one can see that the old input has more than double the average iteration number of the new input. It is also clear from the figure that the new input has less fluctuation than the old input.

Figure (6.4) shows the average error improvement versus the natural log of the average SNR for the wide case for noise removal alone. From the figure one can see that there is no error improvement in the range of AVSNR2 135 to 1000 in the old input case. However, for the new input the error improvement takes place over all the AVSNR2 range. The new input also has a greater error improvement over all the AVSNR2 range, especially over the high AVSNR2 range.

Figure (6.5) is a plot of the average iteration number versus the natural logarithm of the average SNR for noise removal prior to deconvolution for the narrow case. This figure shows that the old input has a higher average iteration number than the new input. Also the new input has less fluctuation, especially in the middle of the AVSNR2 range.

Figure (6.6) shows the average error improvement versus the natural log of the average SNR for noise removal prior to deconvolution for the narrow case. The new input has a greater error improvement than the old input, especially over the low and middle AVSNR2 range. The two inputs have nearly the same error improvement over the higher AVSNR2 range however.

Figures (6.7) and (6.8) represent the average iteration numbers and the error improvements versus the natural log of the average SNR for the wide case for the noise removal prior to deconvolution. Studying Figures (6.7) and (6.8), one can see that the old input has about three times as many iteration numbers as the new input. The new input also shows four times better error improvement than the old input and less fluctuation of the error improvement values over all the range.

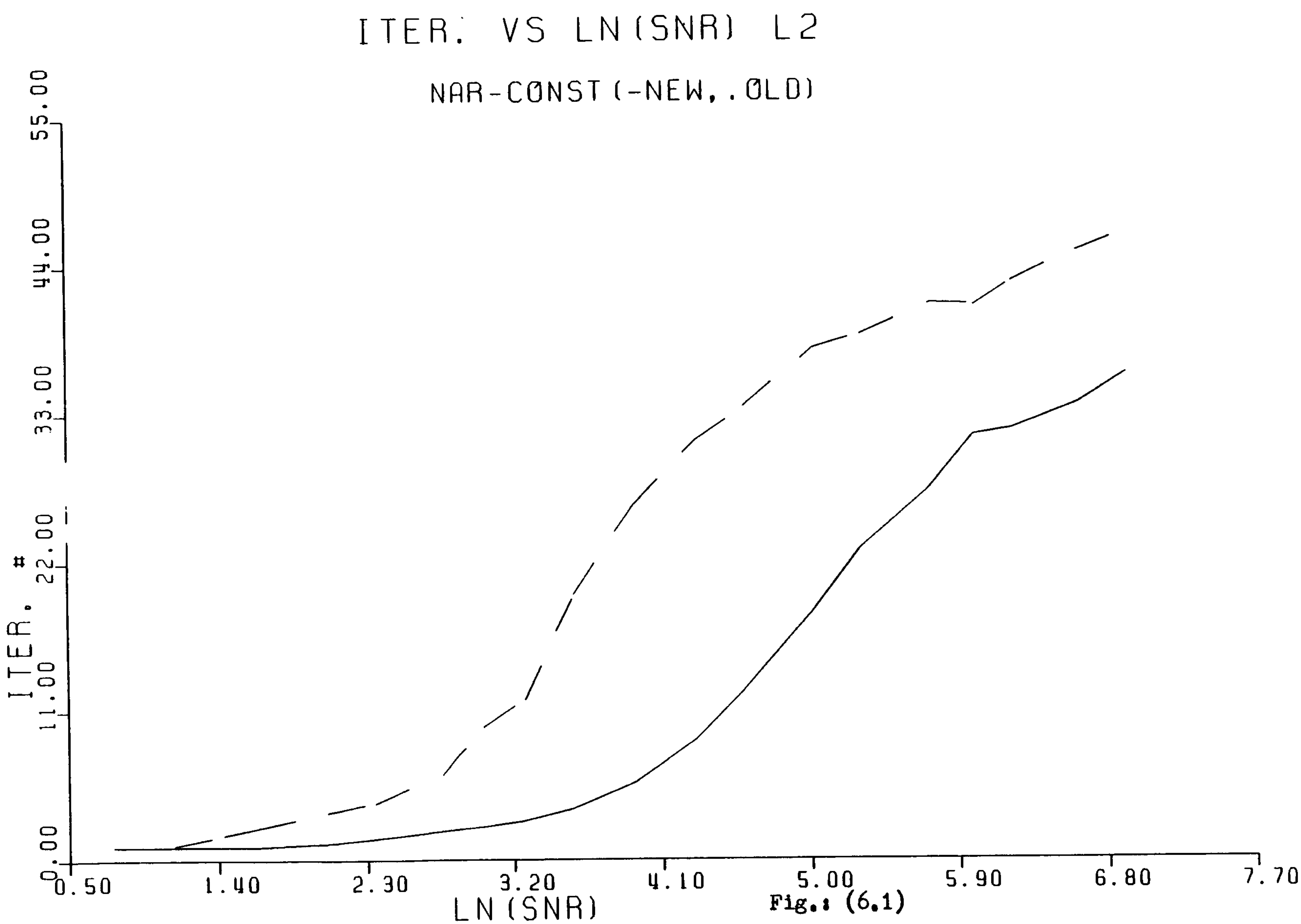
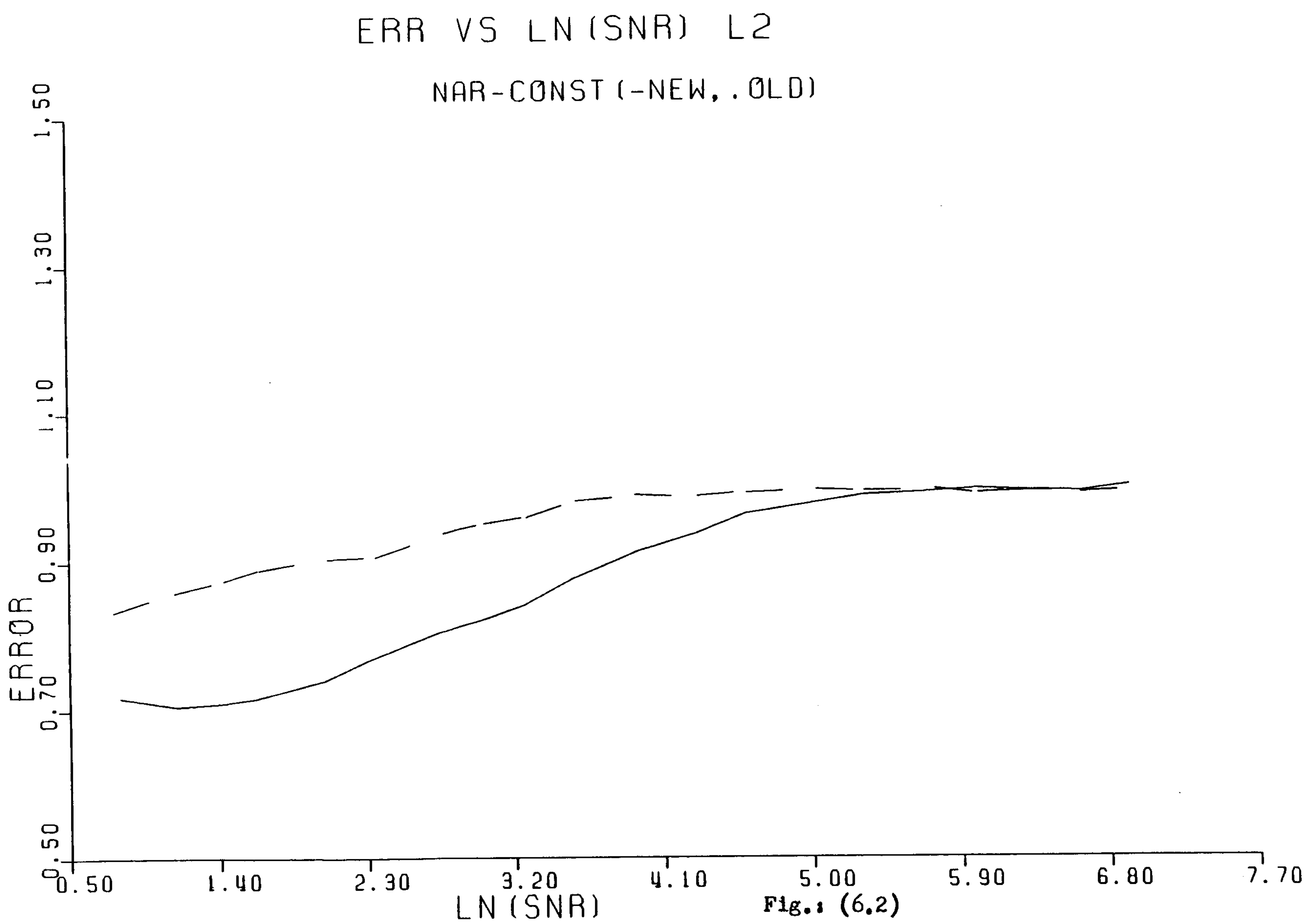

ITER. VS LN(SNR) L2
NAR-CØNST(-NEW,.ØLD)
ITER. #
0.00
11.00
22.00
33.00
44.00
55.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.1)



ERR VS LN(SNR) L2
NAR-CONST(-NEW,.OLD)
ERROR
0.50
0.70
0.90
1.10
1.30
1.50
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.2)

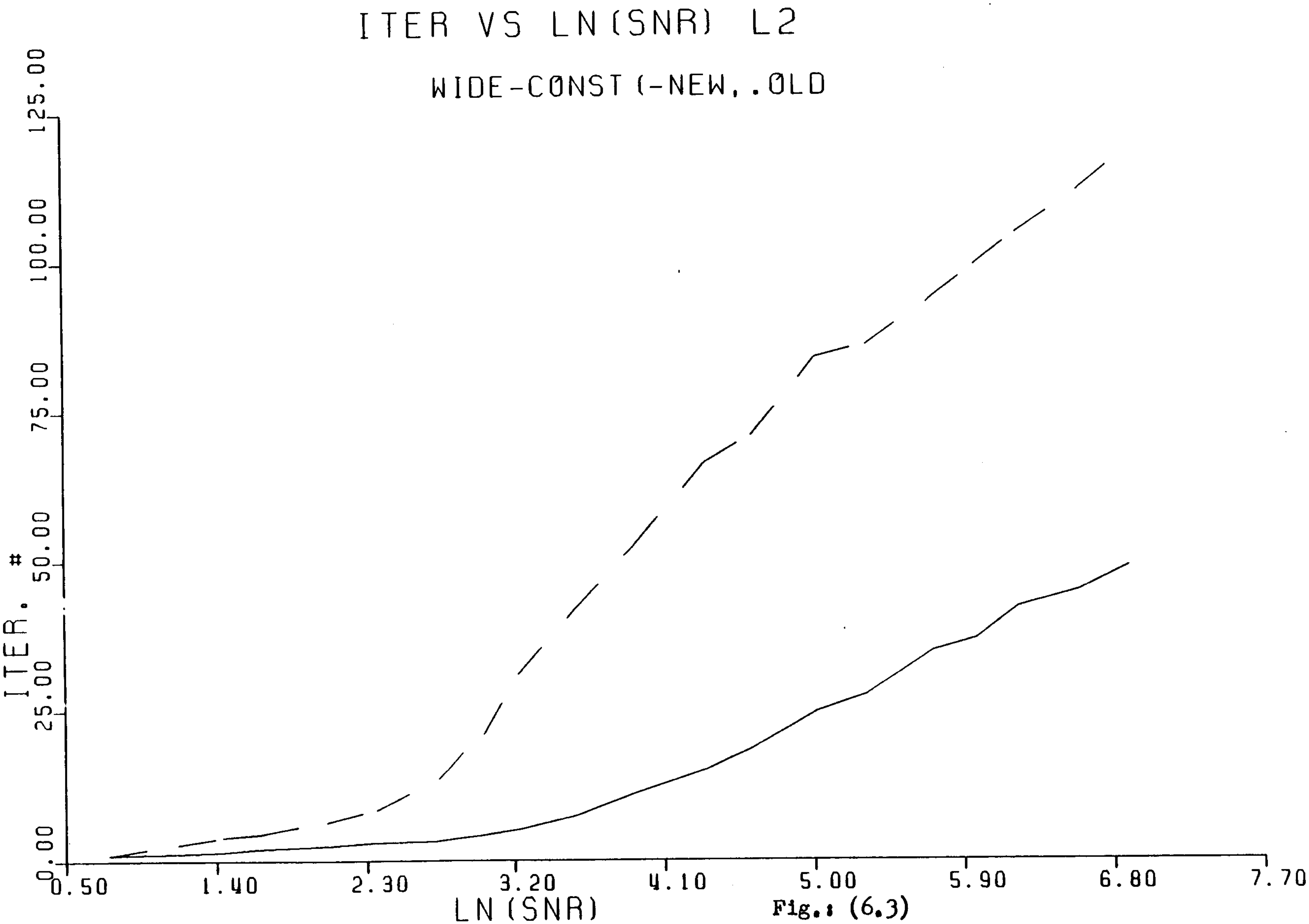

ITER VS LN(SNR) L2
WIDE-CONST(-NEW,.OLD
ITER. #
125.00
100.00
75.00
50.00
25.00
0.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.3)

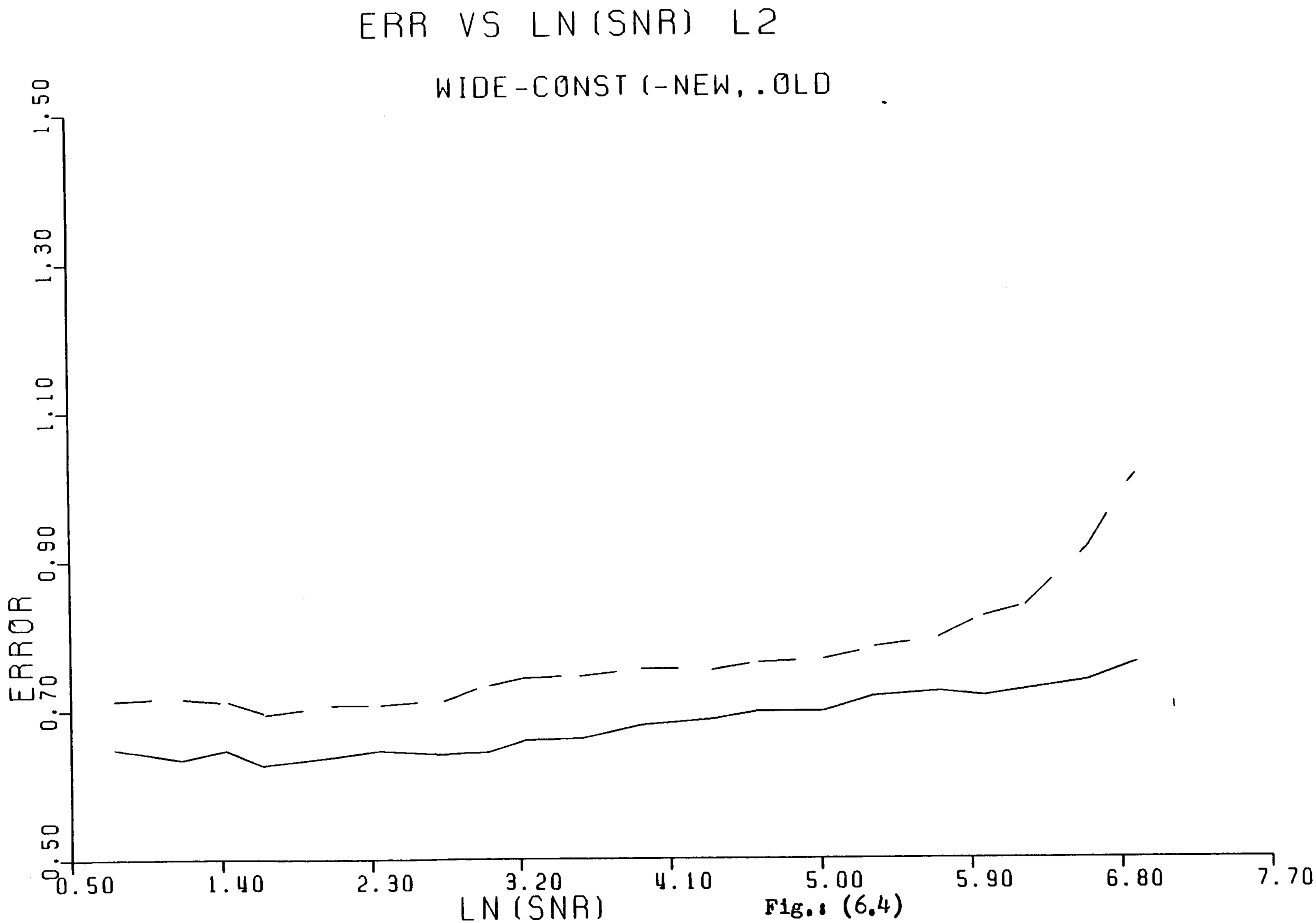

ERR VS LN(SNR) L2
WIDE-CONST(-NEW,.OLD
ERROR
0.50
0.70
0.90
1.10
1.30
1.50
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.4)

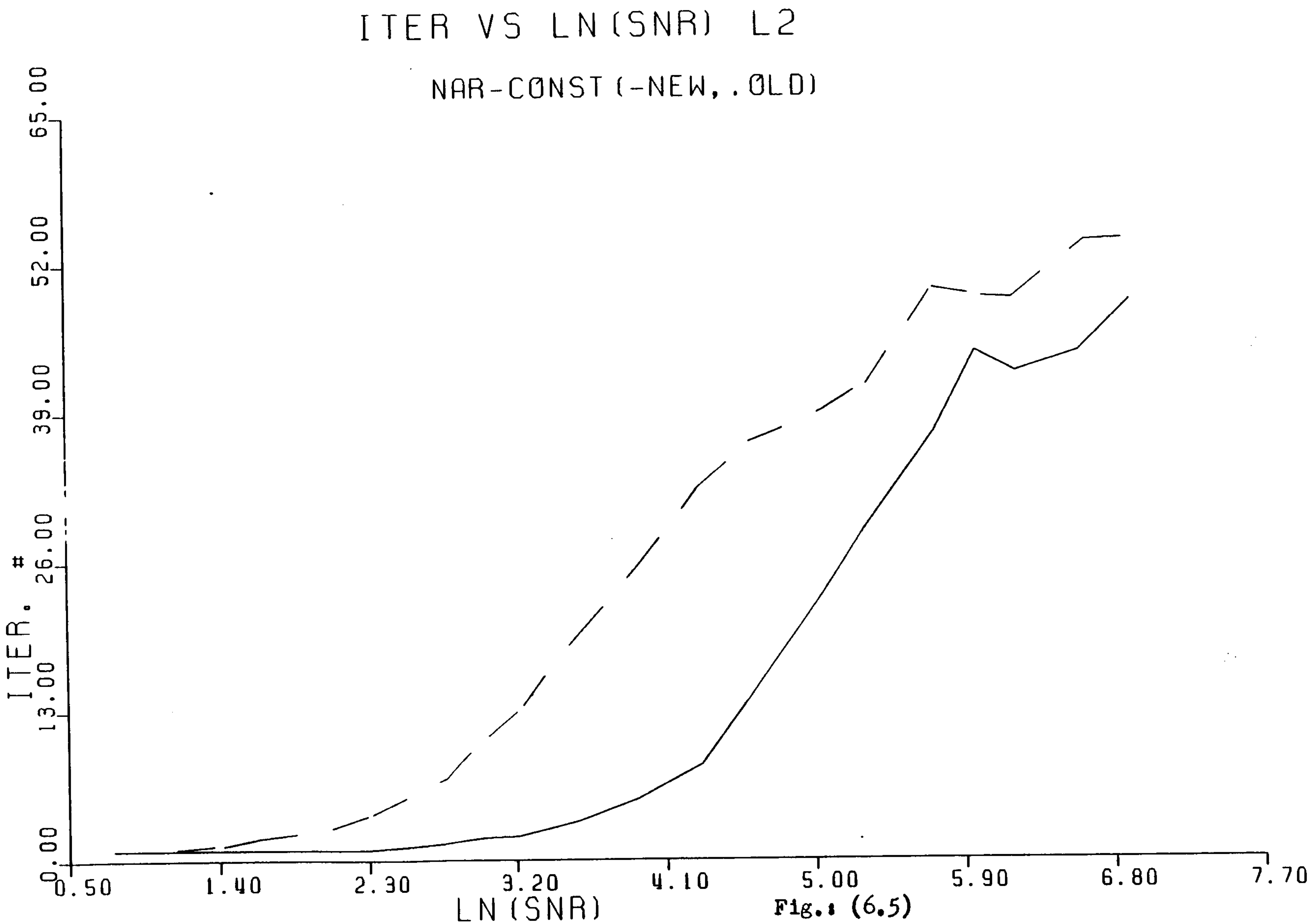

ITER VS LN(SNR) L2
NAR-CØNST(-NEW,.ØLD)
ITER. #
0.00
13.00
26.00
39.00
52.00
65.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.5)

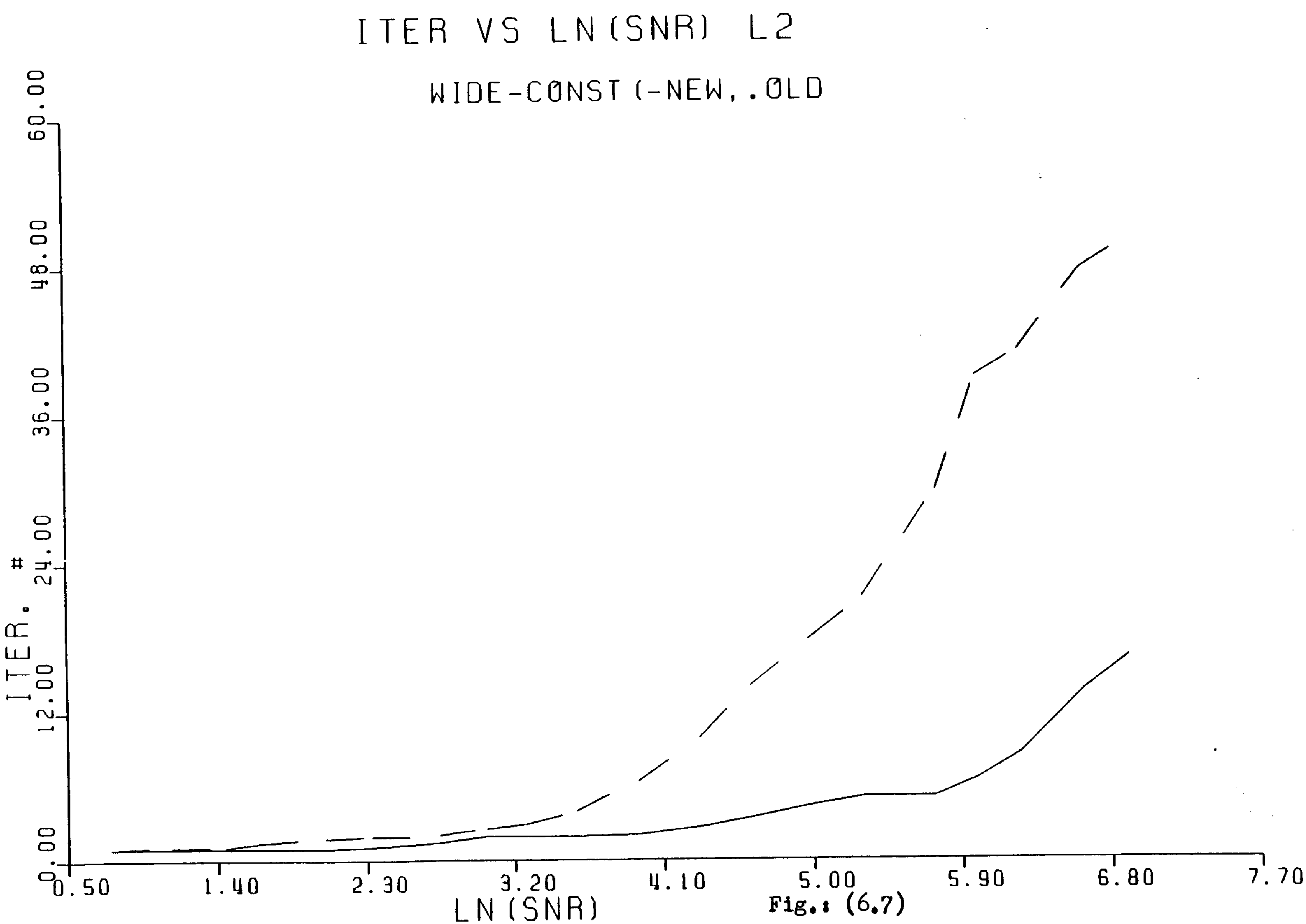

ITER VS LN(SNR) L2
WIDE-CØNST(-NEW,.OLD
ITER. #
0.00
12.00
24.00
36.00
48.00
60.00
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.7)

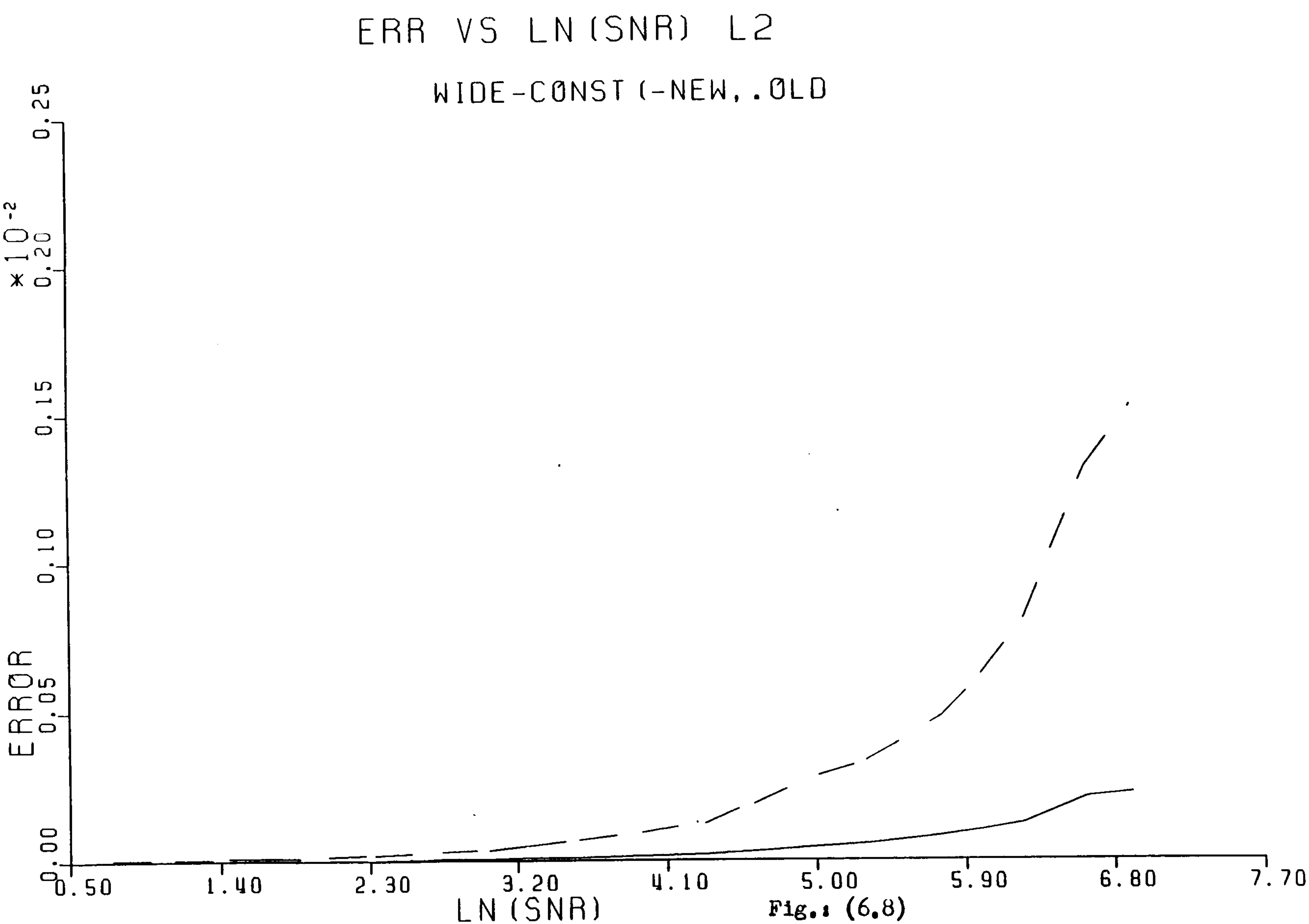

ERR VS LN(SNR) L2
WIDE-CONST(-NEW,.OLD
ERROR
*10^-2
0.00
0.05
0.10
0.15
0.20
0.25
0.50
1.40
2.30
3.20
4.10
5.00
5.90
6.80
7.70
LN(SNR)

Fig.: (6.8)

Chapter VII

Conclusion

Comparison Of The Two Applications Of Morrison's Method

It should be noted that in general after the data are deconvolved, a greater error improvement is expected. This is true for both narrow and wide cases. However, the error improvement for the wide case is much greater than that of the narrow case.

For the purpose of illustration, only the ordinate-dependent noise will be considered in this comparison for the wide and narrow cases. One can refer to the tables in Chapter III and in Chapter IV for the comparison for the constant case.

Studying Tables (3.5), (3.13) and (4.5), (4.13) or their corresponding figures, one can see that both noise removal alone, NRA, and noise removal prior to deconvolution, NRPD, have the same average iteration numbers for the low values of AVSNR2, and that the iteration numbers start to diverge as the AVSNR2 increases. In NRA the average number of iterations is less than that of NRPD for both norms, especially in the AVSNR2 300 to 1000 range. From Tables (3.13) and (4.13) the error improvements for NRPD are greater than that of NRA especially in the low and low middle AVSNR2 range. At a higher AVSNR2 range both methods have nearly the same error improvements except at the last two values, where no error improvement took place in NRA for the L1 norm.

For the wide Gaussian, investigation of Tables (3.9), (3.17) and (4.9), (4.17) or their corresponding figures shows that the number of iterations in NRA is much larger than that of NRPD for both L1 and L2 norms. The larger numbers of iterations occur especially in the middle and higher AVSNR2 range. However, average error improvements for NRPD were much better than those of NRA especially for the L1 norm. A greater error improvement occurs in the low SNR range.

It is clear from Tables (3.17) and (4.17) that the error improvements between results, before and after Morrison's technique is applied, are greater for the deconvolution for both the narrow and wide cases. However, a much greater effect on error improvement takes place in the wide Gaussian case where the relatively large number of small magnitude components at high frequencies in $G(s)$ cause great amplification of noise in deconvolution without the application of Morrison's method.

Further Study

An interesting further study would be a theoretical one to determine a general way to calculate convergence values which could be applied to different inputs. This of course requires some knowledge of all the parameters that affect the convergence criteria. Success in this endeavor would allow one to have a more definitive idea of the behavior of the optimum iteration as well as the optimum error improvements.

Another interesting study would be to see how the results of Chapters III and IV would change with different response widths.

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Appendix

The Computer Program And A Brief Documentation

The computer program, OCDCND, used in this study is similar to that used by Leclere (1984) with some modifications. OCDCND is written in FORTRAN and used to calculate all the results of this thesis.

The input to the program is either expanding or non-expanding deconvolution. The non-expanding choice is used in this study. This is followed by the input for choosing the type of Gaussian, either 1 for narrow or 2 for wide. The length of the Gaussian is 9 points for the narrow and 21 for the wide. Then the size of the output h is to be entered. The size of h is 32 in the case of the narrow g and 44 in the case of the wide g. This is followed by the size of the input, which is 24 points. The number of the SNR's desired is entered and followed by the data file number that contains the SNR's. Next is the number of points of the optimum length inverse filter. The length of the inverse filter transform selected for this study is 256 points in the narrow case and 128 points in the wide case. Then comes the choice of the application of Morrison's method to noise removal alone or prior to deconvolution. Entering number 2 will produce the results of Chapter III while entering 1 will produce the results of Chapter IV. This is followed by the type of noise to be added. Entering number 1 corresponds to ordinate-dependent noise, 2 corresponds to constant noise, and 3 corresponds to a mix of noise (which has not been used in this study). Next the maximum number of restorations is entered. The number of restorations in this study is limited to 900. The iterations will be terminated when the error is minimum or convergence of error is attained. Then the number of data sets to be optimized is chosen, either 100 for the case of noise removal alone or 50 in the case of deconvolution for this study. This is followed by the error window size, the number of points over which the error is to be calculated over. This is either 32 for the narrow case or 44 for the wide case. And lastly the convergence value for the fractional difference and then the value for the absolute difference are entered.

All the results listed in Chapters III, IV, and V are obtained from the output files of OCDCND.

```
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GT,GTH,DATA,GTR,GTMAG,HPMG,HPMAG,HMG
      DIMENSION ER(500),HOLD(512),ERR(30,5),ADDNS(30),MXSNR(30),
     * SVSNR2(200,30),ERIT(900,2),AVSNR2(30),MNSNR(30),OPTIT(100,30,2),
     * AVITNM(30,2),SDITNM(30,2),OPTER(100,30,2),ERBFM(100,30,2),
     * H(256),G(256),F(256),GTR(1025),HO(100),GT(2050),GTMAG(2050),
     * HZ(512),HN(256),HP(256),HAF(100),HBF(100),SNRS(30),SFO(30),
     * HPMAG(2050),ERTRNC(100,30,2),HMG(2050),DC(100,30),SFC(30)
      INTEGER P,Z,ANS,GTYP,SNRNO2,LG1(30,3),LG2(30,3)
      REAL*8 MXSNR,MNSNR,MINER1,MINER2,MAXIM
      COMMON LRAN
      LRAN=999
      LI=0
c
c     ENTER DATA & NUMBER OF POINTS IN GT
      CALL ENTERD(GTYP,N,M,L,G,H,F,NT,SF,SFMIN,ANS,NMRES,NMSNR,
     * NMERWD,CON,CON1,ISC,ITR,IDC,OMIX,CMIX,SNRS,NMNSF,SCLNS,NEX,IEX)
      CALL SCFCTR(M,SNRS,SFO,SFC,MAXIM,SLPO,SLPC,NMNSF,H)
c     ADD ZEROS WITH PREPGT FOR LENGTH NT & IMG. = 0
      CALL PREPGT(GT,NT,N,G)
      CALL FFT(GT,NT,-1)
c     CALCULATE MAGNITUDE OF TRANSFORM GT
      CALL MAGGT(GT,NT,GTMAG)
      IF (IDC.EQ.2) GO TO 80
c     CALCULATE 1/TRANSFORM GT
      CALL INVTRN(GT,NT)
c     BACK TO FUNCTION DOMAIN
      CALL FFT(GT,NT,+1)
c     SHIFT PEAK
      CALL SHIFGT(GT,NT)
c     NORMALIZE INVERSE IMPULSE RESPONSE & MAKE SYMETRIC(ODD)
      CALL NRMSMR(GT,NT)
c     DELETE IMAGINARY PART OF GT
      CALL GTREAL(GTR,GT,NT)
c          G-INV IS NOW CALCULATED --- WILL NOW ADD NOISE TO H
c          CALCULATE AVERAGE SNR FOR 100 NOISE ADDITIONS & SD --
c          CONTINUE ADDING NOISE -- FOR NMSNR WITHIN +/-.5SD RANGE
80    LI=0
45    LI=LI+1
      K=1
50    IF (ANS.EQ.3) CALL BOTH(H,HP,HZ,SFO,SFC,SNR,M,N,OMIX,CMIX,
     * LI,MAXIM,SCLNS)
      IF (ANS.EQ.2) CALL CONST(H,HZ,HP,SFC,RMS,SNR,M,N,LI,MAXIM)
      IF (ANS.EQ.1) CALL ORDNOI(H,HZ,HP,SFO,RMS,SNR,M,N,LI,MAXIM)
      IF (IEX.EQ.1) CALL EXPNH(H,M,N,IEX,NEX,HP,HZ,LI,K)
1      FORMAT(I)
c          DO DECONVOLUTION BEFORE MORRIS. AND AFTER MORRIS. AT EACH
c          ITTERATION & CALC. ERROR OF DECONVOLVED RESULT BY COMPARING
c          TO F-INPUT
      CALL ERROR(K,M,N,H,ER,SNR,LI,ERR,SF,OPTIT,SVSNR2,HN,SNRNO2,
```

```
     *  NM2K,ADDNS,HP,G,HZ,NMRES,OPTER,ERBFM,NT,L,GTR,F,MRS,NMSNR,
     *  NMERWD,CON,CON1,ERTRNC,GTMAG,LG1,LG2,ISC,DC,ITR,IDC)
      IF (IEX.EQ.1) CALL EXPNH(H,M,N,IEX,NEX,HP,HZ,LI,K)
      IF (K.LE.100)GO TO 50
      IF (SNRNO2.LT.NMSNR)GO TO 50
      IF (LI.LT.NMNSF) GO TO 45
      CALL OUTPUT(ERR,LI,NM2K,OPTIT,SNRNO2,SVSNR2,GTYP,ANS,ADDNS,
     *  OPTER,ERBFM,ERTRNC,LG1,LG2,DC,ITR,ISC,IDC,SNRS,OMIX,CMIX,
     *  SFO,SFC,SLPO,SLPC,CON,CON1,NEX,IEX)
      STOP
      END
c       LIMITS FOR NON-EXPANDING DECONVOLUTION
      SUBROUTINE LIMIT(KC,KF,M,NT,N,KCC,KFF)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      INTEGER KC(200),KF(200),P,A,B,D,E,KCC(200),KFF(200),R
      P=NT/2
      DO 10 I=1,M
      A=1
      B=I-P
      IF (A.GE.B) KC(I)=A
      IF (A.LT.B) KC(I)=B
      D=I+P
      E=M
      IF (D.GE.E) KF(I)=E
      IF (D.LT.E) KF(I)=D
10    CONTINUE
      P=NT/2-(N-1)/2
      R=NT/2+(N-1)/2
      DO 20 I=1,M
      A=1
      B=I-P
      IF (A.GE.B) KCC(I)=A
      IF (A.LT.B) KCC(I)=B
      D=I+R
      E=M+N-1
      IF (D.GE.E) KFF(I)=E
      IF (D.LT.E) KFF(I)=D
20    CONTINUE
      RETURN
      END
c       DE-CONVOLUTION PROGRAM
      SUBROUTINE DECONV(GTR,HI,HO,M,NT,N,MRS,KC,KF,KCC,KFF)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GTR,DPHI,DPHO,TEMP
      DIMENSION GTR(1025),HI(256),HO(256),DPHI(256),DPHO(256)
      INTEGER KC(200),KF(200),Q,KCC(200),KFF(200)
c       COMPUTE CONVOLUTION
      IF (MRS.EQ.0) GO TO 20
      Q=(NT/2)+(N-1)/2+1
      DO 1 I=1,M+N-1
      DPHI(I)=HI(I)
```

```
      DO 10 I=1,M
      DPHO(I)=0.
      DO 5 J=KCC(I),KFF(I)
      TEMP=DPHI(J)*GTR(I-J+Q)
5     DPHO(I)=DPHO(I)+TEMP
      HO(I)=DPHO(I)
10    CONTINUE
      IF (MRS.GT.0) GO TO 70
20    Q=(NT/2)+1
      DO 11 I=1,M
11    DPHI(I)=HI(I)
      DO 30 I=1,M
      DPHO(I)=0.
      DO 25 J=KC(I),KF(I)
      TEMP=DPHI(J)*GTR(I-J+Q)
25    DPHO(I)=DPHO(I)+TEMP
      HO(I)=DPHO(I)
30    CONTINUE
70    RETURN
      END
C
C
C
            c       SMOOTH, RESTORE & ERROR AT EACH ITERATION
C
C
      SUBROUTINE SMRSER(N,M,HP,G,K,LI,HZ,H,NMRES,OPTIT,SNRNO2,OPTER,
     * L,GTR,F,NT,MRS,HN,NMERWD,CON,CON1,KC,KF,KCC,KFF,LG1,LG2,ISC,IDC)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GTR
      DIMENSION H(256),HP(256),HN(256),HZ(256),G(256),GTR(1025),
     * OPTIT(100,30,2),ERIT(900,2),OPTER(100,30,2),
     * HAF(100),F(256)
      INTEGER P,Q,SNRNO2,JC(200),JF(200),KC(200),KF(200),KCC(200),
     * KFF(200),LG1(30,3),LG2(30,3)
      REAL*8 MINER1,MINER2
            c        TYPE 1
C1        FORMAT(/' IN SMRSER '/)
      IF (NMRES.EQ.0) GO TO 70
      IF (LI.EQ.1.AND.SNRNO2.EQ.1) CALL LIM(JC,JF,M,N)
            c       SMOOTH AND RESTORE EACH HP
      ITNM=1
62    IF (ITNM.GT.NMRES) GO TO 70
      IF (ITNM.GT.1) GO TO 65
      CALL SMOOTH(N,M,HP,G,HN)
      GO TO 66
65    IF (ISC.EQ.0) CALL RESTOR(N,M,G,HN,HZ,JC,JF)
      IF (ISC.EQ.1) CALL RSTR(N,M,G,HN,HZ,JC,JF)
C
C
```

```
              c       CALCULATE ERROR AT EACH ITERATION
66      MRS=ITNM
        IF (IDC.EQ.2) GO TO 30
        CALL DECONV(GTR,HN,HAF,M,NT,N,MRS,KC,KF,KCC,KFF)
              c        WRITE(62,41)
       FORMAT(/' HAF',10X,'LI',7X,'SNRNO2',7X,'ITNM'/)
           c        WRITE(62,42)LI,SNRNO2,ITNM
C42      FORMAT(3I)
              c        WRITE(62,40)(HAF(I),I=1,M)
C40      FORMAT(8(1PE16.8))
30      CALL ERRITR(N,M,ITNM,NMRES,H,HAF,K,LI,ERIT,OPTIT,SNRNO2,OPTER,L,
         *  F,NT,NMERWD,CON,CON1,LG1,LG2,MRS,IDC,HN)
        ITNM=ITNM+1
68      FORMAT(G)
69      FORMAT(5(I4))
        GO TO 62
        C70      TYPE 69,NMRES,ITNM,K,SNRNO2,LI
70      RETURN
        END
C      SMOOTH DOES THE INITIAL SMOOTHING, AND STORES THE RESULT IN HN
c       HN=H*G
        SUBROUTINE SMOOTH(N,M,HP,G,HN)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DIMENSION HP(256),G(256),HN(256)
        INTEGER A,B,C,D,E,F
405     FORMAT(4G)
        DO 420 I=1,M+N-1
        HN(I)=0.
        A=1
        B=I-N+1
        IF (A.GE.B) C=A
        IF (A.LT.B) C=B
        D=I
        E=M
        IF (D.GE.E) F=E
        IF (D.LT.E) F=D
        DO 410 J=C,F
        TEMP=HP(J)*G(I-J+1)
        HN(I)=HN(I)+TEMP
410     CONTINUE
420     CONTINUE
        RETURN
        END
              c       STORE LIMITS OF RESTORATION CONVOLUTION
        SUBROUTINE LIM(JC,JF,M,N)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        INTEGER P,A,B,D,E,JC(200),JF(200)
        P=(N-1)/2
        K=M+N-1
```

```
      DO 10 I=1,K
      A=1
      B=I-P
      IF (A.GE.B) JC(I)=A
      IF (A.LT.B) JC(I)=B
      D=I+P
      E=K
      IF (D.GE.E) JF(I)=E
      IF (D.LT.E) JF(I)=D
10    CONTINUE
      RETURN
      END
      C       RESTORE DOES RESTORING ITERATIONS
      SUBROUTINE RESTOR(N,M,G,HN,HZ,JC,JF)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION S(512),G(256),HN(256),HZ(256),HOLD(256),V(256)
      INTEGER P,Q,JC(200),JF(200)
      P=(N-1)/2
      Q=(N+1)/2
      K=M+N-1
      DO 300 I=1,K
      HOLD(I)=HN(I)
300   S(I)=HZ(I)-HN(I)
      DO 330 I=1,K
      V(I)=0.
      DO 320 J=JC(I),JF(I)
      TEMP=S(J)*G(I-J+Q)
320   V(I)=V(I)+TEMP
330   CONTINUE
      DO 340 I=1,K
340   HN(I)=HOLD(I)+V(I)
      RETURN
      END
     c RESTORE DOES RESTORING ITERATIONS - POINT SUCCESSIVE
      SUBROUTINE RSTR(N,M,G,HN,HZ,JC,JF)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION S(512),G(256),HN(256),HZ(256)
      INTEGER P,Q,JC(200),JF(200)
      P=(N-1)/2
      Q=(N+1)/2
      K=M+N-1
      DO 300 I=1,K
300   S(I)=HZ(I)-HN(I)
      DO 330 I=1,K
      DO 320 J=JC(I),JF(I)
      TEMP=S(J)*G(I-J+Q)
320   HN(I)=HN(I)+TEMP
330   S(I)=HZ(I)-HN(I)
      RETURN
      END
              c   CALCULATE ERROR FOR DECON. & NOISE REMOVAL ALONE
```

```
      SUBROUTINE ERRR(FHEX,M,HF,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION FHEX(256),HF(256)
      INTEGER P,Q
      P=0
      SUM=0.
      SIGMA=0.
      IF (IEX.EQ.1) JJ=NEX*(N-1)/2
      IF (IEX.NE.1) JJ=0
      IF (IEX.EQ.1) M=M-2*JJ
      IF (IDC.EQ.2) GO TO 30
      IF (NMERWD.EQ.L) GO TO 210
      DO 200 I=1,(M/2-L/2)
      SUM=SUM+ABS(FHEX(I+JJ))
      SIGMA=SIGMA+FHEX(I+JJ)**2
200   CONTINUE
210   DO 300 I=(M/2-L/2+1),(M/2+L/2)
      TEMP=FHEX(I+JJ)-HF(I-M/2+L/2)
      SUM=SUM+ABS(TEMP)
      SIGMA=SIGMA+TEMP**2
300   CONTINUE
      IF (NMERWD.EQ.L) GO TO 70
      DO 400 I=(M/2+L/2+1),M
      SUM=SUM+ABS(FHEX(I+JJ))
      SIGMA=SIGMA+FHEX(I+JJ)**2
400   CONTINUE
      IF (IEX.EQ.1) M=M+2*JJ
      GO TO 70
30    IF (MRS.NE.0) P=(N-1)/2
      DO 50 I=1,M
      Q=I+P
      TEMP=HF(I+JJ)-FHEX(Q+JJ)
      SUM=SUM+ABS(TEMP)
      SIGMA=SIGMA+TEMP*TEMP
50    CONTINUE
      IF (IEX.EQ.1) M=M+2*JJ
70    RETURN
      END
c     TRUNCATE MAG. H TO MAG. G & CALCULATE ERROR
      SUBROUTINE TRNCER(HP,HZ,M,NT,GTMAG,GTR,N,ERTRNC,SNRNO2,LI,
     * NMERWD,F,H,L,KC,KF,KCC,KFF,DC,IDC)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GTR,GTMAG,HPMG,HPMAG,HMG,DHNS
      DIMENSION HP(256),HZ(512),GTMAG(2050),HPMG(2050),GTR(1025),
     * ERTRNC(100,30,2),HTRC(100),F(256),H(256),HMG(2050),HNS(256),
     * DHNS(2050),DC(100,30)
      INTEGER SNRNO2,KC(200),KF(200),KCC(200),KFF(200)
c     PLOT MAGNITUDE OF NOISE SPECTRUM & STORE DC LEVEL OF NOISE
      DO 5 I=1,M
      HNS(I)=HP(I)-H(I)
```

```
5        CONTINUE
      CALL PREPHP(NT,M,HNS,DHNS)
      CALL FFT(DHNS,NT,-1)
      DC(SNRNO2,LI)=DHNS(1)
c           DO 6 I=1,NT
C6       DHNS(I)=DSQRT(DHNS(2*I-1)**2+DHNS(2*I)**2)
c           WRITE(32,10)(DHNS(I),I=1,NT)
c           CLOSE(UNIT=32)
C
c     TRUNCATE & DECONVOLVE
C
      CALL PREPHP(NT,M,HP,HPMG)
      CALL FFT(HPMG,NT,-1)
      CALL TRUNC(HPMG,GTMAG,NT,H,M)
      CALL FFT(HPMG,NT,+1)
C
       DO 15 I=1,2*NT
15     HPMG(I)=HPMG(I)/NT
C
c           WRITE(20,10)(HPMG(2*I-1),I=1,NT)
c           WRITE(20,10)(HPMG(2*I),I=1,NT)
10    FORMAT(G)
c           CLOSE(UNIT=20)
C
      DO 20 I=1,M
      HP(I)=HPMG(2*I-1)
      HZ(I+(N-1)/2)=HP(I)
20    CONTINUE
      MRS=0
C
      IF (IDC.EQ.1) GO TO 30
C
c     CALCULATE ERTRNC-(TRUNCATION NO MORRIS.)
C
      CALL ERRR(HP,M,H,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
      GO TO 410

30    CALL DECONV(GTR,HP,HTRC,M,NT,N,MRS,KC,KF,KCC,KFF)
C
c     PLOT DECONVOLUTION AFTER TRUNCATION
C
c          WRITE(25,10)(HTRC(I),I=1,M)
C
c     CALCULATE ERTRNC-(TRUNCATION BUT NO MORRIS.)
C
      CALL ERRR(HTRC,M,F,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
C
C
c     STORE ERROR
```

```
410     ERTRNC(SNRNO2,LI,1)=SUM/NMERWD
        ERTRNC(SNRNO2,LI,2)=SQRT(SIGMA/NMERWD)
C
        RETURN
        END
C
              c   TRUNCATE HPMAG TO GTMAG
C
        SUBROUTINE TRUNC(HPMG,GTMAG,NT,H,M)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DOUBLE PRECISION GTMAG,HPMAG,HPMG,HMG,TEMP,TEMP1
        DIMENSION HPMG(2050),HPMAG(2050),GTMAG(2050),H(256),HMG(2050)
C
              c   PLOT MAGNITUDE OF H
              c       WRITE(25,20)(HPMG(2*I-1),I=1,NT)
              c       WRITE(25,20)(HPMG(2*I),I=1,NT)
              c       CALL PREPHP(NT,M,H,HMG)
              c       CALL FFT(HMG,NT,-1)
              c       DO 5 I=1,NT
C5       HMG(I)=DSQRT(HMG(2*I-1)**2+HMG(2*I)**2)
              c       WRITE(31,20)(HMG(I),I=1,NT)
C
        DO 10 I=1,NT
        HPMAG(2*I-1)=DSQRT(HPMG(2*I-1)**2+HPMG(2*I)**2)
        TEMP=GTMAG(2*I-1)*HPMAG(1)
        TEMP1=TEMP/HPMAG(2*I-1)
        IF (HPMAG(2*I-1).LE.TEMP) GO TO 10
        HPMG(2*I-1)=HPMG(2*I-1)*TEMP1
        HPMG(2*I)=HPMG(2*I)*TEMP1
10      CONTINUE
              c       CLOSE(UNIT=31)
20      FORMAT(G)
              c       WRITE(36,20)(HPMAG(2*I-1),I=1,NT)
              c       WRITE(38,20)(GTMAG(2*I-1),I=1,NT)
              c       WRITE(39,20)(HPMG(2*I-1),I=1,NT)
              c       WRITE(39,20)(HPMG(2*I),I=1,NT)
              c       CLOSE(UNIT=25)
              c       CLOSE(UNIT=36)
              c       CLOSE(UNIT=38)
              c       CLOSE(UNIT=39)
        RETURN
        END
C
C
c   CALCULATE ERROR BEFORE MORRISON BY 1ST CONVOLVING NOISY H & G-INV
C
        SUBROUTINE BFMER(GTR,HP,M,NT,N,ERBFM,LI,SNRNO2,NMERWD,L,F,KC,KF,
     *  KCC,KFF,IDC,H)
```

```
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GTR
      DIMENSION GTR(1025),HP(256),HBF(100),ERBFM(100,30,2),F(256),
     *  H(256)
      INTEGER SNRNO2,KC(200),KF(200),KCC(200),KFF(200)
C
      MRS=0
C
      IF (IDC.EQ.1) GO TO 30
      CALL ERRR(HP,M,H,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
      GO TO 410
30    CALL DECONV(GTR,HP,HBF,M,NT,N,MRS,KC,KF,KCC,KFF)
                c   PLOT AND PRINT DECONVOLUTION BEFORE MORRIS.
C
                c         WRITE(62,57)(HBF(I),I=1,M)
57      FORMAT(G)
C
                c         WRITE(61,41)
C41     FORMAT(/' HBF',4X,'LI',5X,'SNRNO2'/)
                c         WRITE(61,42)LI,SNRNO2
C42     FORMAT(2I)
                c         WRITE(61,40)(HBF(I),I=1,M)
C40    FORMAT(8(1PE16.8))
C
C
      CALL ERRR(HBF,M,F,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
C
        c   STORE ERROR
C
410   ERBFM(SNRNO2,LI,1)=SUM/NMERWD
      ERBFM(SNRNO2,LI,2)=SQRT(SIGMA/NMERWD)
C
      RETURN
      END
C
C
                c      CALCULATE ERROR AT EACH ITERATION
C
      SUBROUTINE ERRITR(N,M,ITNM,NMRES,H,HAF,K,LI,ERIT,OPTIT,SNRNO2,
     *  OPTER,L,F,NT,NMERWD,CON,CON1,LG1,LG2,MRS,IDC,HN)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION ERIT(900,2),OPTIT(100,30,2),H(256),HAF(100),F(256),
     *  OPTER(100,30,2),HAGR(50,2),HN(256)
      INTEGER P,Q,SNRNO2,LG1(30,3),LG2(30,3)
      REAL*8 MINER1,MINER2
      IF (ITNM.GT.1) GO TO 10
      I1=0
      I2=0
      IND=0
10    IF (IDC.EQ.1) CALL ERRR(HAF,M,F,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
      IF (IDC.EQ.2) CALL ERRR(HN,M,H,MRS,N,SUM,SIGMA,L,NMERWD,IDC)
```

```
      c   STORE ERROR EACH ITERATION
C
59    ERIT(ITNM,1)=SUM/NMERWD
      ERIT(ITNM,2)=SQRT(SIGMA/NMERWD)
      IF (ITNM.GT.1)GO TO 80
       c   FIND OPTIMUM ITERATION
C
      MINER1=ERIT(ITNM,1)
      OPITN1=1
      II1=1
      MINER2=ERIT(ITNM,2)
      OPITN2=1
      II2=1
C
              c   TO PLOT DECON CHANGE 70 TO 100 AND DELETE APPROPRIATE C
C
80    IF (ITNM.EQ.1) GO TO 70
      IF (I1.EQ.1)GO TO 200
       c   CHECK FOR MIN. ERROR 1
C
      IF (ERIT(ITNM,1).LE.MINER1) MINER1=ERIT(ITNM,1)
      IF (ERIT(ITNM,1).EQ.MINER1) OPITN1=ITNM
      IF (ERIT(ITNM,1).EQ.MINER1) II1=ITNM
      IF (ERIT(ITNM,1).GE.ERIT(ITNM-1,1)) I1=1
C
       c   CONVERGENCE CRITERION ERROR 1
C
       DERIT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))/ERIT(ITNM-1,1)
       ERT1=ABS(ERIT(ITNM,1)-ERIT(ITNM-1,1))
        IF (DERIT1.LE.CON.OR.ERT1.LE.CON1) I1=1
C
       c   SET FLAG TO DETERMINE WHICH CONVERGENCE CRITERION L1
C
       c   TO PLOT DECON CHANGE 200 TO 100
      IF (I1.EQ.0) GO TO 200
      IF (SNRNO2.GT.1) GO TO 30
      LG1(LI,1)=0
      LG1(LI,2)=0
      LG1(LI,3)=0
30   IF (DERIT1.LE.CON.AND.II1.EQ.ITNM) LG1(LI,1)=LG1(LI,1)+1
      IF (ERT1.LE.CON1.AND.II1.EQ.ITNM) LG1(LI,2)=LG1(LI,2)+1
      IF ((DERIT1.LE.CON.AND.ERT1.LE.CON1).AND.II1.EQ.ITNM)
     *  LG1(LI,3)=LG1(LI,3)+1
              c      TYPE 37,SNRNO2,LG1(LI,1),LG1(LI,2),LG1(LI,3)
37    FORMAT(I5,'  L1',3I5)
C
       c   PLOT & PRINT OPT. DECON. FOR ERROR L1
C
```

```
              c        IF (I1.EQ.1.AND.II1.LT.ITNM) GO TO 15
C100     DO 11 I=1,M
C11      HAGR(I,1)=HAF(I)
         c              c        IF (I1.EQ.1) GO TO 15
                  c        IF (ITNM.EQ.1) GO TO 150
                  c        GO TO 200
CC15      WRITE(50,21)(HAGR(I,1),I=1,M)
         c              c        WRITE(40,23)LI,SNRNO2,OPITN1
         c              c        WRITE(40,22)(HAGR(I,1),I=1,M)
21       FORMAT(G)
22       FORMAT(8(1PE16.8))
23       FORMAT(/' DECON AT OPT. L1',3I8/)
CC
200      IF (I2.EQ.1) GO TO 300
C
         c   CHECK FOR MIN. ERROR 2
C
         IF (ERIT(ITNM,2).LE.MINER2) MINER2=ERIT(ITNM,2)
         IF (ERIT(ITNM,2).EQ.MINER2) OPITN2=ITNM
         IF (ERIT(ITNM,2).EQ.MINER2) II2=ITNM
         IF (ERIT(ITNM,2).GE.ERIT(ITNM-1,2)) I2=1
C
         c   CONVERGENCE CRITERION ERROR 2
C
          DERIT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))/ERIT(ITNM-1,2)
          ERT2=ABS(ERIT(ITNM,2)-ERIT(ITNM-1,2))
           IF (DERIT2.LE.CON.OR.ERT2.LE.CON1) I2=1
C
         c   SET FLAG TO DETERMINE WHICH CONVERGENCE CRITERION L2
C
                  c        TO PLOT DECON CHANGE 300 TO 150 AND DELETE C
         IF (I2.EQ.0) GO TO 300
         IF (SNRNO2.GT.1) GO TO 35
         LG2(LI,1)=0
         LG2(LI,2)=0
         LG2(LI,3)=0
35      IF (DERIT2.LE.CON.AND.II2.EQ.ITNM) LG2(LI,1)=LG2(LI,1)+1
         IF (ERT2.LE.CON1.AND.II2.EQ.ITNM) LG2(LI,2)=LG2(LI,2)+1
36       FORMAT(I5,'  L2',3I5)
         IF ((DERIT2.LE.CON.AND.ERT2.LE.CON1).AND.II2.EQ.ITNM)
         *  LG2(LI,3)=LG2(LI,3)+1
                  c        TYPE 36,SNRNO2,LG2(LI,1),LG2(LI,2),LG2(LI,3)
C
         c   PLOT & PRINT OPT. DECON. FOR ERROR L2
C
         c              c        IF (I2.EQ.1.AND.II2.LT.ITNM) GO TO 25
C150      DO 31 I=1,M
C31       HAGR(I,2)=HAF(I)
         c              c        IF (I2.EQ.1) GO TO 25
                  c        IF (ITNM.EQ.1) GO TO 70
```

```
                    c        GO TO 300
CC25       WRITE(51,21)(HAGR(I,2),I=1,M)
                    c        WRITE(41,33)LI,SNRNO2,OPITN2
                    c        WRITE(41,22)(HAGR(I,2),I=1,M)
33      FORMAT(/' DECON AT OPT. L2',3I8/)
C
C
C
300     IF (I1.EQ.1.AND.I2.EQ.1) IND=1
        IF (IND.NE.1.AND.ITNM.NE.NMRES) GO TO 70
C
         c   END ITERATIONS AND STORE RESULTS
C
        ITNM=NMRES
        OPTIT(SNRNO2,LI,1)=OPITN1
        OPTIT(SNRNO2,LI,2)=OPITN2
        OPTER(SNRNO2,LI,1)=MINER1
        OPTER(SNRNO2,LI,2)=MINER2
C
C
70      RETURN
        END
C
                    c       ERRORS
C
C
        SUBROUTINE ERROR(K,M,N,H,ER,SNR,LI,ERR,SF,OPTIT,SVSNR2,HN,
         *  SNRNO2,NM2K,ADDNS,HP,G,HZ,NMRES,OPTER,ERBFM,NT,L,GTR,F,MRS,
         *  NMSNR,NMERWD,CON,CON1,ERTRNC,GTMAG,LG1,LG2,ISC,DC,ITR,IDC)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DOUBLE PRECISION GTR,HPMG,HPMAG,GTMAG,HMG
        DIMENSION H(256),ER(500),ERR(30,5),OPTIT(100,30,2),HN(256),
       * SVSNR2(100,30),ADDNS(30),HP(256),G(256),F(256),GTR(1025),
      * HZ(256),HBF(100),OPTER(100,30,2),ERBFM(100,30,2),DC(100,30),
         * GTMAG(2050),ERTRNC(100,30,2),HMG(2050)
        INTEGER SNRNO2,KC(200),KF(200),KCC(200),KFF(200),LG1(30,3),
         * LG2(30,3)
       ER(K)=SNR
         K = K+1
         IF (K.LE.100)GO TO 60
         c
C  OUTPUT RESULTS & AVESNR,VARSNR,SDSNR
C
         K = K-1
        IF (K.GT.100)GO TO 100
        AVESNR=0.
        VARSNR=0.
        SDSNR=0.
        SNRNO2=0
```

```
      DO 50 I=1,K
50    AVESNR=AVESNR+ER(I)
      AVESNR=AVESNR/K
      DO 52 I=1,K
52    VARSNR=VARSNR+((ER(I)-AVESNR)**2)
      VARSNR=VARSNR/K
      SDSNR=SQRT(VARSNR)
C
c   CALCULATE # OF SNR'S IN SDSNR RANGE & DO CALCULATIONS
C
      SNRMX2=AVESNR+SDSNR/2.
      SNRMN2=AVESNR-SDSNR/2.
100   IF (K.LE.100)GO TO 105
      IF (ER(K).LT.SNRMN2.OR.ER(K).GT.SNRMX2) GO TO 53
      SNRNO2=SNRNO2+1
      SVSNR2(SNRNO2,LI)=ER(K)
      IF (LI.EQ.1.AND.SNRNO2.EQ.1.AND.IDC.EQ.1) CALL LIMIT(KC,KF,M,
     * NT,N,KCC,KFF)
      CALL BFMER(GTR,HP,M,NT,N,ERBFM,LI,SNRNO2,NMERWD,L,F,KC,KF,KCC,
     * KFF,IDC,H)
      IF (ITR.EQ.1) CALL TRNCER(HP,HZ,M,NT,GTMAG,GTR,N,ERTRNC,
     * SNRNO2,LI,NMERWD,F,H,L,KC,KF,KCC,KFF,DC,IDC)
      CALL SMRSER(N,M,HP,G,K,LI,HZ,H,NMRES,OPTIT,SNRNO2,OPTER,L,GTR,
C
     * F,NT,MRS,HN,NMERWD,CON,CON1,KC,KF,KCC,KFF,LG1,LG2,ISC,IDC)




53    IF (SNRNO2.LE.NMSNR)NM2K=K
      IF (SNRNO2.LT.NMSNR)GO TO 59
      IF (SNRNO2.EQ.NMSNR)GO TO 65
54    FORMAT(I)
55     FORMAT(8(1PE16.8))
57     FORMAT(G)
105    ERR(LI,2)=AVESNR
       ERR(LI,5)=SDSNR
9     K=K+1
       IF (SNRNO2.LT.NMSNR)GO TO 60
65     ADDNS(LI)=NM2K
C
c          TYPE 68
C68     FORMAT(/////' # OF SNR S COMPLETED ')
67     TYPE 54,LI
60     RETURN
       END
c        ENTER DATA & NUMBER OF POINTS NT
C
      SUBROUTINE ENTERD(GTYP,N,M,L,G,H,F,NT,SF,SFMIN,ANS,NMRES,
     * NMSNR,NMERWD,CON,CON1,ISC,ITR,IDC,OMIX,CMIX,SNRS,NMNSF,SCLNS,
```

```
     *  NEX,IEX)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DIMENSION G(256),H(256),F(256),SNRS(30)
        INTEGER GTYP,ANS
1       FORMAT(I)
        TYPE 111
111     FORMAT(' ENTER 1=EXPAND CONV, 0=OTHERWISE')
        ACCEPT 1,IEX
        IF (IEX.EQ.0) GO TO 113
        TYPE 112
112     FORMAT(' ENTER # OF EXPANSIONS')
        ACCEPT 1,NEX
113     TYPE 2
2       FORMAT(' ENTER 1 FOR NARROW G -- 2 FOR WIDE G ')
        ACCEPT 1,GTYP
        CALL INPUT(N,M,L,G,H,F,GTYP,SNRS,NMNSF,IEX,NEX)
        TYPE 3
3       FORMAT(' ENTER NUMBER OF POINTS IN G-INV-1 & PTS/2 TRANS G&HP ')
        ACCEPT 1,NT
        TYPE 4
4       FORMAT(' ENTER 1 FOR DECON, 2 FOR NOISE REMOVE ALONE')
        ACCEPT 1,IDC
        TYPE 50
50      FORMAT(' ENTER 1 FOR ORD. NOISE, 2=CONST, 3=MIX')
        ACCEPT 1,ANS
        IF (ANS.NE.3) GO TO 80
        TYPE 5
5       FORMAT(' ENTER FRACTION OF ORDINATE NOISE ?/? ')
        ACCEPT 20,KO,LO
        TYPE 6
6       FORMAT(' ENTER FRACTION OF CONSTANT NOISE ?/? ')
        ACCEPT 20,KC,LC
20      FORMAT(I,X,I)
        OMIX=FLOAT(KO)/FLOAT(LO)
        CMIX=FLOAT(KC)/FLOAT(LC)
        TYPE 21,OMIX,CMIX
        SCLNS=1./SQRT(OMIX**2+CMIX**2)
        TYPE 40,SCLNS
21      FORMAT(2G)
80      TYPE 7
7       FORMAT(' ENTER MAX NUMBER OF RESTORATIONS ')
        ACCEPT 1,NMRES
        TYPE 8
8       FORMAT(' ENTER NUMBER OF SNR IN +/- .5SD RANGE ')
        ACCEPT 1,NMSNR
        TYPE 9
9       FORMAT(' ENTER ERROR WINDOW SIZE -- L OR M ')
        ACCEPT 1,NMERWD
        TYPE 11
11      FORMAT(' CHOOSE CONVERGENCE CRITERION = (Ei-(Ei-1))/Ei-1) ')
        ACCEPT 40,CON
```

```
      TYPE 12
12    FORMAT(' CHOOSE CONVERGENCE CRITERION = (Ei-(Ei-1)) ')
      ACCEPT 40,CON1
      TYPE 13
13    FORMAT(' ENTER 0 FOR SIMUL., 1 FOR SUCC. ')
      ACCEPT 1,ISC
      TYPE 14
14    FORMAT(' ENTER 1 FOR TRUNCATION, 0 FOR NO TRUNC. ')
      ACCEPT 1,ITR
40    FORMAT(G)
      RETURN
      END
C
C     INPUT ENTERS THE DATA
C
      SUBROUTINE INPUT(N,M,L,G,H,F,GTYP,SNRS,NMNSF,IEX,NEX)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION H(256),G(256),F(256),SNRS(30),HH(256)
      INTEGER IFL,GTYP
      TYPE 110
110   FORMAT ('   ENTER SIZE OF H')
      ACCEPT 120,M
120   FORMAT(I)
      TYPE 130
130   FORMAT('  ENTER SIZE OF G,ODD ')
      ACCEPT 120,N
      TYPE 135
135   FORMAT(' ENTER SIZE OF F ')
      ACCEPT 120,L
      TYPE 140
140   FORMAT('  ENTER THE INPUT FILE #  ',$)
      ACCEPT 120,IFL
      TYPE 145
145   FORMAT(' ENTER # OF SNR"S DESIRED ',$)
      ACCEPT 120,NMNSF
      TYPE 150
150   FORMAT(' ENTER ENTER INPUT FILE # FOR SNR"S DESIRED')
      ACCEPT 120,IFLN
      READ(IFLN,160)(SNRS(I),I=1,NMNSF)
      READ(IFL,160)(H(I),I=1,M)
      READ(IFL,160)(G(I),I=1,N)
      READ(IFL,160)(F(I),I=1,L)
      WRITE(*,160)(SNRS(I),I=1,NMNSF)
      WRITE(*,160)(H(I),I=1,M)
      WRITE(*,160)(G(I),I=1,N)
      WRITE(*,160)(F(I),I=1,L)
0     FORMAT(4G)
```

```
170     RETURN
        END
C
                  c      PREP_GT
C
        SUBROUTINE PREPGT(GT,NT,N,G)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DOUBLE PRECISION GT
        DIMENSION GT(2050),G(256)
        DO 1 I=1,N
        GT(2*I-1) = G(I)
1       GT(2*I) = 0.0
        DO 2 I=N+1,NT
        GT(2*I-1)=0.0
2       GT(2*I)=0.0
        RETURN
        END
C                 c      MAG_GT
C
        SUBROUTINE MAGGT(GT,NT,GTMAG)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DOUBLE PRECISION GT,GTMAG
        DIMENSION GT(2050),GTMAG(2050)
        DO 1 I=1,NT
        GT(2*I-1)=DSQRT((GT(2*I-1)**2)+(GT(2*I)**2))
1       GT(2*I)=0.0
        DO 2 I=1,2*NT
2       GTMAG(I)=GT(I)
        RETURN
        END
C
                  c      1/TRANS. GT
C
        SUBROUTINE INVTRN(GT,NT)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        DOUBLE PRECISION GT
        DIMENSION GT(2050)
        DO 10 I=1,NT
        IF (GT(2*I-1).EQ.0)GO TO 5
        GT(2*I-1)=1./GT(2*I-1)
        GO TO 10
5       GT(2*I-1)=0.
10      CONTINUE
        RETURN
        END
C
                  c      SHIFT-GT
C
        SUBROUTINE SHIFGT(GT,NT)
```

```
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GT,GTH
      DIMENSION GT(2050),GTH(1024)
      DO 1 I=1,NT
1     GTH(I)=GT(I)
      DO 5 I=1,NT
5     GT(I)=GT(NT+I)
      DO 10 I=1,NT
10    GT(NT+I)=GTH(I)
      RETURN
      END
C                 c       NRMSMR
C
      SUBROUTINE NRMSMR(GT,NT)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GT
      DIMENSION GT(2050)
      DO 5 I=1,2*NT
5     GT(I)=GT(I)/NT
                c       MAKE INV. IMPULSE RES. SYMETRIC
      GT(1)=GT(1)/2.0
      GT(2*NT+1)=GT(1)
      RETURN
      END
            c       GT REAL
C
      SUBROUTINE GTREAL(GTR,GT,NT)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION GT,GTR
      DIMENSION GTR(1025),GT(2050)
      DO 10 I=1,NT+1
      GTR(I)=GT(2*I-1)
10    CONTINUE
      RETURN
      END
C
                c    PREP_HP
C
      SUBROUTINE PREPHP(NT,M,DHP,DHPMG)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION DHPMG
      DIMENSION DHPMG(2050),DHP(256)
      DO 10 I=1,M
      DHPMG(2*I-1)=DHP(I)
10    DHPMG(2*I)=0.
      DO 20 I=M+1,NT
      DHPMG(2*I-1)=0.
20    DHPMG(2*I)=0.
      RETURN
      END
      SUBROUTINE EXPNH(H,M,N,IEX,NEX,HP,HZ,LI,K)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
```

```
      DIMENSION HH(256),H(256),HP(256),HZ(512),HHP(256),HHZ(512)
      IF (IEX.EQ.1.AND.NEX.EQ.0) GO TO 170
      JJ=NEX*(N-1)/2
      IF (LI.EQ.1.AND.K.EQ.1) M1=M
      IF (M.EQ.M1+2*JJ) GO TO 165
      Q=(N-1)/2
      DO 161 I=1,M
      HHP(I+JJ)=HP(I)
      HHZ(I+JJ)=HZ(I+Q)
161   HH(I+JJ)=H(I)
      DO 162 I=1,JJ
      HP(I)=0.
      HZ(I)=0.
162   H(I)=0.
      DO 163 I=JJ+1,JJ+M
      HP(I)=HHP(I)
      HZ(I+Q)=HHZ(I)
163   H(I)=HH(I)
      DO 164 I=JJ+M+1,M+2*JJ
      HP(I)=0.
      HZ(I+2*Q)=0.
164   H(I)=0.
      DO 10 I=JJ+1,JJ+(N-1)/2
10    HZ(I)=0.
      DO 11 I=JJ+(N-1)/2+M+1,JJ+M+(N-1)
11    HZ(I)=0.
      M=M+2*JJ
      GO TO 170
165   M=M-2*JJ
      DO 166 I=1,M
166   HH(I)=H(I+JJ)
      DO 167 I=1,M
167   H(I)=HH(I)
      DO 12 I=1,2*JJ+(N-1)+M
12    HZ(I)=0.
170   RETURN
      END
C
C         FFT SUBROUTINE
C
     SUBROUTINE FFT(DATA,NN,ISIGN)
       IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DOUBLE PRECISION DATA,TEMPR,TEMPI,THETA,DSINTH,WR,WI,WSTPR,
     * WSTPI
       DIMENSION DATA(2050)
       INTEGER N,NN,ISIGN
       N=2*NN
       J=1
       DO 5 I=1,N,2
       IF (I.GE.J) GOTO 2
```

```
1       TEMPR=DATA(J)
        TEMPI=DATA(J+1)
        DATA(J)=DATA(I)
        DATA(J+1)=DATA(I+1)
        DATA(I)=TEMPR
        DATA(I+1)=TEMPI
2       M=N/2
3       IF (J.LE.M) GO TO 5
4       J=J-M
        M=M/2
        IF (M.GE.2) GO TO 3
5       J=J+M
        MMAX=2
6       IF (MMAX.GE.N) GO TO 10
7       ISTEP=2*MMAX
        THETA=6.2831853/FLOAT(ISIGN*MMAX)
        DSINTH=DSIN(THETA/2.)
        WSTPR=-2.*DSINTH*DSINTH
        WSTPI=DSIN(THETA)
        WR=1.
        WI=0.
        DO 9 M=1,MMAX,2
        DO 8 I=M,N,ISTEP
        J=I+MMAX
        TEMPR=WR*DATA(J)-WI*DATA(J+1)
        TEMPI=WR*DATA(J+1)+WI*DATA(J)
        DATA(J)=DATA(I)-TEMPR
        DATA(J+1)=DATA(I+1)-TEMPI
        DATA(I)=DATA(I)+TEMPR
8       DATA(I+1)=DATA(I+1)+TEMPI
        TEMPR=WR
        WR=WR*WSTPR-WI*WSTPI+WR
9       WI=WI*WSTPR+TEMPR*WSTPI+WI
        MMAX=ISTEP
        GO TO 6
   10 RETURN
        END
                c   CALCULATE NSF'S FOR SNR'S DESIRED - FOR BOTH ORD. & CONST. NOISE
C
         SUBROUTINE SCFCTR(M,SNRS,SFO,SFC,MAXIM,SLPO,SLPC,NMNSF,H)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
         DIMENSION SNRS(30),SFO(30),SFC(30),H(256)
         REAL*8 MAXIM
         COMMON LRAN
         MAXIM=H(1)
         DO 10 I=2,M
 10      IF (MAXIM.LT.H(I)) MAXIM=H(I)
         HLO=0.
         HLC=0.
```

```
      DO 20 J=1,1000
      HOLDO=0.
      HOLDC=0.
      DO 30 I=1,M
      A=0.
      DO 1 II=1,12
1     A=A+RAN(LRAN)
      HOLDC=HOLDC+(A-6)**2
30    HOLDO=HOLDO+((A-6)*SQRT(H(I)))**2
      HOLDC=SQRT(HOLDC)
      HOLDO=SQRT(HOLDO)
      HLC=HLC+(1/HOLDC)
      HLO=HLO+(1/HOLDO)
20    CONTINUE
      SLPO=(SQRT(FLOAT(M))*MAXIM/1000.)*HLO
      SLPC=(SQRT(FLOAT(M))*MAXIM/1000.)*HLC
      DO 40 I=1,NMNSF
      SFO(I)=(SLPO/SNRS(I))**2
      SFC(I)=(SLPC/SNRS(I))**2
40    CONTINUE
      RETURN
      END
C
            c        ADDS BOTH ORD. & CONST. NOISE
C
      SUBROUTINE BOTH(H,HP,HZ,SFO,SFC,SNR,M,N,OMIX,CMIX,LI,MAXIM,
     *   SCLNS)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION H(256),HP(256),HZ(512),SFO(30),SFC(30)
      REAL*8 MAXIM
      INTEGER Q
      Q=(N-1)/2
      RMS=0.
      DO 230 I=1,M
      SD=SQRT(SFC(LI))*CMIX*SCLNS
      CALL GAUSS(SD,H(I),HP(I))
      SD=SQRT(SFO(LI)*H(I))*OMIX*SCLNS
      IF (H(I).LT.0.0000001) SD=SQRT(SFO(LI)*0.0000001)*OMIX*SCLNS
      CALL GAUSS(SD,HP(I),HP(I))
      IF (HP(I).LT.0) HP(I)=-HP(I)
      HZ(I+Q)=HP(I)
      RMS=RMS+(HP(I)-H(I))**2
230   CONTINUE
      RMS=SQRT(RMS/M)
      IF (RMS.EQ.0) GO TO 235
      SNR=MAXIM/RMS
235   RETURN
      END
C      ORDNOI ADDS ORDINATE DEPENDENT NOISE
C
```

```
      SUBROUTINE ORDNOI(H,HZ,HP,SFO,RMS,SNR,M,N,LI,MAXIM)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION H(256),HZ(256),HP(256),SFO(30)
      REAL*8 MAXIM
      INTEGER Q,L
      Q=(N+1)/2
      RMS=0.
      DO 210 I=1,M
    SD =SQRT( SFO(LI) * H(I))
    IF(H(I).LT..0000001)  SD =SQRT( SFO(LI) * .0000001)
    CALL GAUSS(SD,H(I),HP(I))
      IF (HP(I).LT.0.) HP(I)=-HP(I)
      L=I+Q-1
      HZ(L)=HP(I)
      RMS=(HP(I)-H(I))**2+RMS
210   CONTINUE
      RMS=SQRT(RMS/(M))
      IF (RMS.EQ.0.) GOTO 215
      SNR=MAXIM/RMS
215   RETURN
      END
C
C        CONST ADDS CONSTANT NOISE
C
      SUBROUTINE CONST(H,HZ,HP,SFC,RMS,SNR,M,N,LI,MAXIM)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION H(256),HZ(512),HP(256),SFC(30)
      REAL*8 MAXIM
      INTEGER Q,L
      Q=(N+1)/2
      RMS=0.
      DO 230 I=1,M
    SD=SQRT(SFC(LI))
    CALL GAUSS(SD,H(I),HP(I))
      IF (HP(I).LT.0.) HP(I)=-HP(I)
      L=I+Q-1
      HZ(L)=HP(I)
      RMS=(HP(I)-H(I))**2+RMS
230   CONTINUE
      RMS=SQRT(RMS/(M))
      IF (RMS.EQ.0.) GO TO 235
      SNR=MAXIM/RMS
235   RETURN
      END
C
                c      GAUSS COMPUTES RANDOM NUMBERS
C
```

```
      SUBROUTINE GAUSS(S,AM,V)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON LRAN
      A=0.0
      DO 1 I=1,12
    1 A=A+RAN(LRAN)
      V=(A-6.0)*S + AM
      RETURN
      END
c           OUTPUT
C
       SUBROUTINE OUTPUT(ERR,LI,NM2K,OPTIT,SNRNO2,SVSNR2,GTYP,ANS,
     *    ADDNS,OPTER,ERBFM,ERTRNC,LG1,LG2,DC,ITR,ISC,IDC,SNRS,OMIX,
     *    CMIX,SFO,SFC,SLPO,SLPC,CON,CON1,NEX,IEX)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
       DIMENSION ERR(30,5),SVSNR2(100,30),MXIT(30,2),MNTR(30,2),
     *    AVSNR2(30),ADDNS(30),MXSNR(30),MNSNR(30),SDITNM(30,2),
     *    OPTER(100,30,2),ERBFM(100,30,2),AVERNM(30,2),SDERNM(30,2),
     *    OPTIT(100,30,2),AVITNM(30,2),MNIT(30,2),MXER(30,2),MXTR(30,2),
     *    MNER(30,2),ERTRNC(100,30,2),AVTRER(30,2),SDTRER(30,2),
     *    SDMXTR(30,2),SDMNTR(30,2),SDMXIT(30,2),SDMNIT(30,2),SDER(30,2),
     *    SDMXER(30,2),SDMNER(30,2),SAVSNR(30),AVER(30,2),AVTR(30,2)
       DIMENSION SDTR(30,2),MNR(30,2),MXR(30,2),MNT(30,2),MXT(30,2),
     *    DC(100,30),AVDC(30),SDDC(30),MXDC(30),MNDC(30),NNG(30),NPS(30),
     *    SNRS(30),SFO(30),SFC(30)
       INTEGER SNRNO2,GTYP,ANS,LG1(30,3),LG2(30,3)
       REAL*8 MXSNR,MNSNR,MXER,MNER,MXIT,MNIT,MNTR,MXTR,MNR,MXR,
     *    MNT,MXT,MNDC,MXDC
      IF (ISC.EQ.0) WRITE(35,31)
      IF (ISC.EQ.1) WRITE(35,32)
31    FORMAT(//' POINT SIMULTANEOUS ')
32    FORMAT(//' POINT SUCCESSIVE ')
      IF (ITR.EQ.0) WRITE(35,131)
      IF (ITR.EQ.1) WRITE(35,132)
      IF (IDC.EQ.1) WRITE(35,33)
      IF (IDC.EQ.2) WRITE(35,34)
       IF(IEX.EQ.1)WRITE(35,300)
300    FORMAT(/' EXPANDING RESTORATION, # OF EXPANSIONS-1 =')
       IF(IEX.EQ.1) WRITE(35,70)NEX
131   FORMAT(/' NO TRUNCATION')
132   FORMAT(/' TRUNCATION')
33    FORMAT(/' DECONVOLUTION')
34    FORMAT(/' NOISE REMOVAL ALONE')
c           WRITE(30,10)
       WRITE(35,10)
c           WRITE(36,10)
10     FORMAT(/' G - TYPE '/)
```

```
                c       WRITE(30,70)GTYP
        WRITE(35,70)GTYP
                c       WRITE(36,70)GTYP
                c       WRITE(30,12)
        WRITE(35,12)
                c       WRITE(36,12)
12      FORMAT(/' NOISE - TYPE '/)
                c       WRITE(30,70)ANS
        WRITE(35,70)ANS
                c       WRITE(36,70)ANS
        WRITE(35,301)
301     FORMAT(/' FRACTIONAL DIFFERENCE CRITERION =',$)
        WRITE(35,60)CON
        WRITE(35,302)
302     FORMAT(/' ABSOLUTE DIFFERENCE CRITERION =',$)
        WRITE(35,60)CON1
        WRITE(35,14)
14      FORMAT(///' USING 100 NOISE ADDITIONS '///)
        WRITE(35,2)
2       FORMAT(//18X,'THEO. SNR',8X,'AVESNR',10X,'SDSNR '//)
        WRITE(35,38)(SNRS(I),ERR(I,2),ERR(I,5),I=1,LI)
37
      FORMAT(13X,1PE16.8,4E16.8/)
38      FORMAT(13X,1PE16.8,2E16.8/)
39      FORMAT(13X,1PE16.8,3E16.8/)
40      FORMAT(13X,1PE16.8,7E16.8/)
                c       WRITE(45,60)(ERR(I,1),I=1,LI)
                c       WRITE(46,60)(ERR(I,2),I=1,LI)
        WRITE(35,42)
42      FORMAT(///' TOTAL # OF SNR IN RANGE '//)
        WRITE(35,70)SNRNO2
C
                c   CALC. NEW AVERAGE USING SNR IN GIVEN RANGE AND AVE ITERATION #
                c   CALC. ERROR BEFORE MOR. / ERROR AFTER MOR.
C
        DO 50 I=1,LI
C
                c   PRINT ERROR AFTER MORRIS, BEFORE MORRIS, & TRUNC. ONLY
C
                c       WRITE(36,51)
C51       FORMAT(//' ERROR AFTER MORRIS. '/)
                c       WRITE(36,70)I
                c       WRITE(36,40)(OPTER(J,I,1),J=1,SNRNO2)
                c       WRITE(36,70)I
                c       WRITE(36,40)(OPTER(J,I,2),J=1,SNRNO2)
                c       WRITE(36,20)
C20       FORMAT(//' ERROR BEFORE MORRIS '/)
                c       WRITE(36,70)I
                c       WRITE(36,40)(ERBFM(J,I,1),J=1,SNRNO2)
                c       WRITE(36,70)I
```

```
             c         WRITE(36,40)(ERBFM(J,I,2),J=1,SNRNO2)

             c   CALCULATION OF ACTUAL TRUNC. ERROR
C
        IF (ITR.EQ.0) GO TO 157
             c         WRITE(36,21)
C21      FORMAT(//' ERROR TRUNC. ONLY'/)
             c         WRITE(36,70)I
             c         WRITE(36,40)(ERTRNC(J,I,1),J=1,SNRNO2)
             c         WRITE(36,70)I
             c         WRITE(36,40)(ERTRNC(J,I,2),J=1,SNRNO2)
C
        AVDC(I)=0.
        AVTR(I,1)=0.
        AVTR(I,2)=0.
        SDDC(I)=0.
        SDTR(I,1)=0.
        SDTR(I,2)=0.
        DO 80 J=1,SNRNO2
        AVDC(I)=AVDC(I)+DC(J,I)
        AVTR(I,1)=AVTR(I,1)+ERTRNC(J,I,1)
        AVTR(I,2)=AVTR(I,2)+ERTRNC(J,I,2)
80      CONTINUE
        AVDC(I)=AVDC(I)/SNRNO2
        AVTR(I,1)=AVTR(I,1)/SNRNO2
        AVTR(I,2)=AVTR(I,2)/SNRNO2
        DO 81 J=1,SNRNO2
        D=DC(J,I)-AVDC(I)
        DT1=ERTRNC(J,I,1)-AVTR(I,1)
        DT2=ERTRNC(J,I,2)-AVTR(I,2)
        SDDC(I)=SDDC(I)+D**2
        SDTR(I,1)=SDTR(I,1)+DT1**2
        SDTR(I,2)=SDTR(I,2)+DT2**2
81      CONTINUE
        SDDC(I)=SDDC(I)/SNRNO2
        SDTR(I,1)=SDTR(I,1)/SNRNO2
        SDTR(I,2)=SDTR(I,2)/SNRNO2
        SDDC(I)=SQRT(SDDC(I))
        SDTR(I,1)=SQRT(SDTR(I,1))
        SDTR(I,2)=SQRT(SDTR(I,2))
C
        MNDC(I)=DC(1,I)
        MXDC(I)=DC(1,I)
        MNT(I,1)=ERTRNC(1,I,1)
        MXT(I,1)=ERTRNC(1,I,1)
        MNT(I,2)=ERTRNC(1,I,2)
        MXT(I,2)=ERTRNC(1,I,2)
C
        DO 83 K=2,SNRNO2
        IF (DC(K,I).GE.MXDC(I)) MXDC(I)=DC(K,I)
        IF (DC(K,I).LE.MNDC(I)) MNDC(I)=DC(K,I)
        IF (ERTRNC(K,I,1).GE.MXT(I,1)) MXT(I,1)=ERTRNC(K,I,1)
```

```
      IF (ERTRNC(K,I,1).LE.MNT(I,1)) MNT(I,1)=ERTRNC(K,I,1)
      IF (ERTRNC(K,I,2).GE.MXT(I,2)) MXT(I,2)=ERTRNC(K,I,2)
      IF (ERTRNC(K,I,2).LE.MNT(I,2)) MNT(I,2)=ERTRNC(K,I,2)
83    CONTINUE
C
c     CALCULATE NUMBER OF DC POS. & NEG.
C
      NNG(I)=0
      NPS(I)=0
      DO 156 J=1,SNRNO2
      IF (DC(J,I).LT.0) NNG(I)=NNG(I)+1
      IF (DC(J,I).GE.0) NPS(I)=NPS(I)+1
156   CONTINUE
      AVTRER(I,1)=0.
      AVTRER(I,2)=0.
      DO 84 J=1,SNRNO2
      ERTRNC(J,I,1)=ERTRNC(J,I,1)/ERBFM(J,I,1)
      ERTRNC(J,I,2)=ERTRNC(J,I,2)/ERBFM(J,I,2)
      AVTRER(I,1)=AVTRER(I,1)+ERTRNC(J,I,1)
      AVTRER(I,2)=AVTRER(I,2)+ERTRNC(J,I,2)
84    CONTINUE
c         WRITE(36,22)
C22    FORMAT(//' ERROR TRUNC. ONLY / ERROR BEFORE MORRIS.'/)
c         WRITE(36,70)I
c         WRITE(36,40)(ERTRNC(J,I,1),J=1,SNRNO2)
c         WRITE(36,70)I
c         WRITE(36,40)(ERTRNC(J,I,2),J=1,SNRNO2)
C
      AVTRER(I,1)=AVTRER(I,1)/SNRNO2
      AVTRER(I,2)=AVTRER(I,2)/SNRNO2
C
c     CALC. SD OF AVERAGE ITERATION NUMBER & SD OF ERROR
C
      SDTRER(I,1)=0.
      SDTRER(I,2)=0.
      DO 85 J=1,SNRNO2
      DFF1=ERTRNC(J,I,1)-AVTRER(I,1)
      DFF2=ERTRNC(J,I,2)-AVTRER(I,2)
      SDTRER(I,1)=SDTRER(I,1)+DFF1**2
      SDTRER(I,2)=SDTRER(I,2)+DFF2**2
85    CONTINUE
      SDTRER(I,1)=SDTRER(I,1)/SNRNO2
      SDTRER(I,2)=SDTRER(I,2)/SNRNO2
      SDTRER(I,1)=SQRT(SDTRER(I,1))
      SDTRER(I,2)=SQRT(SDTRER(I,2))
      MNTR(I,1)=ERTRNC(1,I,1)
      MXTR(I,1)=ERTRNC(1,I,1)
      MNTR(I,2)=ERTRNC(1,I,2)
      MXTR(I,2)=ERTRNC(1,I,2)
      DO 86 K=2,SNRNO2
      IF (ERTRNC(K,I,1).GE.MXTR(I,1)) MXTR(I,1)=ERTRNC(K,I,1)
      IF (ERTRNC(K,I,1).LE.MNTR(I,1)) MNTR(I,1)=ERTRNC(K,I,1)
L
```

```
      IF (ERTRNC(K,I,2).GE.MXTR(I,2)) MXTR(I,2)=ERTRNC(K,I,2)
      IF (ERTRNC(K,I,2).LE.MNTR(I,2)) MNTR(I,2)=ERTRNC(K,I,2)
86    CONTINUE
C
C
            c   CALCULATION OF ACTUAL ERROR
C
157   AVER(I,1)=0.
      AVER(I,2)=0.
      SDER(I,1)=0.
      SDER(I,2)=0.
      DO 147 J=1,SNRNO2
      AVER(I,1)=AVER(I,1)+OPTER(J,I,1)
      AVER(I,2)=AVER(I,2)+OPTER(J,I,2)
147   CONTINUE
      AVER(I,1)=AVER(I,1)/SNRNO2
      AVER(I,2)=AVER(I,2)/SNRNO2
      DO 145 J=1,SNRNO2
      D1=OPTER(J,I,1)-AVER(I,1)
      D2=OPTER(J,I,2)-AVER(I,2)
      SDER(I,1)=SDER(I,1)+D1**2
      SDER(I,2)=SDER(I,2)+D2**2
145   CONTINUE
      SDER(I,1)=SDER(I,1)/SNRNO2
      SDER(I,2)=SDER(I,2)/SNRNO2
      SDER(I,1)=SQRT(SDER(I,1))
      SDER(I,2)=SQRT(SDER(I,2))
C
      MNR(I,1)=OPTER(1,I,1)
      MXR(I,1)=OPTER(1,I,1)
      MNR(I,2)=OPTER(1,I,2)
      MXR(I,2)=OPTER(1,I,2)
C
      DO 155 K=2,SNRNO2
      IF (OPTER(K,I,1).GE.MXR(I,1)) MXR(I,1)=OPTER(K,I,1)
      IF (OPTER(K,I,1).LE.MNR(I,1)) MNR(I,1)=OPTER(K,I,1)
      IF (OPTER(K,I,2).GE.MXR(I,2)) MXR(I,2)=OPTER(K,I,2)
      IF (OPTER(K,I,2).LE.MNR(I,2)) MNR(I,2)=OPTER(K,I,2)
155   CONTINUE
      AVSNR2(I)=0.
      AVITNM(I,1)=0.
      AVITNM(I,2)=0.
      AVERNM(I,1)=0.
      AVERNM(I,2)=0.
      DO 47 J=1,SNRNO2
      OPTER(J,I,1)=(OPTER(J,I,1)/ERBFM(J,I,1))
      OPTER(J,I,2)=(OPTER(J,I,2)/ERBFM(J,I,2))
      AVSNR2(I)=AVSNR2(I)+SVSNR2(J,I)
```

```
              AVITNM(I,1)=AVITNM(I,1)+OPTIT(J,I,1)
              AVITNM(I,2)=AVITNM(I,2)+OPTIT(J,I,2)
              AVERNM(I,1)=AVERNM(I,1)+OPTER(J,I,1)
              AVERNM(I,2)=AVERNM(I,2)+OPTER(J,I,2)
47            CONTINUE
C
              AVSNR2(I)=AVSNR2(I)/SNRNO2
              AVITNM(I,1)=AVITNM(I,1)/SNRNO2
              AVITNM(I,2)=AVITNM(I,2)/SNRNO2
              AVERNM(I,1)=AVERNM(I,1)/SNRNO2
              AVERNM(I,2)=AVERNM(I,2)/SNRNO2
C
              c   CALC. SD OF AVERAGE ITERATION NUMBER & SD OF ERROR
C
              SDITNM(I,1)=0.
              SDITNM(I,2)=0.
              SDERNM(I,1)=0.
              SDERNM(I,2)=0.
              DO 45 J=1,SNRNO2
              DIF1=OPTIT(J,I,1)-AVITNM(I,1)
              DIF2=OPTIT(J,I,2)-AVITNM(I,2)
              DF1=OPTER(J,I,1)-AVERNM(I,1)
              DF2=OPTER(J,I,2)-AVERNM(I,2)
              SDERNM(I,1)=SDERNM(I,1)+DF1**2
              SDERNM(I,2)=SDERNM(I,2)+DF2**2
              SDITNM(I,1)=SDITNM(I,1)+DIF1**2
              SDITNM(I,2)=SDITNM(I,2)+DIF2**2
45            CONTINUE
              SDITNM(I,1)=SDITNM(I,1)/SNRNO2
              SDITNM(I,2)=SDITNM(I,2)/SNRNO2
              SDERNM(I,1)=SDERNM(I,1)/SNRNO2
              SDERNM(I,2)=SDERNM(I,2)/SNRNO2
              SDERNM(I,1)=SQRT(SDERNM(I,1))
              SDERNM(I,2)=SQRT(SDERNM(I,2))
              SDITNM(I,1)=SQRT(SDITNM(I,1))
              SDITNM(I,2)=SQRT(SDITNM(I,2))
C
              c   OUTPUT AVESNR & SNR'S IN +/- RANGE
C
                      c          WRITE(30,210)
C210           FORMAT(///' AVESNR FOR SNRNO2 '//)
                      c          WRITE(30,40)AVSNR2(I)
                      c          WRITE(30,46)
C46            FORMAT(///' SNR S IM +/- .5SD RANGE '//)
                      c          WRITE(30,40)(SVSNR2(K,I),K=1,SNRNO2)
C
              c   CALC. MAX & MIN OF SNRNO2 SNR'S, OPTIT'S & OPTER'S IN RANGE
C
              MXSNR(I)=SVSNR2(1,I)
```

```
      MNSNR(I)=SVSNR2(1,I)
      MXIT(I,1)=OPTIT(1,I,1)
      MNIT(I,1)=OPTIT(1,I,1)
      MXIT(I,2)=OPTIT(1,I,2)
      MNIT(I,2)=OPTIT(1,I,2)
      MXER(I,1)=OPTER(1,I,1)
      MNER(I,1)=OPTER(1,I,1)
      MXER(I,2)=OPTER(1,I,2)
      MNER(I,2)=OPTER(1,I,2)
      DO 55 K=2,SNRNO2
      IF (SVSNR2(K,I).GE.MXSNR(I))MXSNR(I)=SVSNR2(K,I)
      IF (SVSNR2(K,I).LE.MNSNR(I))MNSNR(I)=SVSNR2(K,I)
      IF (OPTIT(K,I,1).GE.MXIT(I,1)) MXIT(I,1)=OPTIT(K,I,1)
      IF (OPTIT(K,I,1).LE.MNIT(I,1)) MNIT(I,1)=OPTIT(K,I,1)
      IF (OPTIT(K,I,2).GE.MXIT(I,2)) MXIT(I,2)=OPTIT(K,I,2)
      IF (OPTIT(K,I,2).LE.MNIT(I,2)) MNIT(I,2)=OPTIT(K,I,2)
      IF (OPTER(K,I,1).GE.MXER(I,1)) MXER(I,1)=OPTER(K,I,1)
      IF (OPTER(K,I,1).LE.MNER(I,1)) MNER(I,1)=OPTER(K,I,1)
      IF (OPTER(K,I,2).GE.MXER(I,2)) MXER(I,2)=OPTER(K,I,2)
      IF (OPTER(K,I,2).LE.MNER(I,2)) MNER(I,2)=OPTER(K,I,2)
55    CONTINUE
50    CONTINUE
C
C
C
      WRITE(35,72)
72    FORMAT(///' NUMBER OF AVERAGE SNR"S '//)
      WRITE(35,70)LI
      WRITE(35,270)
270   FORMAT(4X,' THEO. ORD. SLOPE',4X,'THEO. CON. SLOPE',6X,
     *   'OMIX',12X,'CMIX'//)
      WRITE(35,139)SLPO,SLPC,OMIX,CMIX
139   FORMAT(4X,1PE16.8,4X,3(1PE16.8))
      WRITE(35,271)
271   FORMAT(///6X,'ORD. NSF',6X,'CONST. NSF'//)
      WRITE(35,272)(SFO(I),SFC(I),I=1,LI)
272   FORMAT(2(1PE16.8))
      WRITE(35,79)
77    FORMAT(///' NEW AVE USING SNR IN +/-.5SD RANGE '//)
      WRITE(35,79)
      WRITE(35,87)
87    FORMAT(/18X,'THEO. SNR',8X,'AVSNR2',11X,'MAXSNR',11X,'MINSNR',
     *   11X,'# NS ADD'//)
      WRITE(35,37)(SNRS(I),AVSNR2(I),MXSNR(I),MNSNR(I),
     *   ADDNS(I),I=1,LI)
      WRITE(35,79)
79    FORMAT('1')
      WRITE(35,74)
74    FORMAT(///' OPT. ITER. # - SD - MAX & MIN - FOR # OF SNR '//)
```

```
      WRITE(35,75)
75    FORMAT(/18X,'AVSNR2',8X,'ITERATION1#',7X,'IT1SD',7X,
     *   'ITERATION2#',6X,'IT2SD'//)
      WRITE(35,37)(AVSNR2(I),AVITNM(I,1),SDITNM(I,1),AVITNM(I,2),
     *   SDITNM(I,2),I=1,LI)
      WRITE(35,79)
      WRITE(35,165)
165   FORMAT(///18X,'AVE ITER #1'[B,5X,'MIN ITER#1',6X,'MAX ITER#1',
     *   5X,'AVE ITER #2',5X,'MIN ITER#2',6X,'MAX ITER#2'//)
      WRITE(35,177)(AVITNM(I,1),MNIT(I,1),MXIT(I,1),AVITNM(I,2),
     *   MNIT(I,2),MXIT(I,2),I=1,LI)
      WRITE(35,79)
      WRITE(35,76)
76    FORMAT(///' ERROR 1 & 2 AT OPTIMUM ITERATION '//)
      WRITE(35,176)
176   FORMAT(/18X,'AVSNR2',10X,'ERROR #1',8X,'SD ERR1',8X,
     *   'ERROR #2',8X,'SD ERR2'//)
      WRITE(35,37)(AVSNR2(I),AVERNM(I,1),SDERNM(I,1),AVERNM(I,2),
     *   SDERNM(I,2),I=1,LI)
      WRITE(35,79)
      WRITE(35,178)
178   FORMAT(///18X,'ERROR #1',7X,'MIN ERR1',8X,'MAX ERR1',8X,
     *   'ERROR #2',7X,'MIN ERR2',8X,'MAX ERR2'//)
      WRITE(35,177)(AVERNM(I,1),MNER(I,1),MXER(I,1),AVERNM(I,2),
     *   MNER(I,2),MXER(I,2),I=1,LI)
177   FORMAT(13X,1PE16.8,5E16.8/)
      WRITE(35,79)
      WRITE(35,190)
190   FORMAT(///18X,'AVSNR2',8X,'AVER  #1',9X,'SDER #1',8X,'AVER  #2',
     *   8X,'SDER #2'//)
      WRITE(35,37)(AVSNR2(I),AVER(I,1),SDER(I,1),AVER(I,2),SDER(I,2),
     *   I=1,LI)
      WRITE(35,79)
      WRITE(35,192)
192   FORMAT(///18X,'MIN ERR1',7X,'MAX ERR1',8X,'MIN ERR2',8X,
     *   'MAX ERR2'//)
      WRITE(35,39)(MNR(I,1),MXR(I,1),MNR(I,2),MXR(I,2),I=1,LI)
      WRITE(35,79)
      WRITE(35,197)
197   FORMAT(///1X,'# OF TIMES CON. CRITERION ARE MET;CON=FRAC. DIF.
     *   - CON1=ABS. DIF. ')
      WRITE(35,198)
198   FORMAT(///18X,'AVSNR2',10X,'L1-CON',4X,'L1-CON1',3X,'L1BOTH',
     *   4X,'L2-CON',4X,'L2-CON1',3X,'L2BOTH'//)
      WRITE(35,200)(AVSNR2(I),LG1(I,1),LG1(I,2),LG1(I,3),LG2(I,1),
     *   LG2(I,2),LG2(I,3),I=1,LI)
200   FORMAT(1PE16.8,6I10)
C
C
```

```
      IF (ITR.EQ.0) GO TO 205
      WRITE(35,180)
180   FORMAT(///7X,'AVSNR2',8X,'AVTRER#1',9X,'SDTRER1',8X,
     *   'AVTRER#2',8X,'SDTRER2'//)
      WRITE(35,37)(AVSNR2(I),AVTRER(I,1),SDTRER(I,1),AVTRER(I,2),
     *   SDTRER(I,2),I=1,LI)
      WRITE(35,182)
182   FORMAT(///6X,'AVTRER#1',7X,'MIN ERR1',8X,'MAX ERR1',8X,
     *   'AVTRER#2',7X,'MIN ERR2',8X,'MAX ERR2'//)
      WRITE(35,177)(AVTRER(I,1),MNTR(I,1),MXTR(I,1),AVTRER(I,2),
     *   MNTR(I,2),MXTR(I,2),I=1,LI)
      WRITE(35,194)
194   FORMAT(///7X,'AVSNR2',8X,'AVTR  #1',9X,'SDTR #1',8X,'AVTR  #2',
     *   8X,'SDTR #2'//)
      WRITE(35,37)(AVSNR2(I),AVTR(I,1),SDTR(I,1),AVTR(I,2),SDTR(I,2),
     *   I=1,LI)
      WRITE(35,196)
196   FORMAT(///6X,'MIN ERR1',7X,'MAX ERR1',8X,'MIN ERR2',8X,
     *   'MAX ERR2'//)
      WRITE(35,39)(MNT(I,1),MXT(I,1),MNT(I,2),MXT(I,2),I=1,LI)
      WRITE(35,201)
201   FORMAT(///7X,'AVSNR2',10X,'AVDC',12X,'SDDC',12X,'MNDC',12X,
     *   'MXDC'//)
      WRITE(35,37)(AVSNR2(I),AVDC(I),SDDC(I),MNDC(I),MXDC(I),I=1,LI)
      WRITE(35,202)
202   FORMAT(///7X,'AVSNR2',15X,'POS.  DC',8X,'NEG.  DC'//)
      WRITE(35,203)(AVSNR2(I),NPS(I),NNG(I),I=1,LI)
203   FORMAT(1PE16.8,2I16)
C
      CLOSE(UNIT=35)
C
      DO 88 I=1,LI
      SDMXTR(I,1)=AVTRER(I,1)+SDTRER(I,1)
      SDMXTR(I,2)=AVTRER(I,2)+SDTRER(I,2)
      SDMNTR(I,1)=AVTRER(I,1)-SDTRER(I,1)
      SDMNTR(I,2)=AVTRER(I,2)-SDTRER(I,2)
      88       CONTINUE
      WRITE(48,61)(MNSNR(I),AVTRER(I,1),I=1,LI)
      WRITE(49,61)(MNSNR(I),AVTRER(I,2),I=1,LI)
      WRITE(50,61)(MXSNR(I),AVTRER(I,1),I=1,LI)
      WRITE(51,61)(MXSNR(I),AVTRER(I,2),I=1,LI)
205    CLOSE(UNIT=35)
C
                c   CALCULATE ITT # & ERROR (+ & -) SD
C
      DO 90 I=1,LI
      SDMXIT(I,1)=AVITNM(I,1)+SDITNM(I,1)
      SDMXIT(I,2)=AVITNM(I,2)+SDITNM(I,2)
      SDMNIT(I,1)=AVITNM(I,1)-SDITNM(I,1)
```

```
      SDMNIT(I,2)=AVITNM(I,2)-SDITNM(I,2)
      SDMXER(I,1)=AVERNM(I,1)+SDERNM(I,1)
      SDMXER(I,2)=AVERNM(I,2)+SDERNM(I,2)
      SDMNER(I,1)=AVERNM(I,1)-SDERNM(I,1)
      SDMNER(I,2)=AVERNM(I,2)-SDERNM(I,2)
90    CONTINUE
C
c     PLOT OF ITERATION # & ERROR VS SNR, MAX & MIN OF SNR
C
      WRITE(40,61)(MNSNR(I),AVERNM(I,1),I=1,LI)
      WRITE(41,61)(MNSNR(I),AVERNM(I,2),I=1,LI)
      WRITE(42,61)(MXSNR(I),AVERNM(I,1),I=1,LI)
      WRITE(43,61)(MXSNR(I),AVERNM(I,2),I=1,LI)
      WRITE(44,61)(MNSNR(I),AVITNM(I,1),I=1,LI)
      WRITE(45,61)(MNSNR(I),AVITNM(I,2),I=1,LI)
      WRITE(46,61)(MXSNR(I),AVITNM(I,1),I=1,LI)
      WRITE(47,61)(MXSNR(I),AVITNM(I,2),I=1,LI)
C
C
c     PLOT AVERAGE ITT# VS LN(AVSNR2) & ITT SD'S & LN(MX-MN SNR)
C
       DO 95 I=1,LI
       SAVSNR(I)=AVSNR2(I)
       AVSNR2(I)=DLOG(AVSNR2(I))
       MXSNR(I)=DLOG(MXSNR(I))
       MNSNR(I)=DLOG(MNSNR(I))
95     CONTINUE
C
C
      IF (ITR.EQ.0) GO TO 206
C
      WRITE(48,61)(MNSNR(I),AVTRER(I,1),I=1,LI)
      WRITE(49,61)(MNSNR(I),AVTRER(I,2),I=1,LI)
      WRITE(50,61)(MXSNR(I),AVTRER(I,1),I=1,LI)
      WRITE(51,61)(MXSNR(I),AVTRER(I,2),I=1,LI)
       CLOSE(UNIT=48)
       CLOSE(UNIT=49)
       CLOSE(UNIT=50)
       CLOSE(UNIT=51)
C
C
c     PLOT OF ITERATION #, & ERROR VS SNR
C
      WRITE(54,61)(SAVSNR(I),AVTRER(I,1),I=1,LI)
      WRITE(55,61)(SAVSNR(I),AVTRER(I,2),I=1,LI)
C
c          PLOT AVERAGE ERROR & ITERATION VS. LN(SNR)
       WRITE(17,61)(AVSNR2(I),AVTRER(I,1),I=1,LI)
       WRITE(18,61)(AVSNR2(I),AVTRER(I,2),I=1,LI)
```

```
C
      CLOSE(UNIT=54)
      CLOSE(UNIT=55)
C
      WRITE(26,61)(AVSNR2(I),SDMXTR(I,1),I=1,LI)
      WRITE(27,61)(AVSNR2(I),SDMXTR(I,2),I=1,LI)
      WRITE(28,61)(AVSNR2(I),SDMNTR(I,1),I=1,LI)
      WRITE(29,61)(AVSNR2(I),SDMNTR(I,2),I=1,LI)
206   WRITE(75,61)(MNSNR(I),AVERNM(I,1),I=1,LI)
      WRITE(76,61)(MNSNR(I),AVERNM(I,2),I=1,LI)
      WRITE(77,61)(MXSNR(I),AVERNM(I,1),I=1,LI)
      WRITE(78,61)(MXSNR(I),AVERNM(I,2),I=1,LI)
      WRITE(79,61)(MNSNR(I),AVITNM(I,1),I=1,LI)
      WRITE(81,61)(MNSNR(I),AVITNM(I,2),I=1,LI)
      WRITE(82,61)(MXSNR(I),AVITNM(I,1),I=1,LI)
      WRITE(83,61)(MXSNR(I),AVITNM(I,2),I=1,LI)
C
      c   CLOSE FILES
C
      CLOSE(UNIT=40)
      CLOSE(UNIT=41)
      CLOSE(UNIT=42)
      CLOSE(UNIT=43)
      CLOSE(UNIT=44)
      CLOSE(UNIT=45)
      CLOSE(UNIT=46)
      CLOSE(UNIT=47)
C
C
              c   PLOT OF ITERATION #, & ERROR VS SNR
C
      WRITE(56,61)(SAVSNR(I),AVERNM(I,1),I=1,LI)
      WRITE(57,61)(SAVSNR(I),AVERNM(I,2),I=1,LI)
      WRITE(58,61)(SAVSNR(I),AVITNM(I,1),I=1,LI)
      WRITE(59,61)(SAVSNR(I),AVITNM(I,2),I=1,LI)
C
              c      PLOT AVERAGE ERROR & ITERATION VS. LN(SNR)
C
      WRITE(85,61)(AVSNR2(I),AVERNM(I,1),I=1,LI)
      WRITE(86,61)(AVSNR2(I),AVERNM(I,2),I=1,LI)
      WRITE(87,61)(AVSNR2(I),AVITNM(I,1),I=1,LI)
      WRITE(88,61)(AVSNR2(I),AVITNM(I,2),I=1,LI)
C
      CLOSE(UNIT=56)
      CLOSE(UNIT=57)
      CLOSE(UNIT=58)
      CLOSE(UNIT=59)
C
      WRITE(33,61)(AVSNR2(I),SDMXER(I,1),I=1,LI)
      WRITE(34,61)(AVSNR2(I),SDMXER(I,2),I=1,LI)
```

```
            WRITE(37,61)(AVSNR2(I),SDMNER(I,1),I=1,LI)
            WRITE(30,61)(AVSNR2(I),SDMNER(I,2),I=1,LI)
            WRITE(60,61)(AVSNR2(I),SDMXIT(I,1),I=1,LI)
            WRITE(61,61)(AVSNR2(I),SDMXIT(I,2),I=1,LI)
            WRITE(62,61)(AVSNR2(I),SDMNIT(I,1),I=1,LI)
            WRITE(63,61)(AVSNR2(I),SDMNIT(I,2),I=1,LI)
C          c   PRINT OUT OPTIT 1 & 2 AND OPTER 1 & 2
C
                      c         DO 400 I=1,LI
                      c         WRITE(36,52)
C52          FORMAT(//' OPTIMUM ITERATION NUMBER '/)
                      c         WRITE(36,70)I
                      c         WRITE(36,40)(OPTIT(J,I,1),J=1,SNRNO2)
                      c         WRITE(36,70)I
                      c         WRITE(36,40)(OPTIT(J,I,2),J=1,SNRNO2)
                      c         WRITE(36,53)
C53          FORMAT(//' ERROR BEFORE MORRIS / ERROR AFTER MORRIS '/)
                      c         WRITE(36,70)I
                      c         WRITE(36,40)(OPTER(J,I,1),J=1,SNRNO2)
                      c         WRITE(36,70)I
                      c         WRITE(36,40)(OPTER(J,I,2),J=1,SNRNO2)
C400          CONTINUE
C
78          FORMAT(2(1PE16.8))
60          FORMAT(G)
61          FORMAT(2G)
                      c         TYPE 73
C73          FORMAT(' NUMBER OF AVERAGE SNR"S '//)
            TYPE 70,LI
70          FORMAT(I)
            RETURN
            END
```

Vita

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OPTIMIZATION OF CONVERGENT ITERATIVE NOISE REMOVAL AND DECONVOLUTION AND AN EVALUATION OF PHASE-SHIFT MIGRATION

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TABLE OF CONTENTS

Acknowledgments....ii

Table of Content....iii

List of Figures....vi

List of Tables....xi

Abstract....xiii

Chapter 1 Introduction....1

Chapter 2 Theoretical Background....5

2.1 Introduction....5

2.2 The Fourier Transform And a Related Theorem...6

2.3 Convolution And Deconvolution....8

2.3.1 Convolution....8

2.3.2 Deconvolution....11

2.4 Basic Iterative Deconvolution Techniques.....16

2.4.1 van Cittert's Method....17

2.4.2 Convergence Criteria For van Cittert's Method....19

2.4.3 Point Successive And Point Simultaneous Approaches....20

2.4.4 Always-Convergent Method of Ioup....21

2.4.5 Reblurring Procedure of Kawata And Ichioka...23

2.5 Noise....27

2.5.1 Morrison's Method of Noise Removal....30

2.5.2 Always-Convergent and Reblurring Procedure Applied to Morrison's Method....33

Chapter 3	Seismic Data	41
3.1	Introduction	41
3.2	Discussion of The Data	43
3.3	Method	44
3.4	Results	47
3.4.1	Always-Convergent Technique	47
3.4.2	Reblurring Procedure And Least Squares	49
3.6	Conclusion	51
Chapter 4	Gaussian Data	94
4.1	Introduction	94
4.2	Discussion of Data	96
4.3	Results	99
4.3.1	The Narrow Gaussian	99
4.3.2	The Wide Gaussian	102
4.4	Conclusion	105
Chapter 5	Phase-Shift Method of Migration	166
5.1	Introduction	166
5.2	Theoretical Background	172
5.3	Programming Considerations	175
5.3.1	Migration Program	175
5.3.2	Modeling Program	176
5.3	Results	178
5.5	Conclusion	179
Deconvolution References		188

Migration References....................................191
Appendix A Seismic 192
Appendix B Narrow Gaussian..............................294
Appendix C Wide Gaussian................................377
Appendix D Migration....................................432
Vita..441

LIST OF FIGURES

Fig. Page

(2.1) : The Convolution Integral 35

(2.2) : Convolution Operation, Transform Domain......36

(2.3) : Principal Solution...........................37

(2.4) : Effect of Noise..............................38

(2.5) : Convergence Conditions.......................39

(2.6) : Gaussian Distributed Noise...................40

Seismic

(3.1) : Input, f.....................................52

(3.2) : Impulse Response, g..........................53

(3.3) : f Convolved With g...........................54

(3.4) : MSE vs SNR...................................55

(3.5) : MSE vs SNR Sm=0..............................56

(3.6) : Figs. 3.4 And 3.5 Together...................57

(3.7) : Fig. 3.6 Overlap.............................58

(3.8) : Fig. 3.6 Without Standard Deviation..........59

(3.9) : Unfolding Iteration Number vs SNR............60

(3.10): Unfolding Iteration Number vs SNR SM=0.......61

(3.11): Figs. 3.9 And 3.10 Together..................62

(3.12): Smoothing Iteration Number vs SNR............63

(3.13): Deconvolved Result, Noise Free...............64

(3.14): Noisy Data SNR=10............................65

(3.15): Smoothed Data SNR=10.........................66

(3.16): Deconvolved Result SNR=10 Sm=0 67

(3.17): Deconvolved Result SNR=10 68

(3.18): Noisy Data SNR=40 69

(3.19): Smoothed Data SNR=40 70

(3.20): Deconvolved Result SNR=40 Sm=0 71

(3.21): Deconvolved Result SNR=40 72

(3.22): Noisy Data SNR=147 73

(3.23): Deconvolved Result SNR=147 Sm=0 74

RB-Seismic

(3.24): MSE vs SNR 75

(3.25): Unfolding Iteration Number vs SNR 76

(3.26): Deconvolution Result, Noise free 77

(3.27): Deconvolution Result SNR=10 78

(3.28): Deconvolution Result SNR=40 79

(3.29): Deconvolution Result SNR=150 80

LS-Seismic

(3.30): MSE vs SNR 81

(3.31): Deconvolution Result, Noise free 82

(3.32): Deconvolution Result SNR=10 83

(3.33): Deconvolution Result SNR=40 84

(3.34): Deconvolution Result SNR=150 85

AC-Narrow Gaussian

(4.1) : Input, f 106

(4.2) : Impulse Response, g....................107

(4.3) : f Convolved With g....................108

(4.4) : MSE vs SNR....................109

(4.5) : Ln(MSE) vs Ln(SNR)....................110

(4.6) : Ln(MSE) vs Ln(SNR) Sm=0....................111

(4.7) : Figs. 4.5 And 4.6 Together....................112

(4.8) : Fig. 4.7 Without Standard Deviation........113

(4.9) : Unfolding Iteration Number vs SNR..........114

(4.10): Unfolding Iteration Number vs SNR Sm=0.....115

(4.11): Figs. 4.9 And 4.10 Together................116

(4.12): Fig. 4.11 Without Standard Deviation.......117

(4.13): Smoothing Iteration Number vs SNR..........118

(4.14): Deconvolved Result Noise Free..............119

(4.15): Noisy Data SNR=11....................120

(4.16): Smoothed Data SNR=11....................121

(4.17): Deconvolve Result SNR=11 Sm=0..............122

(4.18): Deconvolved Result SNR=11..................123

(4.19): Noisy Data SNR=36....................124

(4.20): Smoothed Data SNR=36....................125

(4.21): Deconvolved Result SNR=36 Sm=0.............126

(4.22): Deconvolved Result SNR=36..................127

(4.23): Noisy Data SNR=135....................128

(4.24): Smoothed Data SNR=135....................129

(4.25): Deconvolved Result SNR=135 Sm=0............130

(4.26): Deconvolved Result SNR=135.................131

AC-Wide Gaussian

(4.27) : Impulse Response, g 132

(4.28) : f Convolved With g 133

(4.29) : MSE vs Ln(SNR) 134

(4.30) : MSE vs Ln(SNR) Sm=0 135

(4.31) : Figs. 4.30 And 4.31 Together 136

(4.32) : Fig. 4.32 Without Standard Deviation 137

(4.33) : Unfolding Iteration Number vs SNR 138

(4.34): Unfolding Iteration Number vs SNR SM=0 139

(4.35): Figs. 4.34 And 4.35 Together 140

(4.36): Fig. 4.36 Without Standard Deviation 141

(4.37): Smoothing Iteration Number vs SNR 142

(4.38): Deconvolved Result, Noise Free 143

(4.39): Noisy Data SNR=10 144

(4.40): Smoothed Data SNR=10 145

(4.41): Deconvolved Result SNR=10 Sm=0 146

(4.42): Deconvolved Result SNR=10 147

(4.43): Noisy Data SNR=43 148

(4.44): Smoothed Data SNR=43 149

(4.45): Deconvolved Result SNR=43 Sm=0 150

(4.46): Deconvolved Result SNR=43 151

(4.47): Noisy Data SNR=155 152

(4.48): Smoothed Data SNR=155 153

(4.49): Deconvolved Result SNR=155 Sm=0 154

(4.50): Deconvolved Result SNR=155 155

Migration

(5.1) : The Original Spike 181

(5.2) : A Migrated Spike....................................182

(5.3) : 5.1 Migrated...183

(5.4) : Velocity And Migration..........................184

(5.5) : A Modeled Spike.......................................185

(5.6) : 5.5 With Increase In Space Sampling 186

(5.7) : Migrated Spike Using Stolt's Method.......187

LIST OF TABLES

Table		Page
	AC-Seismic	
(3.1)	: Average MSE	86
(3.2)	: Average Unfolding Iteration Number	87
(3.3)	: Average Smoothing Iteration Number	88
(3.4)	: Average MSE Without Smoothing	89
(3.5)	: Average Unfolding Without Smoothing	90
	RB-Seismic	
(3.6)	: Average MSE	91
(3.7)	: Average Unfolding Iteration Number	92
	LS-Seismic	
(3.8)	: MSE	93
(3.9)	: Average MSE	93
	AC-Narrow Gaussian	
(4.1)	: Average MSE	156
(4.2)	: Average Unfolding Iteration Number	157
(4.3)	: Average Smoothing Iteration Number	158
(4.4)	: Average MSE Without Smoothing	159
(4.5)	: Average Unfolding Without Smoothing	160

AC-Wide Gaussian

(4.6) : Average MSE 161

(4.7) : Average Unfolding Iteration Number 162

(4.8) : Average Smoothing Iteration Number 163

(4.9) : Average MSE Without Smoothing 164

(4.10): Average Unfolding Without Smoothing 165

ABSTRACT

Noise removal and deconvolution are often considered to be a necessity for data processing work. There are many methods of deconvolution and noise removal available Among those are the iterative methods.

The iterative method used for this research is primarily the always-convergent method of Ioup (AC), which includes noise removal and deconvolution iterations. It has been optimized for Gaussian response functions and a seismic wavelet. In addition to the AC method, the reblurring procedure of Kawata and Ichioka (RB), and least squares inverse filtering (LS) have also been used for seismic data. No noise removal method is used prior to unfolding when working with the RB and LS methods. The deconvolution performance by the AC and RB methods (at the optimum iteration number) is compared to the LS performance for SNR's (signal-to-noise ratios) of 10 , 40, and 150. The AC method is also optimized for the wide Guassian, SNR's of 24, 43,55,....,155 and 11,23,36,....,754 for the narrow Gaussian.

Deconvolution is one data analysis technique used in reflection seismology; another is migration.In this thesis the phase-shift method of migration and modeling is evaluated and the results are compared to Stolt's approach.

A single spike is fed into the phase-shift modeling and migration methods; a hyperbola and a half circle are obtained, respectively.

This thesis introduces a method by which one can find the optimum iteration number for deconvolution of sampled data. The method employs the mean squared error (MSE), the square of the difference between the deconvolved result and the input, for optimization. The MSE decreases as the deconvolution iterations proceed, but at the optimum iteration number, it starts to increase. The research is carried out for three types of data: (1) seismic, (2) narrow Gaussian (fast convergence), (3) wide Gaussian (slow convercent).

This procedure can be repeated for various signal-to-noise ratio (SNR) data sets to obtain plots of deconvolution and noise removal iteration number vs SNR. By knowing the SNR one can find the optimum iteration number from the plots, and therefore the application of an equivalent window becomes feasible.

CHAPTER 1

INTRODUCTION

Whenever a set of data is obtained from a recording instrument or system, one should consider deconvolution as a method for recovering the original data or for enhancement of the results. The actual input data can be profoundly affected by the spreading and blurring caused by the instrument being used. The recovery of the spectrum as it would be observed by a hypothetical, perfectly resolving instrument is an exciting goal. Deconvolution is an approach to undo the damage inflicted by instrumental or other distortions.

The primary purpose of this research is to introduce a methodology in which convergent iterative noise removal and deconvolution are optimized. It is called a methodology since from one data type to another the optimized quantities (noise removal and deconvolution iterations number) can be different.

Although the iterative method of deconvolution and noise removal perform much better for very noisy data than least squares inverse filtering (LS), they are not generally considered as being usable in a production environment.The main reason for not using the iterative methods is the computer time required to achieve an optimum deconvolution.

In the transform domain the iterative methods can be replaced by their equivalent windows. The window transfer function is obtained by successive substitution of the iterations in the transform domain. The use of an equivalent window is also known as one-shot deconvolution. Using the equivalent window solves the computer time problem, but one must know the optimum iteration number. See Chapter 2, Section 2.4.4, for the window expression.

Once these optimum quantities are found for a particular sample of data (seismic, Gaussian, etc......), they can be used for deconvolution by either an equivalent window in the transform domain or iteratively in the time or function domain.

The convergent iterative noise removal and deconvolution techniques used are the always-convergent method of Ioup (AC) (Ioup, 1981) and the reblurring procedure of Kawata and Ichioka (RB) (1980).These iterative,methods are modified versions of van Cittert's (1931) approach.Theories concerning convolution and deconvolution as well as the convergence of the iterations and a discussion of the methods are given in Chapter 2, section 2.4.4 and 2.4.5.

The AC noise removal iterations smooth the data at the first iteration and proceed to restore the data back to its original noisy form except for incompatible noise. To optimize, deconvolution is performed after each restoration iteration.The optimum number of iterations is found when the MSE (mean squared error), the squared difference between the known input (or expected deconvolution result in the case of real data) and the deconvolution result, is a minimum.

Three types of data are used for optimization in this thesis: (1) seismic, (2) wide Gaussian, and (3) narrow Gaussian. Each data type is optimized for 15 signal-to-noise ratios (SNR,s).To account for noise variability from one data set to another and to obtain good statistical results, 50 noisy data sets, each with a SNR close to or equal to the one of interest, are produced.

The seismic data are a spike train with same polarity spikes of various separations and with the same heights. This is particularly of interest since some closely-spaced peaks are difficult to resolve, and it gives a calibrated measure of resolution. This is discussed in Chapter 3, where various plots of iteration number vs SNR and some deconvolved results are given. The results for narrow and wide Gaussians (fast and slow convergence, respectively) are given in Chapter 4.

Chapter 5 contains an introduction and evaluation of the phase shift migration and modeling method. A single spike (a point reflector) in depth is used for modeling. The same spike in time vs distance is used for migration to evaluate the method and compare results with Stolt's method (Claerbout, 1985).

CHAPTER 2

THEORETICAL BACKGROUND

2.1 INTRODUCTION

Our daily experience abounds with phenomena that can be described by the mathematical process of convolution. Spreading, blurring, and mixing are qualitative terms frequently used to describe these phenomena. Sometimes the spreading is caused by physical occurrences unrelated to our mechanisms of perception; sometimes our sensory inputs are directly involved. The blurred visual image is an example that comes to mind. The blur may exist in the image that the eye views, or it may result from a physiological defect. Biological sensory perception has parallels in the technology of instrumentation. Like the human eye, most instruments cannot discern the finest detail. Instruments are frequently designed to determine some observable quantity while an independent parameter is varied. An otherwise isolated measurement is often corrupted by undesired contributions that should rightfully have been confined to neighboring measurements. When such contributions add up linearly in a certain way, the distortion may be described by the mathematics of convolution.

In this chapter a brief mathematical background concerning the work of this thesis is given. This includes The Fourier transform, convolution and deconvolution, iterative deconvolution methods, noise, and the iterative noise removal techniques of Morrison(Morrison, 1963; loup, 1968) and (loup, 1981)

2.2 THE FOURIER TRANSFORM AND RELATED THEOREMS

The customary formulas exhibiting the Fourier transformation are

$$F(s)=\int_{-\infty}^{\infty} f(x)\, e^{-i2\pi xs}\, dx$$

$$f(x)=\int_{-\infty}^{\infty} F(s)\, e^{+i2\pi xs}\, ds$$

where F(s) is the forward transform of f(x), and f(x) is the inverse transform of F(s). F(s) and f(x) are said to be a transform pair. This process is possible if f(x) satisfies the Dirichlet conditions, that is:

1) The integral of |f(x)| exists from $-\infty$ to ∞
2) Any discontinuities in f(x) are finite.

The symbol) means "has transform", for example:

f(x) has transform F(s)

f(x)) F(s).

Capital letters refer to functions in the Fourier transform domain while lower case letters to functions in the function domain.

There are many theorems relating operations in one domain to the corresponding operations in the other domain. One of the most important is the convolution theorem:

If	f(x)	)	F(s)
and	g(x)	)	G(s)
then	f(x)*g(x)	)	F(s)G(s).

As is often the case, the operation in the transform domain is simpler than in the function domain.

The Fourier transform of a continuous function rather than the replicated transform of a discrete function is considered. The ideas can be carried over to the discrete case if enough zero padding is done to reduce the effects of wraparound and if aliasing is negligible.

2.3 CONVOLUTION AND DECONVOLUTION

2.3.1 CONVOLUTION

Is there a perfect recording instrument or measuring device? The answer to this question is perhaps non, since every instrument distorts the input data somehow according to its imperfection or impulse response function (broadening effect). In simple terms the output of a system is a distorted form of input to the system.

Every linear instrument has an impulse response function. This is the instrument reaction to an impulsive input. Fourier transformation of this impulse response function determines the domain of frequencies the instrument can pass. Therefore if an input signal contains frequencies beyond the frequency range of the instrument, some of the signal is lost. The instrument is simply unable to register the data corresponding to these frequencies. If the system is linear and shift invariant, the relationship between the input signal and the output is called convolution.

Convolution describes the action of an observing instrument as it takes the weighted running mean of some quantity over a narrow range of some variable. When the form of the weighting function does not change as the central value of the variable changes over the measurement, then the observed quantity is the convolution of the described quantity with the weighting function.

he following diagram shows a convolution model:

```
                         system
                  ____________________
                  |                  |
     f            |                  |        h
 ---------->|     |        g         |----------------->
   input          |                  |    output
                  |                  |
                  --------------------
```

The mathematical expression for the convolution is

$$h(x) = \int_{-\infty}^{\infty} f(u)\, g(x-u)\, du$$

$$h(x)= f(x)*g(x),$$

where $h(x)$ is the output signal, $f(x)$ is the input signal, and $g(x)$ the instrument impulse response function.As x, in the domain of the output, is varied, the value of the area under the curve, $f(u)g(x-u)$ vs. u, corresponds to the output, h. See Fig. 2.1.

If there is a perfect instrument, its impulse response function is a delta function, $\delta(x)$. For such an instrument

$$h(x)= f(x)*\ (x)=\delta f(x)$$

or

$$h(x)= \int_{-\infty}^{\infty} f(u)\delta(x-u)\, du = f(x).$$

The input signal is equal to the output signal with no distortion. The delta function is the identity operator under convolution.

Data are recorded in a discrete form or converted to discrete form by an analog-to-digital converter for computer use. The convolution integral becomes a summation and the continuous functions $f(x)$ and $g(x)$ are simply replaced by their approximated sampled sequences. If f is an infinite sequence, the serial product or discrete convolution is obtained by the following formula:

$$h_n = \sum_{m=-\infty}^{\infty} f_m g_{n-m} ,$$

where h_n, f_m, g_{n-m} are quantized functions and n and m are discrete variables.

2.3.2 DECONVOLUTION

So far the relationship between the output signal of a shift-invarient instrument and its input signal has been established. It is often desirable to remove the effects of the impulse response function of the instrument and to recover the actual input signal f in terms of g and h. This process is called deconvolution.

There are several methods of deconvolution. Among these are the ones considered here:

1. van Cittert's method (van Cittert, 1931)
2. Always-convergent technique of Ioup (AC) (Ioup, 1981)
3. Reblurring procedure of Kawata and Ichioka (RB) (also called the mirror image approach by Lacoste) (Kawata and Ichioka, 1980; Lacoste, 1982)
4. Least squares inverse filtering (LS) (Robinson, 1980)
5. Inverse filtering.

In this work the AC of Ioup and the RB of Kawata and Ichioka are of primary concern.

The following diagram shows the inverse filtering method of deconvolution in the function domain.

$$\xrightarrow{\ f\ } \boxed{\ g\ } \xrightarrow{\ h\ } \boxed{\ g^{-1}\ } \xrightarrow{\ f\ }$$

$$h = f * g$$

$$f = h * g^{-1} = f * g * g^{-1} = f * \delta = f$$

The above operation in the transform domain, by the Convolution Theorem developed earlier, becomes

$$f(x)*g(x)=h(x)$$

$$F(s)\,G(s)=H(s)$$

$$F(s)=H(s)/G(s)\ .$$

This procedure is undefined for s values for which $G(s)=0$. The principal solution suggested by Bracewell and Roberts (1954) is

$$F_p(s)=\begin{cases} H(s)/G(s) & \{s:\ G(s)\neq 0\} \\ 0 & \{s:\ G(s)=0\} \end{cases}$$

The magnitudes of the transforms are shown in Fig. 2.2. Because of the symmetry property of the magnitude, only positive frequencies are presented. Fig. 2.2 shows $|F|$, $|G|$, and $|H|$ while Fig 2.3. shows $|F_p|$, $|G|$, and $|H|$.

The source of possible Gibbs oscillations in the solution

$$f_p(x)=F^{-1}\{F_p(s)\}$$

is obvious in the truncated transform (Bracewell and Roberts, 54; Frieden, 75). Setting F(s) to zero at places where G(s) is zero is equivalent to multiplying F (s) by a truncating function such as a rectangle window,

$$F_p(s) = F(s)\Pi(s/s_c).$$

But according to the convolution theorem:

$$f_p(x) = f(x) * s_c \operatorname{sinc} 2s_c x$$

This happens for every zero region of G(s) and results in multiplication by a rectangular pulse of the corresponding duration. The supperposition of these effects (convolution with the sinc-like inverse transform) is the approximate solution $f_p(x)$. Proper tapering of the rectangular window reduces these oscillations.

$f_p(x)$ is not a unique solution since any data having a non-zero transform for $\{s:G(s)=0\}$ can be added to $f_p(x)$ to give a solution to the convolution model (BW and RB, 1954; Ioup and Ioup 1983).

If additive noise n(x) is present in the data, h(x) becomes:

$$d(x) = h(x) + n(x) .$$

The resulting experimental data d(x) are given by:

$$d(x) = h(x) + n(x) = f*g + n(x),$$

and the principal solution if no noise removal is applied becomes:

$$F_d(s) = H(s)/G(s) + N(s)/G(s).$$

Beyond s_c, the cutoff frequency of G(s) (the maximum frequency present), H(s) is zero; however, N(s) is not necessarily zero in this region. This portion of the noise spectrum is called incompatible noise as is any non-zero part where G(s) is zero. (Morrison, 1963) defines the incompatible region as that part of the spectrum where N(s) and G(s) are uncorrelated. The remainder of the noise is compatible. The incompatible part of the noise can be entirely removed, since no finite (physical) F(s) times zero (G(s)=0) will give a non-zero result. If the incompatible noise is not removed, the solution in this region goes from being undefined in the absence of noise to being infinite (Ioup and Ioup, 1983). With van Cittert iterative deconvolution incompatible noise builds linearly with iteration number (Bracewell and Roberts, 1954).

In the region where $|G(s)|$ is small, compatible noise becomes dominant, since in the quotient $N(s)/G(s)$, small changes in $G(s)$ lead to large changes in $F_d(s)$, thus amplifying the noise. The noise amplification gets worse as the deconvolution iterations proceed, since noise is increasingly amplified with each iteration. If $|H(s)|$ is also small where $|G(s)|$ is small the result is even worse, since a small amount of noise can cause large variations in the value of $F_d(s)$.

The principal solution may be redefined as:

$$F_{dp} = \begin{cases} D(s)/G(s) & \{s: G(s) \neq 0\} \\ 0 & \{s: G(s) = 0\} \end{cases}$$

Fig. 2.4 illustrates the magnitude of the transforms with no noise removal applied (Ioup et al; in preparation).

2.4 BASIC ITERATIVE DECONVOLUTION TECHNIQUES

The iterative methods of deconvolution considered here are:

1. van Cittert (1931).
2. Always-convergent technique of Ioup (1981).
3. Reblurring procedure of Kawata and Ichioka (1980).

2.4.1 VAN CITTERT'S METHOD

Van Cittert (1931) recognized that the image data h(x) could be considered as a first approximation, $f_0(x)$, to the object f(x). After all, in the absence of unfolding, the spectroscopist often ignores (rightly or wrongly) instrumental spreading and uses the data as if they represent the true spectrum. This being the case, could we not blur the approximation $f_0(x)$ to yield an "approximation " to the data h(x)? This is the form that the data would take if $f_0(x)$ were the true object. Certainly we could, but we already have the data h(x), and so what would be the purpose?

This blurring actually serves a useful function. the function. The difference $h(x)-h_0(x)$, the easily computed error in the image estimate, is in some way related to the object estimate, $f(x) - f_0(x)$. Van Cittert recognized that this image-estimate error could be applied as a correction to the object estimate, thus producing a new object estimate:

$$f_0(x) = h(x)$$

$$f_1(x) = f_0(x) + [h(x) - g(x)*f_0(x)]$$

$$f_2(x) = f_1(x) + [h(x) - g(x)*f_1(x)]$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$f_n(x) = f_{n-1}(x) + [h(x) - g(x)*f_{n-1}(x)].$$

In the transform domain these iterations become:

$$F_0 = H$$

$$F_1 = F_0 + [H - G F_0]$$

$$F_2 = F_1 + [H - G F_1]$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$F_n = F_{n-1} + [H - G F_{n-1}]$$

$$F_n = [\ 1 + (1-G)^1 + (1-G)^2 + \ldots\ldots + (1-G)^n\ ]\ H\ . \quad (1)$$

The final result has been obtained by successive substitution (BR,RB 54 FR 75).

2.4.2 CONVERGENCE CRITERIA FOR VAN CITTERT'S METHOD

In the absence of noise, convergence depends only on properties of the impulse response function g(x). Bracewell and Roberts (1954) gave these conditions. Hill (1973) and Hill and Ioup (1976) used these conditions to find necessary restrictions on the shape and position of the function g(x).

From equation (1), the series in the braces is the first n+1 terms of the convergent binomial expansion of

$$\{ 1 - [1 - G(s)] \}^{-1} = \{1 - 1 + G(s) \}^{-1} = 1/G(s), \qquad (2)$$

if $|1-G(s)|<1$. Substituting (2) in (1)

$$\lim_{n \to \infty} F_n = H(s)/G(s) \qquad \{s : G(s) \neq 0\}$$

Therefore there is convergence if and only if

$$|1-G(s)|<1 \qquad \{s: G(s) \neq 0\} \qquad (3a)$$

$$H(s) = 0 \qquad \{s: G(s)=0\} \qquad (3b)$$

In fulfilling condition (3a), the origin of g(x) is of importance (Hill, 1973; Hill and Ioup, 1976), especially with an asymmetrical function. The question is, what choice faithfully represents the physical impulse response? Or, is there an origin of g(x) for which van Cittert's method converges? Condition (3b) is satisfied by removing the incompatible noise described earlier.

One way of satisfying condition (3a) is by trial and error. The transform of g(x) with a selected origin is taken. This transform is then tested to see if it satisfies condition (3a). If not, the procedure is repeated with a new origin until condition (3a) is satisfied. The method of trial and error can be sometime avoided, if g(x) is, or can be, mathematically manipulated such that its transform satisfies condition (3a) (see Hill, 1973; Hill and Ioup, 1976).

2.4.3 POINT SUCCESSIVE AND POINT SIMULTANEOUS APPROACHES

In the point successive approach to deconvolution the value of f(x) is updated when performing the convolution, g * f, for each x value within the deconvolution iteration. In point simultaneous iterations, this update procedure is not done until the iteration is complete, and the convolution g * f is performed with the f of the previous iteration rather than updating f point by point.

2.4.4 ALWAYS-CONVERGENT METHOD OF IOUP

The always-convergent method of Ioup (1981) is a modified version of the van Cittert method of deconvolution. There are two major differences between the always-convergent method and the van Cittert method. First, the impulse response function is replaced by

$$G_m(s) = | G(s) | / | G |_{max} ,$$

and second, the form of the iteration equation is modified and, h is replaced by the principal solution f_p.

The most important condition to be satisfied is $| 1 - G | < 1$. This is assured by the above modification because the division, $|G| / |G|_{max}$, makes the maximum value of G to be one. Also, since the absolute value of G and G_{max} are used, G_m is real and non-negative. Therefore, the vector G_m lies on the real axis of the plot of real G_m vs imag G_m, with maximum value one, Fig.2.5. As will be seen in section 2.4.5, this is an important condition which guarantees the convergence of the iterations, including image restoration systems where the optical transfer function(OTF) is required to be real and positive. The reblurring procedure of Kawata and Ichioka (1980) also provides the same advantage but it converges slower, because there G is replaced by $|G|^2$, corresponding to an autoccorolation in the function domain. Usually smoothed functions converge slowly.

Applying the above modifications to the van Cittert iterations in the transform domain, the always-convergent method is obtained as follows:

$$F_0 = H$$

$$F_1 = F_0 + [F_p - F_0] G_m$$

$$\vdots$$

$$F_n = F_{n-1} + [F_p - F_{n-1}] G_m ,$$

where $F_p = H/G$. By successive substitution F_2 becomes

$$F_2 = [F_0 + (H/G - F_0) G_m] + \{H/G - [F_0 + (H/G - F_0)G_m]\}G_m$$

with $F_0 = H$. Simplifying yields

$$F_2 = [\,1 - (1 - G)(1 - G_m)^2\,]\,H$$

.
.
.

$$F_n = [\,1 - (1 - G)(1 - G_m)^n\,]\,H / G$$

2.4.5 REBLURRING PROCEDURE OF KAWATA AND ICHIOKA

Iterative methods of deconvolution have been used for resolution enhancement of spectroscopic data. Those methods have the following problems

1. convergence
2. noise amplification.

Convergence is attained only in regions where the transform of the impulse response of the system is non-negative. Also in the case where noise is present, the noise strongly reduces the quality of the result as the number of iterations increases (KA & IC, 1980).

In the case of van Cittert's method, convergence is possible if and only if

$$|\,1 - C\,G(s)\,| < 1 \qquad (1)$$

where $G(s)$ is the transfer function of the system, and C is a normalization imposed for convergence. If the impulse response of the system is replaced by

$$G(s) = |G(s)| e^{iQ(s)} , \qquad (2)$$

equation (1) becomes

$$|1 - C|G| e^{iQ}| < 1$$

$$|1 - C|G| \cos Q - iC|G| \sin Q| < 1$$

$$[(1 - C|G| \cos Q)^2 + (C|G| \sin Q)^2]^{1/2} < 1$$

$$1 - 2C|G| \cos Q + C|G|^2 < 1$$

$$\cos Q > C|G| / 2 \qquad (3)$$

Therefore, inequality (3) must be satisfied to make the iterations converge. However, if Q=180 degrees (i.e., a phase inverted optical transfer function), relation (3) does not hold for any positive C. It holds for systems with Q=0 degrees (i.e., non-inverted OTF) for $0 < C|G| < 2$; therefore the iterations converge for Q=0 degrees if proper normalization is used.

To overcome this problem Kawata and Ichioka (1981) proposed to replace G by $|G|^2$. Therefore, relation (1) is modified to

$$|1 - C|G|^2| < 1 . \qquad (4)$$

Substituting equation (2) into (4) gives

$$|1 - C| |G| e^{iQ}|^2| < 1$$

$$|1 - C|G|^2| < 1 .$$

This shows that the phase Q has been eliminated.

By using the autoccoloration theorem, $|G|^2$ in the function domain becomes

$$g * g(-x) \quad) \quad |G|^2$$

$$g * g_r \quad) \quad |G|^2 .$$

By application of the above modification (replacing G by $|G|^2$) to van Cittert's method with initial approximation, $f_0 = g_r * h$, the following equations describing the reblurring procedure of Kawata and Ichioka are obtained:

$$f_0 = g * h_r$$

$$f_1 = f_0 + [g * h_r - f_0 * g_r * g]$$

.
.
.
.

$$f_n = f_{n-1} + [g * h_r - f_{n-1} * g_r * g].$$

In the transform domain, this modification makes the impulse response to be positive and real; therefore, this part of the convergence problem has been solved.

In addition, the reblurring procedure has a great advantage over other iterative methods for deconvolution of noisy data, if no noise removal technique is used. This is because the noisy data are smoothed in the original approximation ($f_0 = g * h_r$), so noise amplification is reduced. But the disadvantage lies in slowness of the method due to the lack of resolution of the original approximation.

2.5 NOISE

Noise is a part of every physical phenomenon or system, since most are fundamentally limited by some form of statistical variability, or noise.

Data processing systems are usually required to handle a large assortment of signals in the presence of noise.The type of noise present must be specified for each problem; noise can be the wrong signal, or the right signal out of place,and what may be noise to one observer may be signal to another observer. In any case, the design of systems depends to a large extent upon the statistical properties of both the signals and the noise. Noise may be undesired signals which are not coherent with any signals to which meaning is assigned in a system, or signals which are coherent with the desired signals in the system. In any application, care must be given to the classification of which signals are to be considered useful and which ones are to be considered undesirable, or noise (Robinson, 1980).

The interfering noise in exploration seismology may be defined in different ways. One type of noise associated with exploration seismology is random noise, which is random in both amplitude and phase. Random noise is wind noise as well as wave groups arriving from random directions. Such random wave groups may be largely disturbances from secondary sources resulting from initial near surface waves impinging upon randomly-located, near-surface inhomogeneities (Robinson, 1980).

The type of noise considered here is Gaussian distributed noise. Gaussian noise is that which has a Gaussian or bell curve ($\exp(-\pi x^2)$) distribution about any given data point. In this fashion, if enough noise cases are generated, a plot of frequency of occurrence of a number vs the magnitude of that number approaches a Gaussian shape (Fig. 2.6).

There are two types of Gaussian distributed noise of interest here: constant and ordinate-dependent noise. For the constant Gaussian distributed noise, the width of the bell curve is fixed; it is Gaussian noise with the same standard deviation at each point.However, ordinate-dependent Gaussian noise is that for which the width of the bell curve depends on the ordinate size of the data point, i.e, it is noise which has an ordinate-dependent standard deviation.

To add Gaussian noise to the data, one can use the well-known result that the sum of comparatively few random numbers from a uniform distribution gives a very good approximation to a normal Gaussian distribution (Hamming, 1962). Utilization of the Central-Limit Theorem leads to the above conclusion (Hamming, 1962). In the case of a decimal machine (expressed as a base 10 number) it is customary to use 12 numbers (to get a variance of 1 (Hamming, 1962)). Since the sum does not have mean zero (it is half of the number of points; for 12 numbers the mean is 6), the necessary amount (in this case 6) must be subtracted from the sum of the 12 numbers to make the mean zero. For the constant case the expression is:

$$h_{nc}(I) = \left(\sum_{i=1}^{12} (A_i - 6)\, SF^{1/2} + h(I) \right)$$

where A is the generated random number, SF is the scale factor, and h is the noise free data. With help of the SF one can generate a noisy data set which has approximately the SNR of interest (Leclere, 1984).

2.5.1 MORRISON'S METHOD OF NOISE REMOVAL

Morrison's (1963) smoothing and restoration is an iterative technique which smoothes the noisy data in the first iteration, and proceeds to restore the data back to its original noisy form except for incompatible noise in subsequent iterations. Morrison's noise removal applied to noisy data restores both signal and noise with each iteration. In the restoration process little distinction can be made between the restoration of noise and signal except in those frequency regions where one significantly dominates the other. Therefore, to achieve optimum smoothing a decision must be made as to where the iterations should be stopped. There is a trade off between the restoration of noise and restoration of the signal (Wright, 1980; Leclere, 1984; Morrison, 1963; Ioup, 1968; Ioup et al, in preparation).

Morrison's method removes incompatible noise from noisy data. This is noise beyond the cutoff frequency of the impulse response function of the instrument (or any noise in the stopband of the impulse response). Since d (h + n) is convolved with g, the result has no frequency higher than that present in g, the impulse response function of the instrument (Wright, 1980; Leclere, 1984; Morrison, 1963;

Ioup, 1968; Ioup et al, in preparation).

As the noise level of the data to be restored is decreased, the number of iterations increases because there is less noise to obscure the restoration.

Morrison's iterations for noisy data, d, in the function domain are

$$d_1 = d * g$$

$$d_2 = d_1 + [d - d_1] * g$$

$$\vdots$$

$$d_n = d_{n-1} + [d - d_{n-1}] * g .$$

In the transform domain the iterations become (Ioup, 1968)

$$D_1 = D\,G$$

$$D_2 = D_1 + [\,D - D_1\,]\,G = 2\,D\,G - D\,G^2$$

$$D_3 = D_2 + [\,D - D_2\,]\,G = 3\,D\,G - 3\,D\,G^2 + D\,G^3 .$$

By successive substitution the Fourier transform of the nth iteration becomes

$$D_n(s) = [\,1 - (\,1 - G(s))^n\,]\,D(s) .$$

Since

$$\lim_{n \to \infty} [\,1 - G(s)\,]^n = 0 \quad \text{for} \quad |\,1 - G(s)\,| < 1$$

and

$$\lim_{n \to \infty} [\,1 - G(s)\,]^n = 1 \quad \text{for} \quad G(s) = 0$$

the convergence of the sequence D_n is given by

$$\lim_{n \to \infty} D_n(s) = \begin{cases} D(s) & \{ s : | 1 - G(s) | < 1 \} \\ 0 & \{ s : G(s) = 0 \} . \end{cases}$$

For the remaining values of G(s) the sequence diverges (Ioup, 1968; Ioup et al, in preparation).

2.5.2 AC AND RB PROCEDURE APPLIED TO MORRISON'S METHOD

Ioup (1981) also applied the always-convergent approach, using $G_m = |G|/|G|_{max}$ instead of G, to Morrison's method method, to assure the convergence of the iterations. The modifications in the function domain (with $g_m \supset G_m$) are

$$d_1 = d * g_m$$

$$d_2 = d_1 + [d - d_1] * g_m$$

$$d_n = d_{n-1} + [d - d_{n-1}] * g_m .$$

The application of the reblurring modifications to Morrison's iterations (Ioup and Ioup, 1984) produces

$$d_1 = d * g * g_r$$

$$d_2 = d_1 + [d - d_1] * g * g_r$$

$$d_n = d_{n-1} + [d - d_{n-1}] * g * g_r .$$

Since the reblurring procedure already has strong noise removal built into it, using the modified Morrison's iterations may not be justified, especially since the combination of the two is extremely slowly convergent.

Fig. 2.1

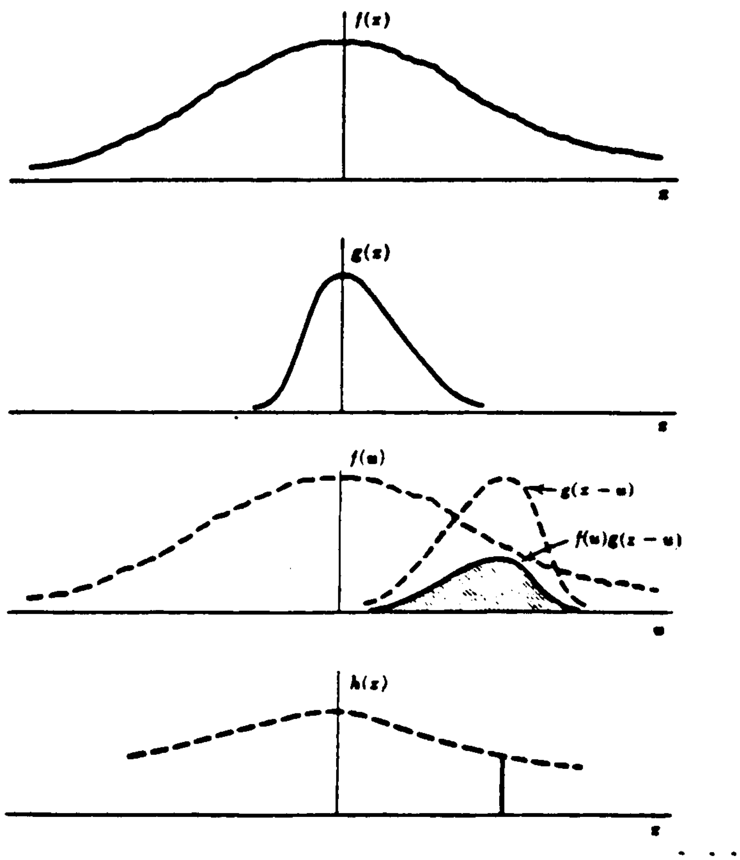


Fig. 2.2

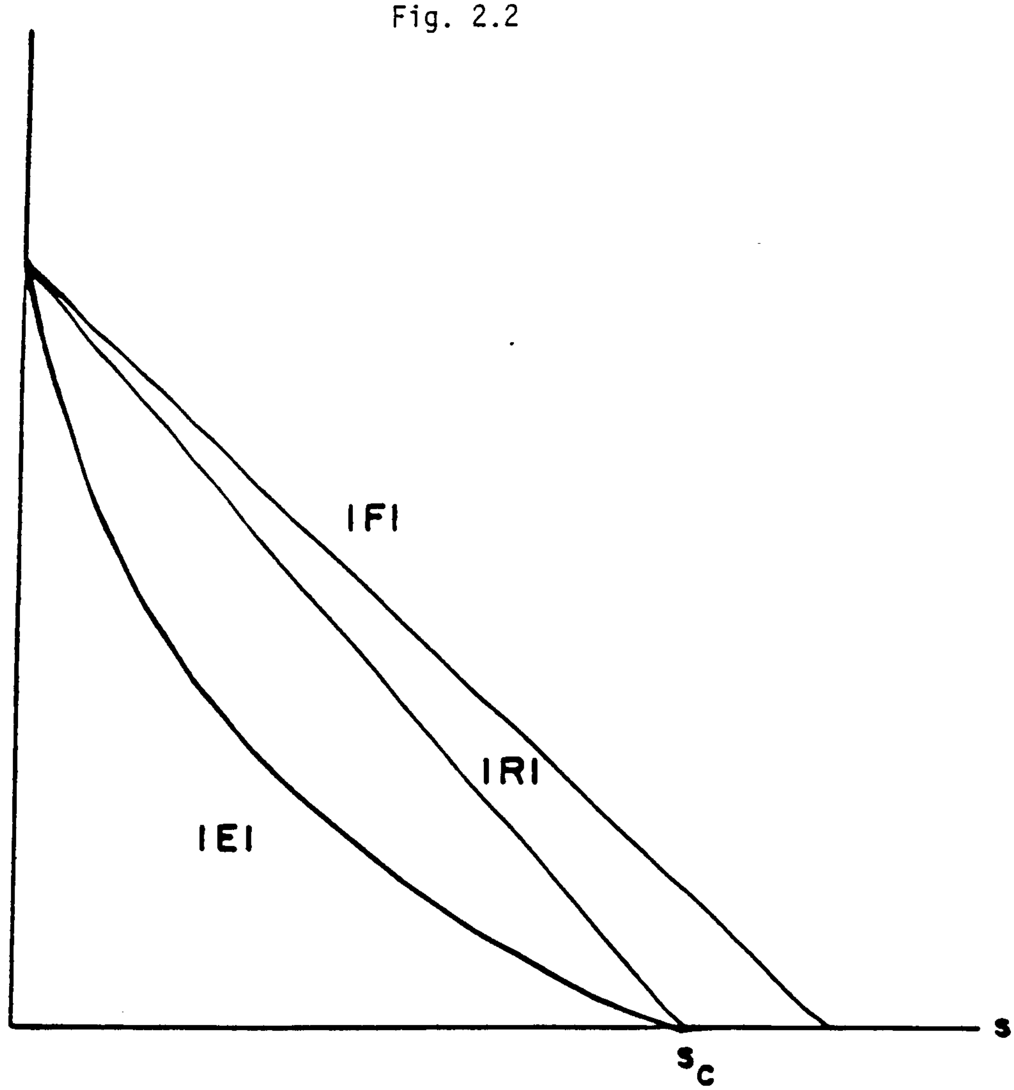


Fig. 2.3

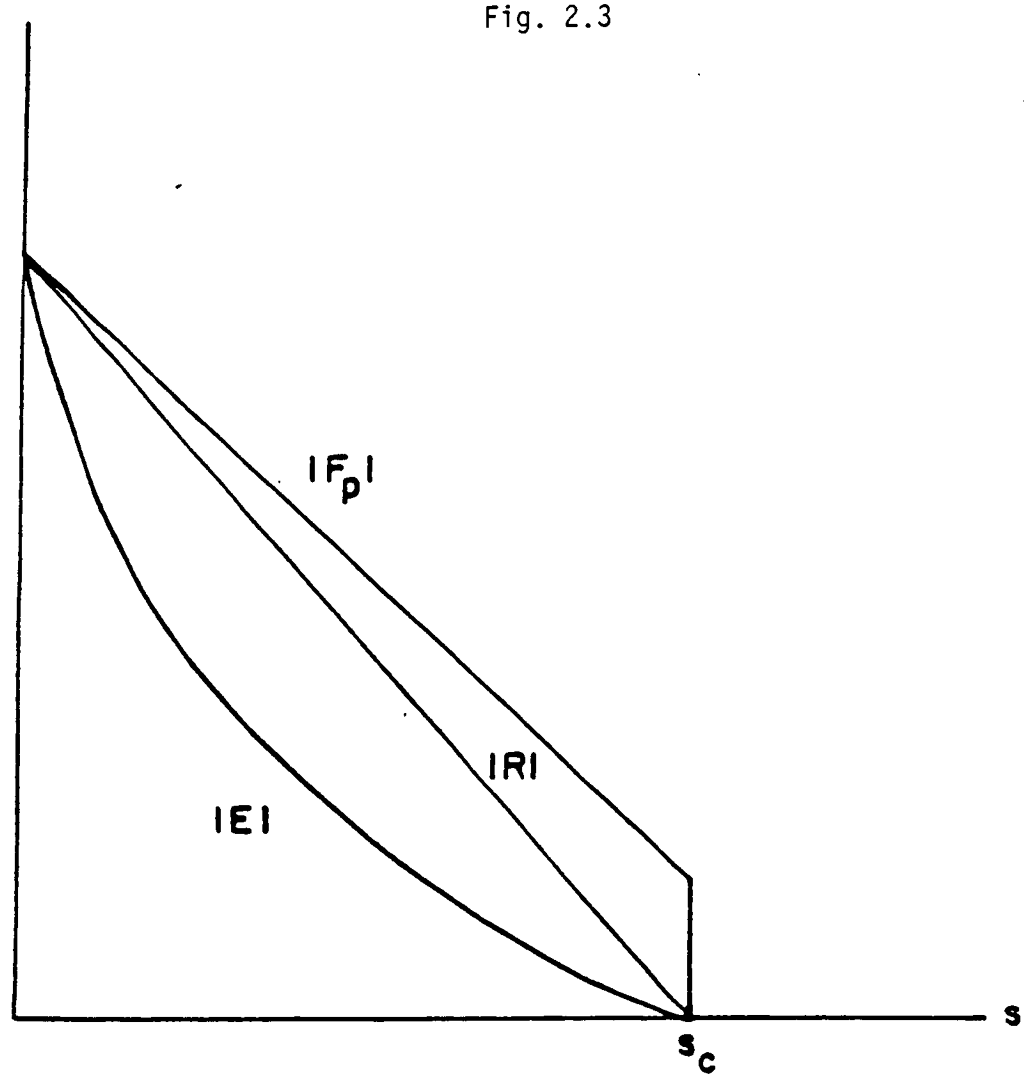


Fig. 2.4

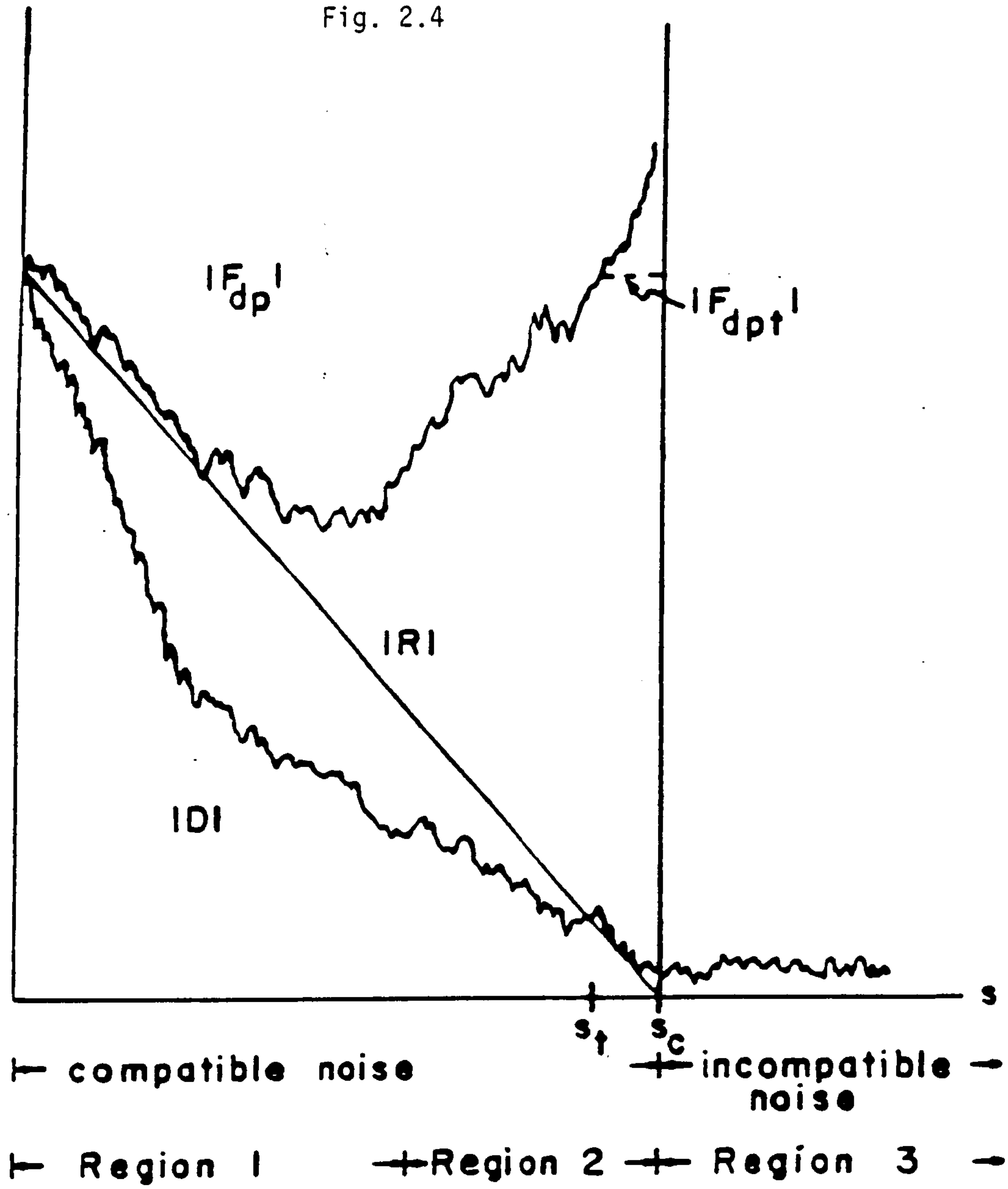

|F_dp|
|F_dpt|
|R|
|D|
s
s_t
s_c
compatible noise
incompatible noise
Region 1
Region 2
Region 3

Fig. 2.5

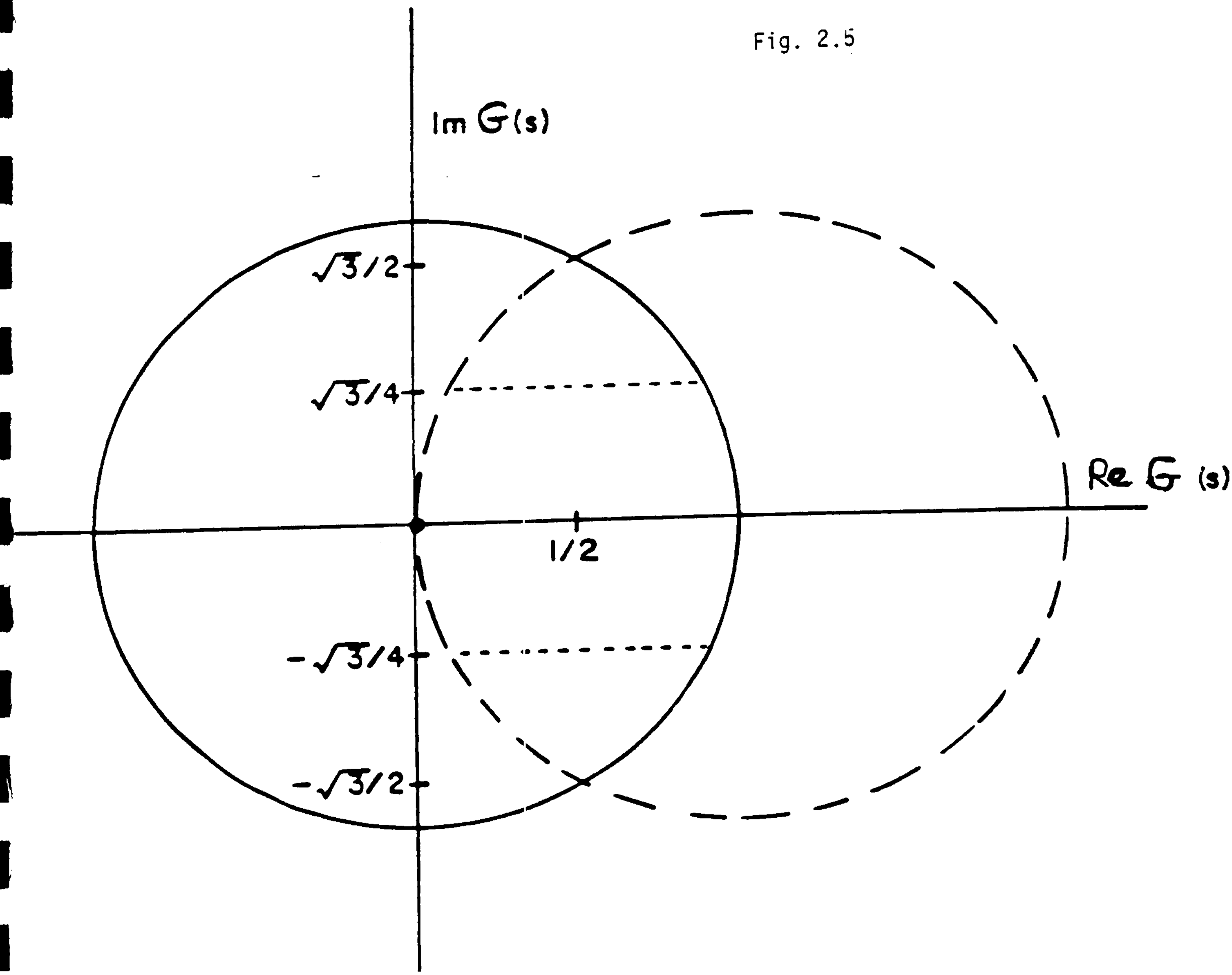
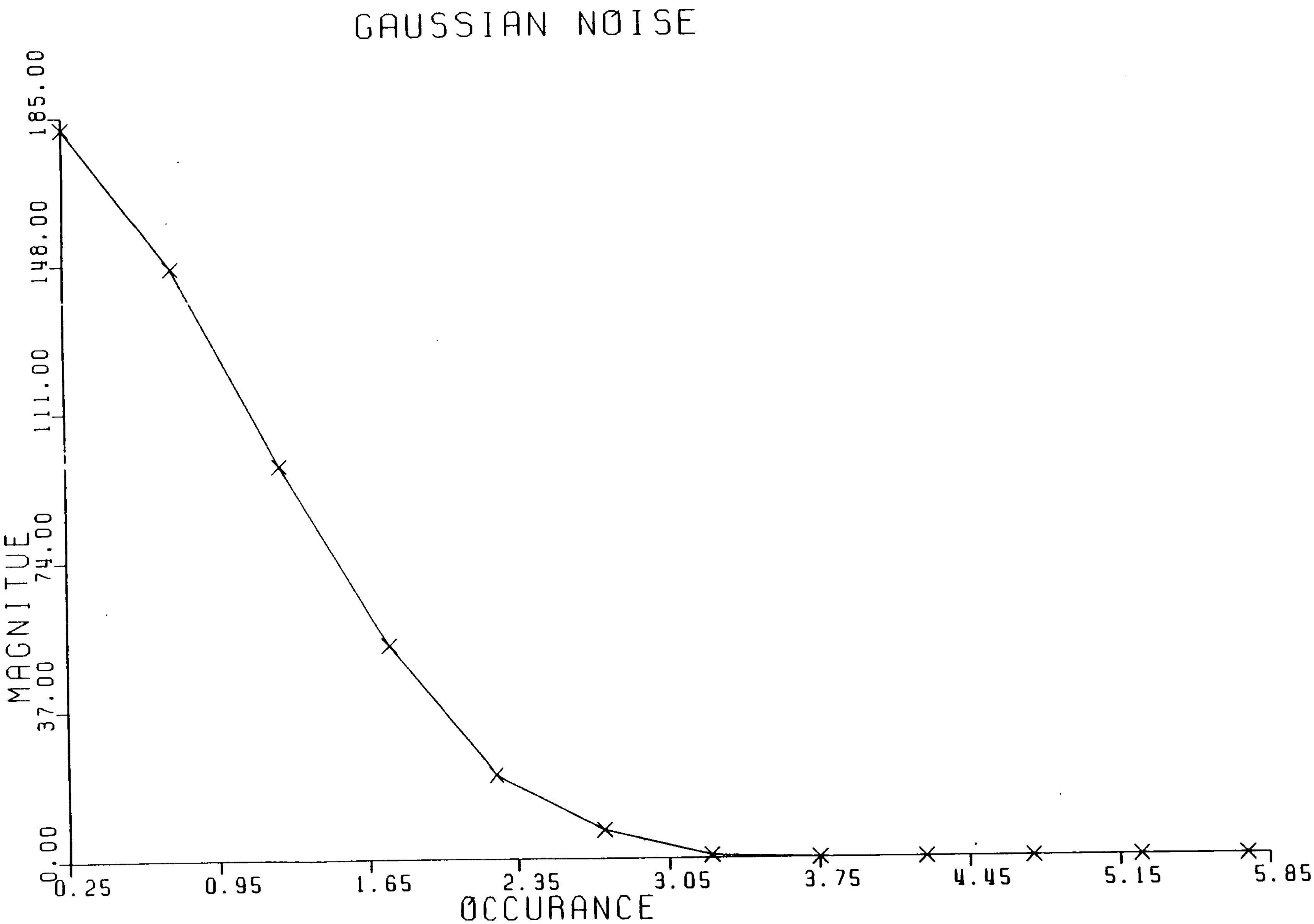


Fig. 2.6


GAUSSIAN NØISE
MAGNITUE
185.00
148.00
111.00
74.00
37.00
0.00
0.25
0.95
1.65
2.35
3.05
3.75
4.45
5.15
5.85
ØCCURANCE

CHAPTER 3

SEISMIC DATA

3.1 INTRODUCTION

In this chapter Ioup's always-convergent method (AC) and the reblurring procedure (RB) of Kawata and Ichioka are applied to synthetic seismic data. The data consist of a same polarity spike train of various separations but with equal heights convolved with a minimum phase wavelet.For a given SNR, 50 cases of constant Gaussian distributed noise (described in Chapter 2) are generated, and each is added to the convolution of the minimum phase wavelet and the spike train to obtain 50 cases of noisy data.The AC and RB methods are then applied to each of the 50 noisy data sets. By studying the mean square error (MSE), the optimum deconvolution iteration number as well as the optimum number of noise removal iterations for the AC are found.

These procedures are repeated for 15 different SNR cases. For the AC method the noise removal is followed by deconvolution iterations. A single case whose MSE is close to that of the average of the 50 cases for a given SNR is used to show sample results. These plots include the noisy data set followed by the result after the use of the AC smoothing method at the optimum iteration. Then the deconvolution results at the optimum iteration are shown with and without prior smoothing. The results for each SNR (50 cases each) are tabulated and given in Appendix A. These tables are used to find the MSE average, the unfolding (deconvolution) iteration average, and the smoothing iteration average for each SNR case. These averages are used for plots of each of the above averages vs SNR. These plots help in determining the average unfolding and smoothing iteration number needed for the best MSE possible if the SNR of the given data is known.

In this chapter optimization of the iterative methods of deconvolution (AC and RB) is reported. The results are compared to those of least-squares inverse filtering (LS) for selected SNR cases (10, 40, 150). In section 2 the type of data used is discussed; followed in section 3 by a discussion of the method employed for optimization. In sections 4 and 5 results and conclusion are given.

3.2 DISCUSSION OF THE DATA

To test the resolution and achieve an optimization of the iterative deconvolution methods, a spike train of various separations but with the same height and polarity for each spike is generated. This is especially useful since this spike train varies systematically in its ability to be resolved. It can also be thought of as representative seismic data. The separation of the first spike train is two sample intervals, and each succeeding pair has a separation one sample interval greater, up to seven sample intervals for the sixth pair (Fig. 3.1).

The seismogram of Fig. 3.3 has been produced by convolving the spike train of Fig. 3.1 with an impulse response function which is a minimum phase wavelet and is 46 points long (Fig. 3.2). To generate a noisy data set with approximately the desired SNR,constant Gaussian distributed noise is added to the seismogram based on a scale factor. To obtain a good statistical result fifty sets of noisy data are generated for each SNR.

3.3 THE METHOD

Optimization of the always convergent method and the reblurring procedure is based on the study of the mean squared error (MSE). For a noisy data set deconvolution iterations toward the input proceeds with noise being amplified at each iteration. The MSE (the square of the difference between the output of the method being used and the original spike train) starts to decrease as the deconvolution iterations first increase. At the same time the magnitude of the noise is increased. At the optimum iteration number noise amplificationjust begins to dominate the deconvolution and the MSE starts to increase. The iteration just before this is therefore the optimum deconvolution iteration for that particular data set of a SNR case.This approach is used to optimize RB.The approach used for AC is slightly different because noise removal iterations must be optimized at the same time as the deconvolution iteration.

As was described in Chapter 2, the AC noise removal technique smoothes the noisy data in the first iteration and then proceeds to restore the data back to its original noisy form. To optimize the AC noise removal iteration one has to determine at what iteration the data being processed by noise removal and deconvolution correspond best to the noise free data. Using knowledge of the MSE behavior for noisy data (first decreasing and then increasing), one can perform a deconvolution after each noise removal iteration (restoration process) to find the MSE. This process, performing a deconvolution after each noise removal iteration, is continued until an increase in the magnitude of MSE is noted. The noise removal and deconvolution iteration number corresponding to the value of the MSE just before the start of the increase is therefore the optimum iteration number.

Statistical results are more reliable as the number of trials is increased, which in this case corresponds to the number of data sets for each SNR case. The noise variability from one noise set to another for a given SNR provides a second reason to increase the number of data sets. Computer time (CPU time) imposes a restriction, however, because simultaneous optimization can be time consuming, particularly at higher SNR's where there is less noise to obscure the data (Chapter 2, section 2.5) and thus an increase in the number of iterations (Fig. 3.9).

From consideration of the above, 50 noisy data sets for each SNR were produced. Each of the 50 noisy data sets has a SNR approximately equal to the one of interest. For each case the SNR, MSE, and the optimum unfolding and noise removal iterations are averaged to be used for various plots of these averages vs SNR.

Depending on the criticality of having a narrow spread of SNR, a criterion can be established to reject noisy sets which fall outside the given limits about the mean.

The AC method is also optimized without noise removal applied. Some of the tables and plots are given in this chapter and some in Appendix A .

3.4 RESULTS

3.4.1 THE ALWAYS-CONVERGENT TECHNIQUE

The results for the AC method are summarized in Tables 3.1 through 3.5. These tables include the average MSE and the average unfolding and noise removal iteration numbers of 50 cases for a given average SNR. Tables 3.3 and 3.4 are the averages without noise removal applied.

These tables are used to produce plots of the average MSE vs SNR, the average unfolding iteration number vs SNR, and the average noise removal iteration number vs SNR (Fig.'s 3.4 through 3.12). Also the same plots when no noise removal is applied are given alone and together with the above plots (noise removal applied) on the same axes. Of particular interest is the plot of MSE vs SNR, where one can clearly see the advantage of noise removal at the lower SNR's (less than 60) and the overlapping portion of the plot (61 to 110) which shows where there is no need for noise removal (Fig. 3.8). Therefore at higher SNR's (from greater than 111 up to infinity, corresponding to noise free data), application of the noise removal iterations is not necessary. To test this prediction, noise removal was applied to a single case of SNR 150.Well over 1000 iterations were required to achieve a MSE equivalent to the one with no noise removal applied.

In each of these plots the dashed line indicates the standard deviation and the solid line the mean. In Figs. 3.4 through 3.12 where the results of applying the noise removal iterations are shown together with those of not applying them, the solid line corresponds to the result with the noise removal iterations applied and the dashed line corresponds to no noise removal. The noise removal iterations are applied up to SNR 108, although, according to Fig 3.8 , above SNR 60 improvement is not so obvious, and at the higher SNR's, from 80 on, there is no improvement in MSE at all.

Fig. 3.11 is the result of the unfolding iterations with and without noise removal applied. This plot is the proof of the claim made out earlier that noise amplification dominates the unfolding improvement at smaller iteration number, if no noise removal is applied.

The plots of Fig.'s 3.9 and 3.12 show the unfolding and noise removal iterations vs SNR. From these plots it can be inferred that the unfolding and noise removal iterations vs SNR are almost linear.With an interpolation or extrapolation method one can predict the optimum number of iterations needed for a given SNR. In fact,this is the purpose of this research; to establish a methodology for prediction of the optimum number of iterations.

For SNR equal to infinity (the noise free case), a MSE of 8.230E-11 was obtained after 1878 iterations. Iterations were stopped due to computer round-off error or negligible improvement in MSE. It is impossible to apply a very large number of iterations because of the limitations of computer. This result is in contrast to the assumption that, as the number of iterations approach infinite, F becomes H/G.

At each SNR a single case whose MSE was close to that of the average SNR is selected to show the deconvolution with and without the application of noise removal. The noisy and the smoothed data are given. The results for SNR's of 10, 40, and 150 are given here (Fig.'s 3.13 through 3.23) and the rest with tables of MSE for each SNR in Appendix A.

3.4.2 REBLURRING PROCEDURE AND LEAST SQUARES

The results for the RB as well as LS are given in Tables 3.6 through 3.9 . Because the reblurring method is a slow function of the number of iterations, only three SNR cases are presented. For the noise free case the magnitude of the MSE is 0.00276. This corresponds to 90000 iterations with no minimum reached. The iterations were stopped due to the computer time required.

Table 3.8 contains the results of the LS method. Three SNR cases of 10, 40, and 150 (10 cases each) were selected. For the noise free case the MSE was order of magnitude 1.0E-06.

Fig. 3.24 shows the average MSE vs SNR for RB. The dashed line is the MSE for noise free data (SNR infinity) after 90000 iterations. The solid curve approaches this value as the SNR is increased. Fig 3.30 is the same result for LS.

Fig 3.25 displays the unfolding iteration number vs SNR for the RB. The iterations are assumed to approach the dashed line (SNR= infinity, iterations=90000) as SNR increases. Deconvolution results are shown for cases whose MSE is the closest to the average in Fig's. 3.26 through 3.34.

3.5 CONCLUSIONS

By comparing the deconvolution of the AC and RB methods with that of LS, it can be concluded that the iterative methods are superior at low SNR'S. The average MSE obtained for the AC method with noise removal applied at SNR=10 is 8.73. For RB it is 8.68 and for LS 10.64 . This shows that the optimum use of the iterative methods of deconvolution at low SNR'S is superior to that of LS not only for MSE but also, from Figs. 3.17, 3.27,and 3.32,for resolution. The resolution can be even better if the iterations are allowed to continue, at the price of further noise amplification and .thus an increase in MSE. At higher SNR's the difference in MSE and resolution is not noticeable among all three methods. Thus one may choose to work with any of the methods provided that the computer time is not a problem.If it is, then LS is clearly superior unless one uses the one-shot deconvolution equivalent of the iterative methods.

To achieve higher resolution using iterative methods one may choose to work with other norms rather than the MSE.In image processing systems this is preferred because the human visual system filters noise and therefore a higher resolution is often preferred (Andrews and Hunt, 1977; Hunt, 1978).

Fig. 3.1

INPUT DATA

SPIKE TRAIN

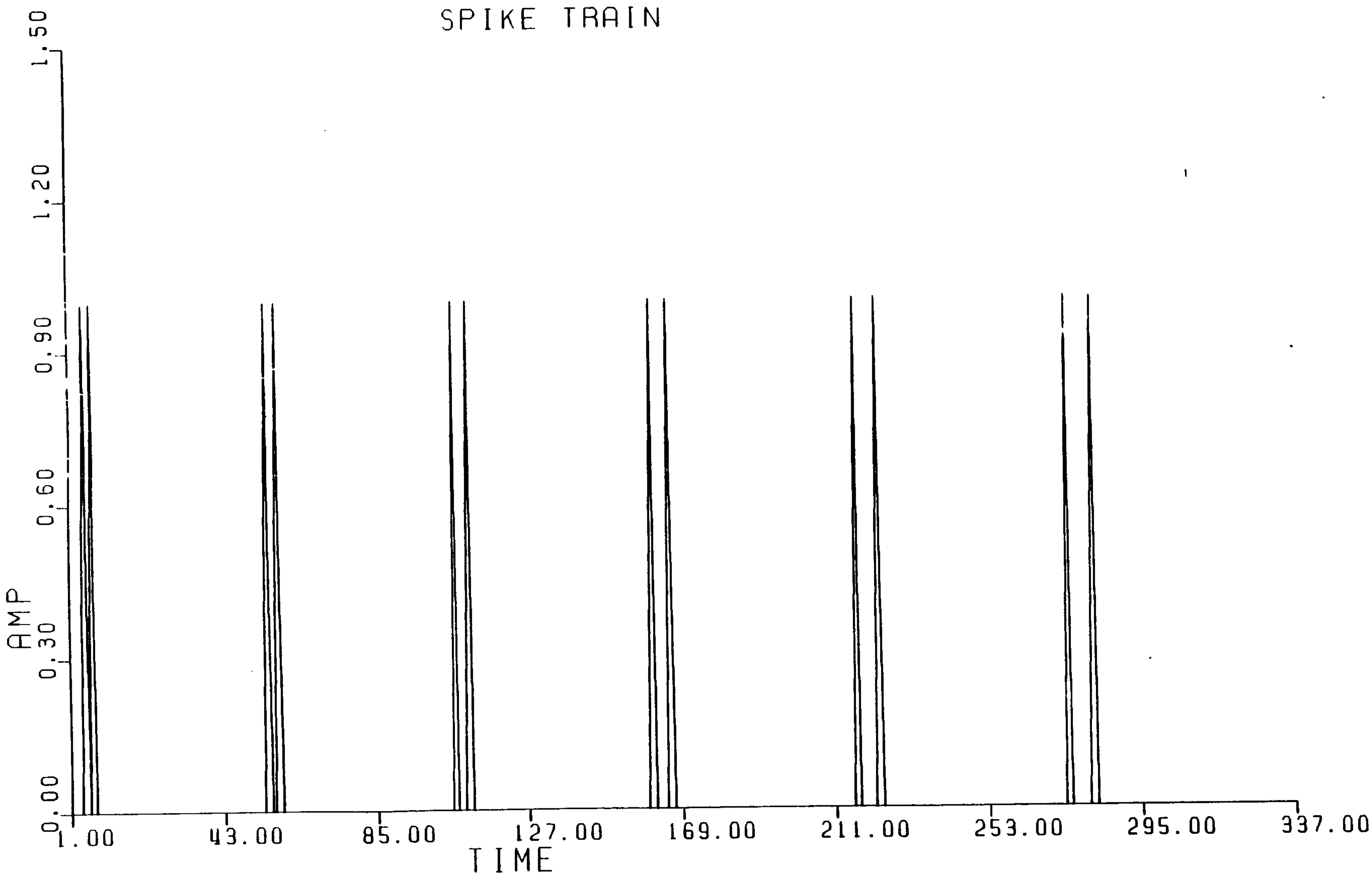


Fig. 3.2 IMPULSE RESPONSE FUNCTION

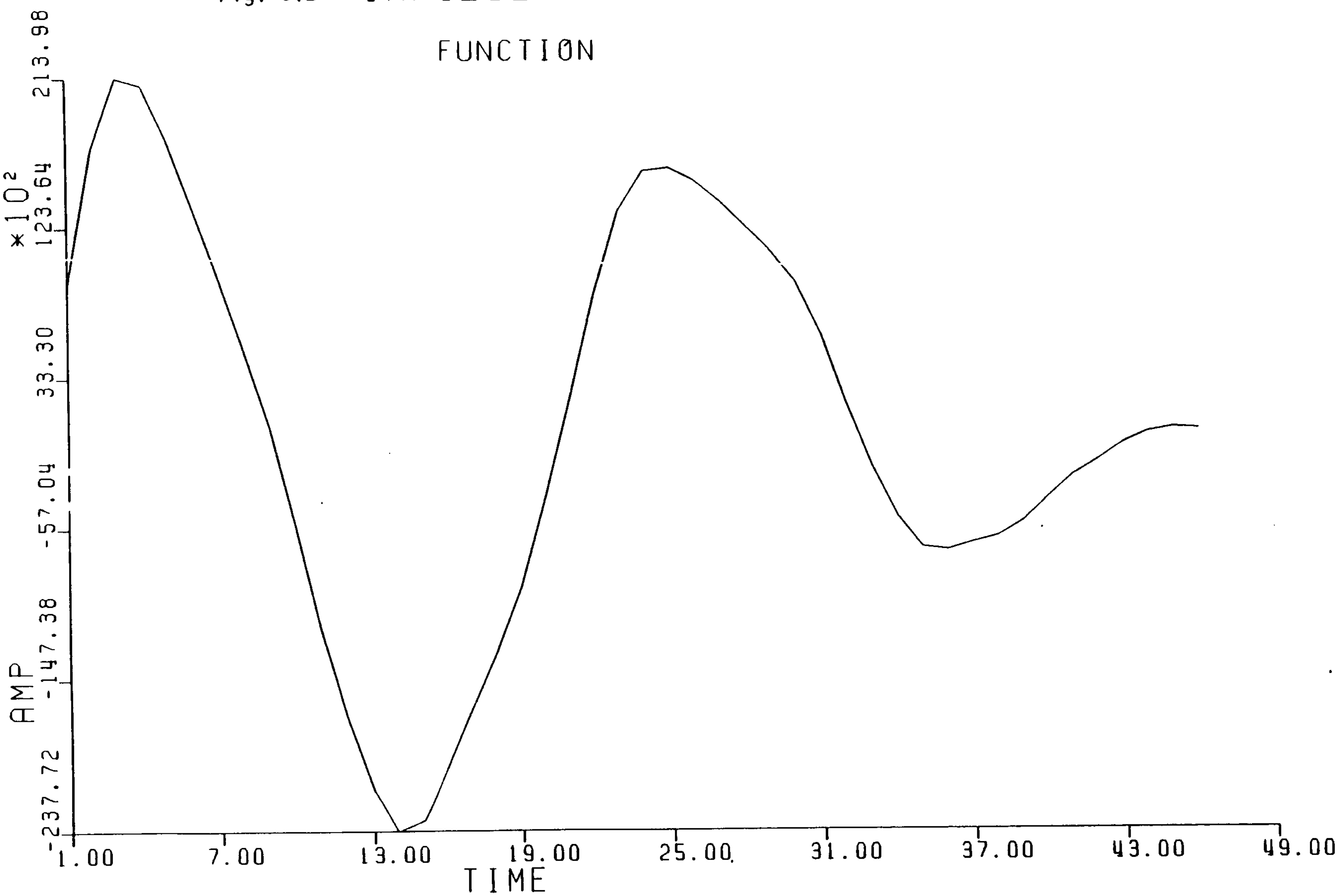


Fig. 3.3 BROADENED DATA

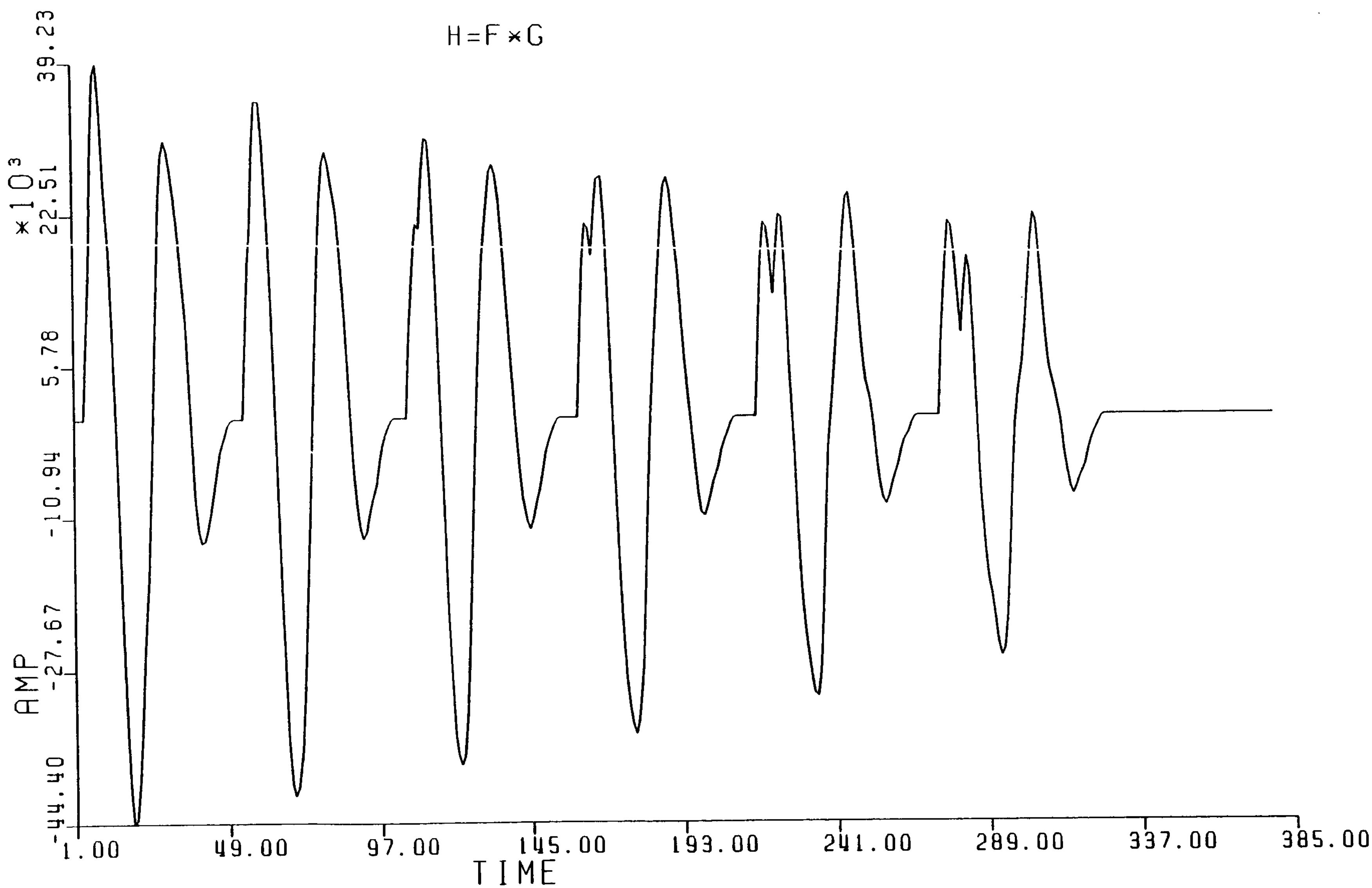


Fig. 3.4 MSE VS SNR

SMOOTHED SEISMIC DAT

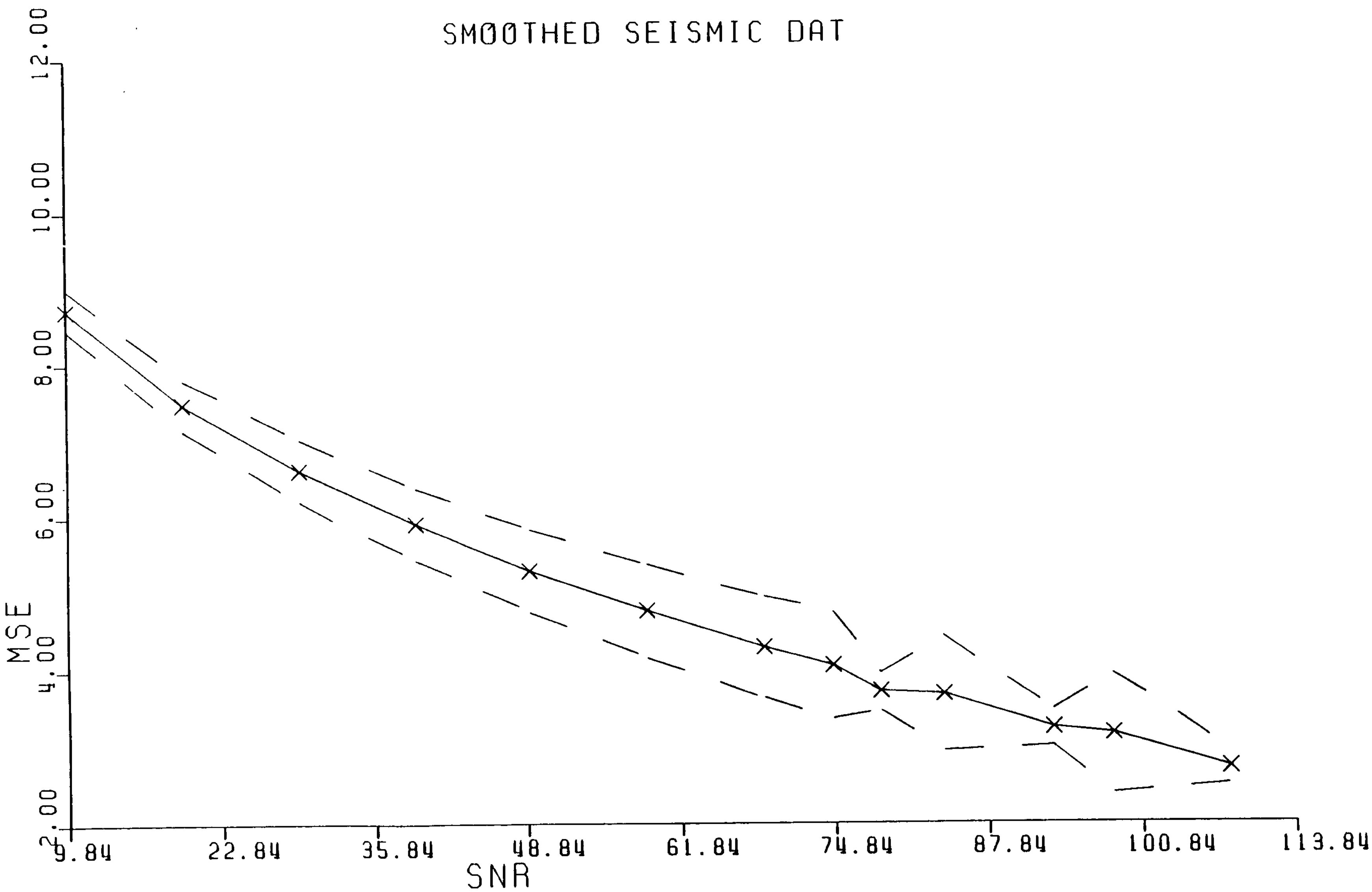


Fig. 3.5 MSE VS SNR

WITHOUT SMOOTHING

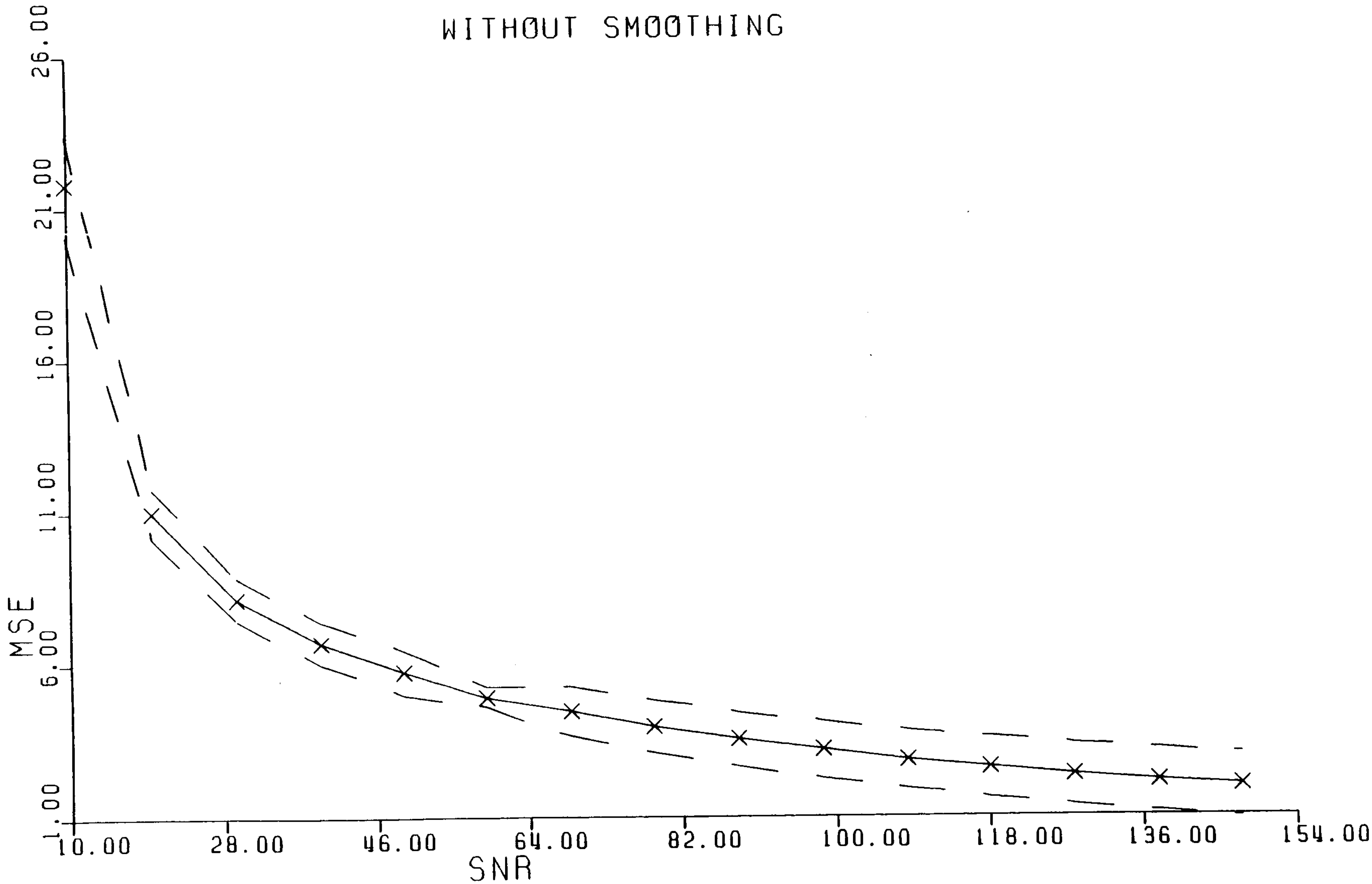


Fig. 3.6

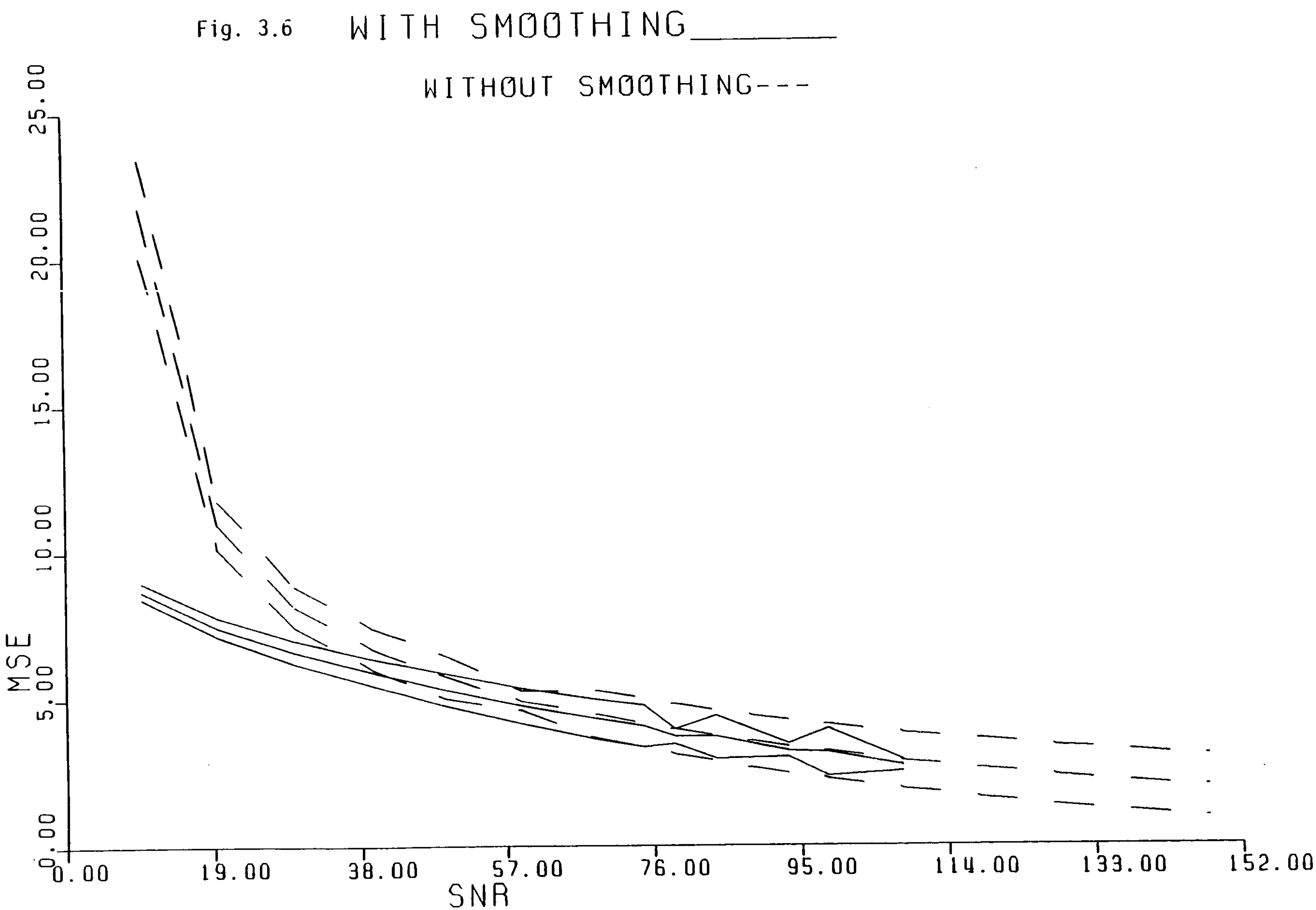
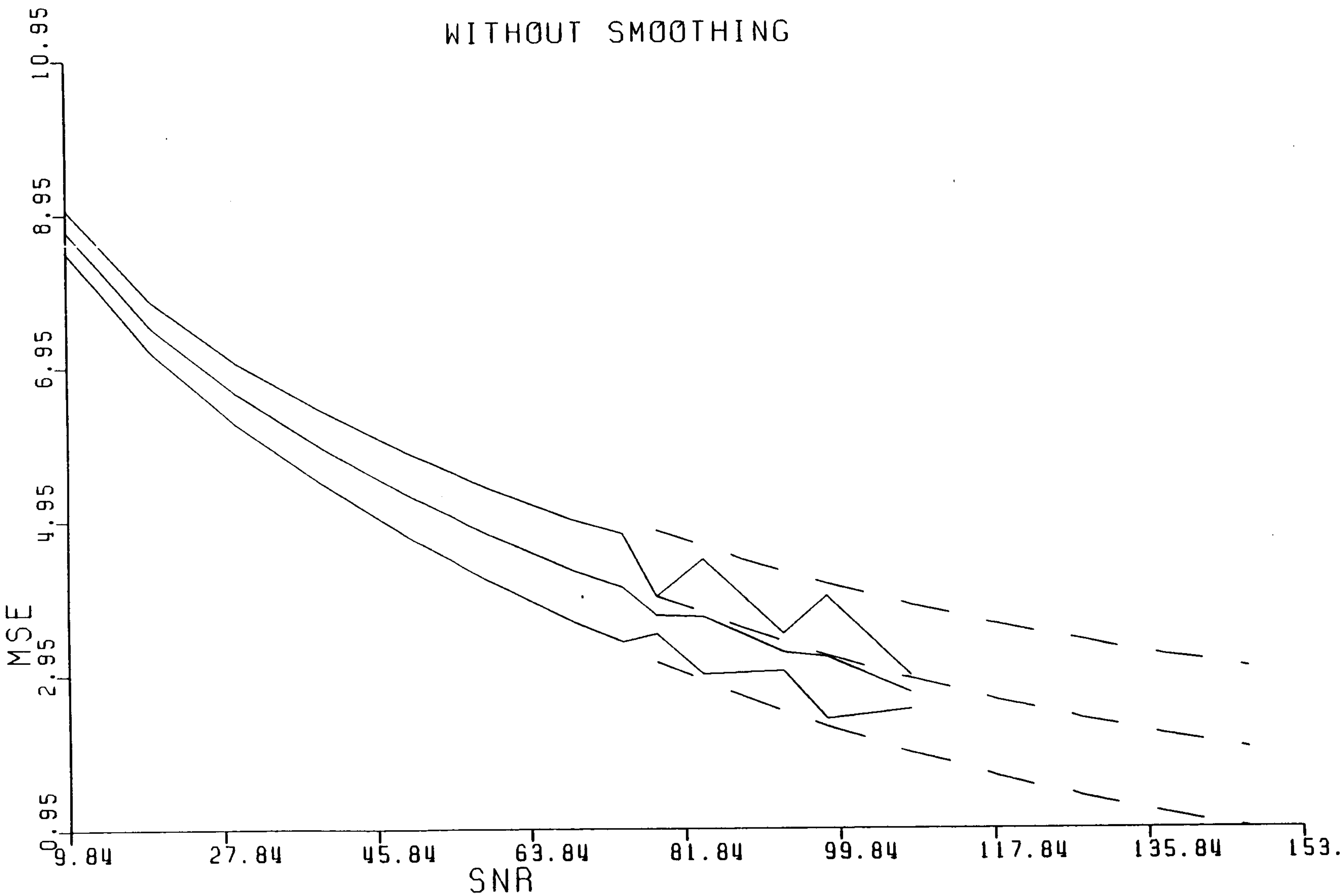

WITH SMOOTHING______
WITHOUT SMOOTHING---
MSE
0.00
5.00
10.00
15.00
20.00
25.00
SNR
0.00
19.00
38.00
57.00
76.00
95.00
114.00
133.00
152.00

Fig. 3.7 WITH SMOOTHING ______

WITHOUT SMOOTHING



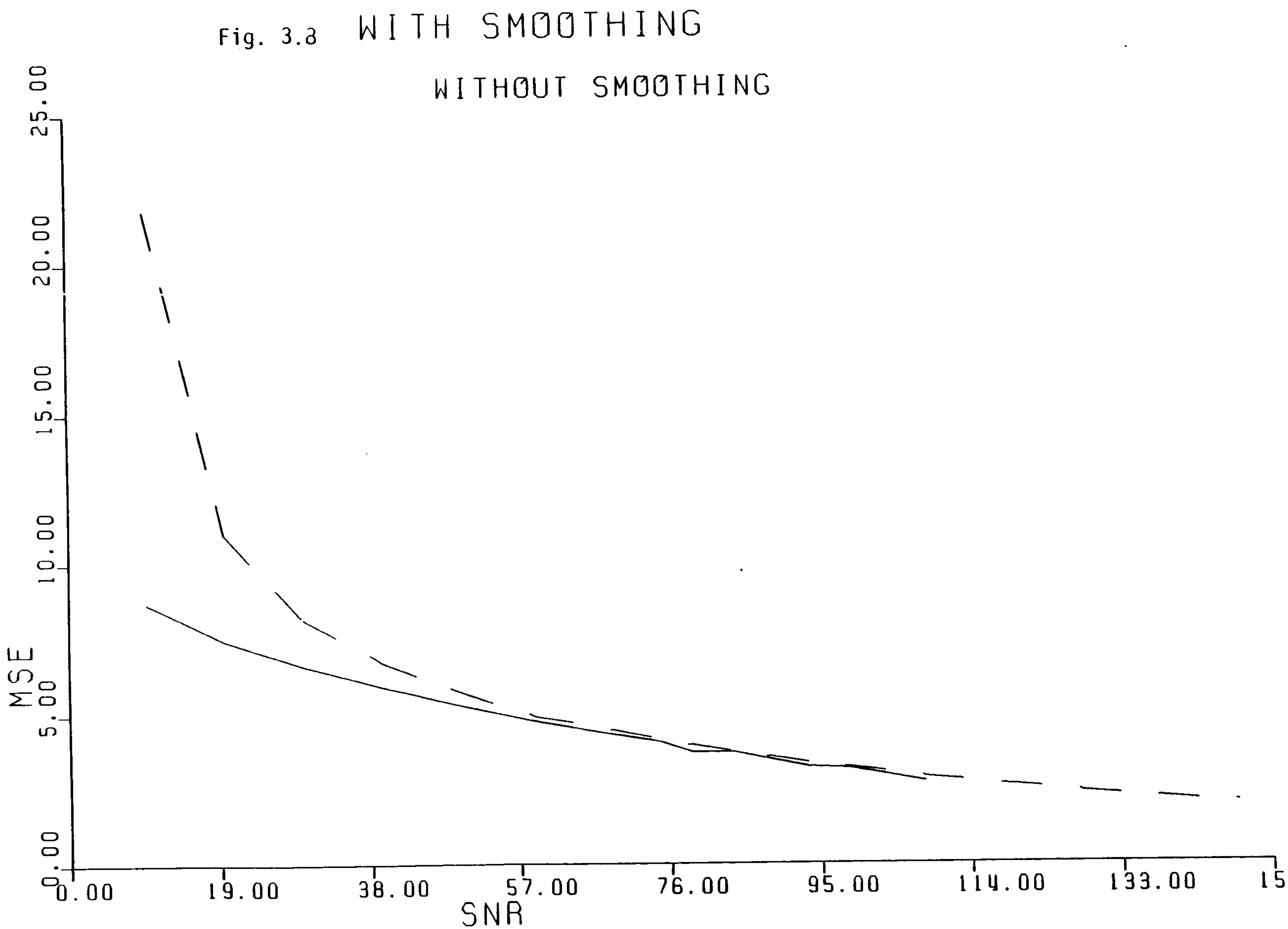

WITH SMOOTHING
WITHOUT SMOOTHING
MSE
0.00
5.00
10.00
15.00
20.00
25.00
SNR
0.00
19.00
38.00
57.00
76.00
95.00
114.00
133.00
152.00

Fig. 3.8

Fig. 3.9 UNFOLDING VS SNR

SMOOTHED SEISMIC DAT

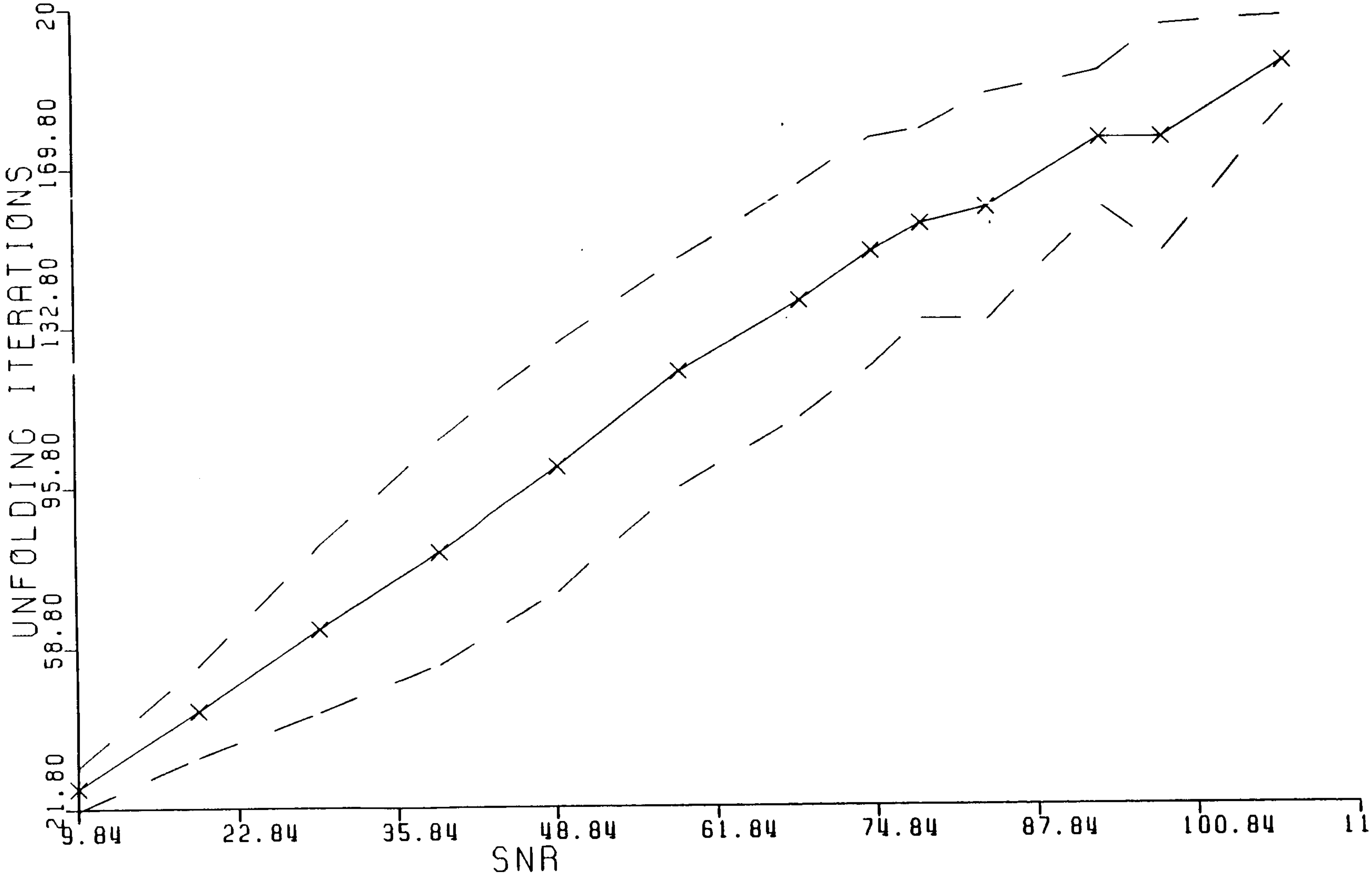
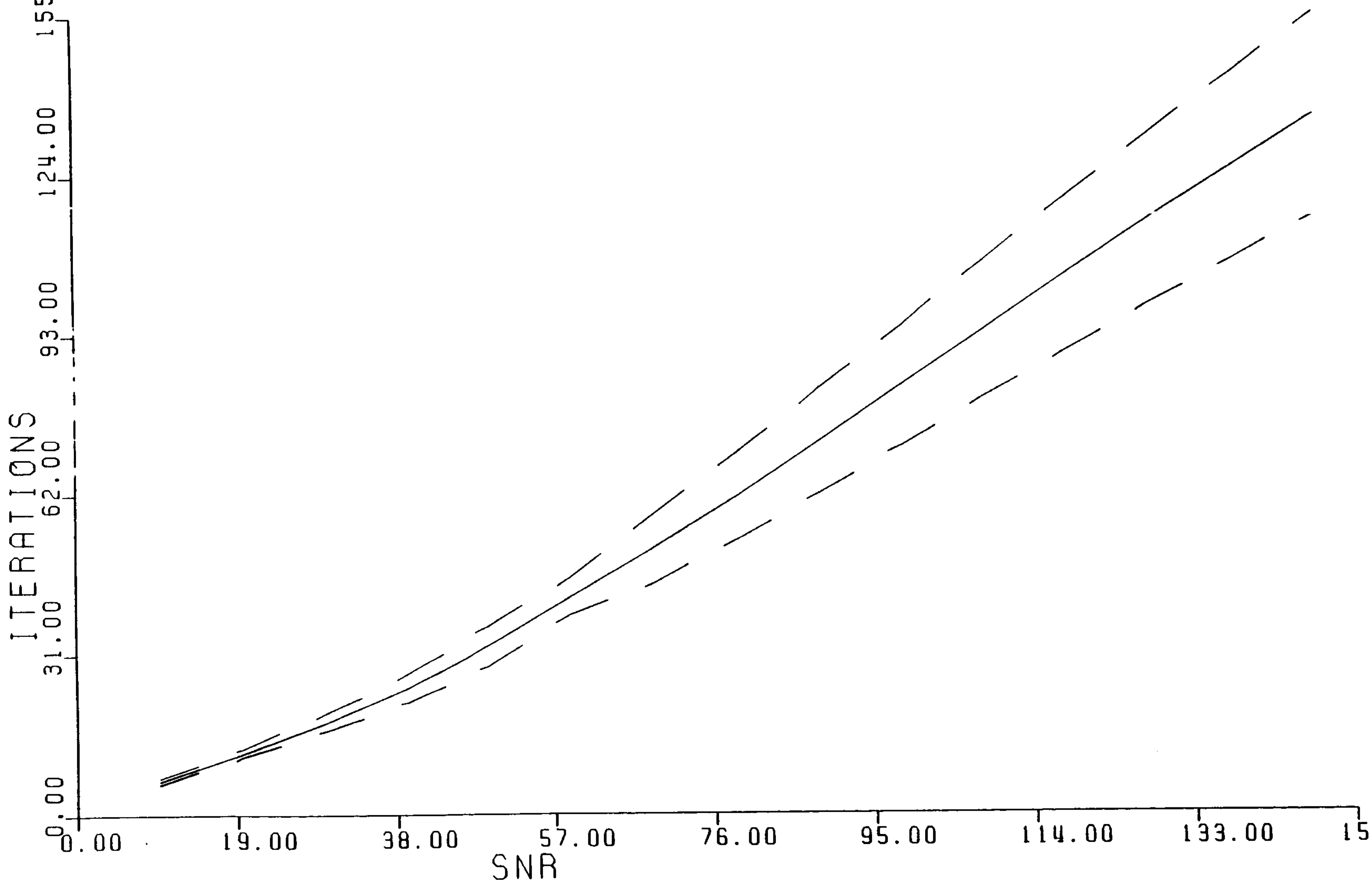
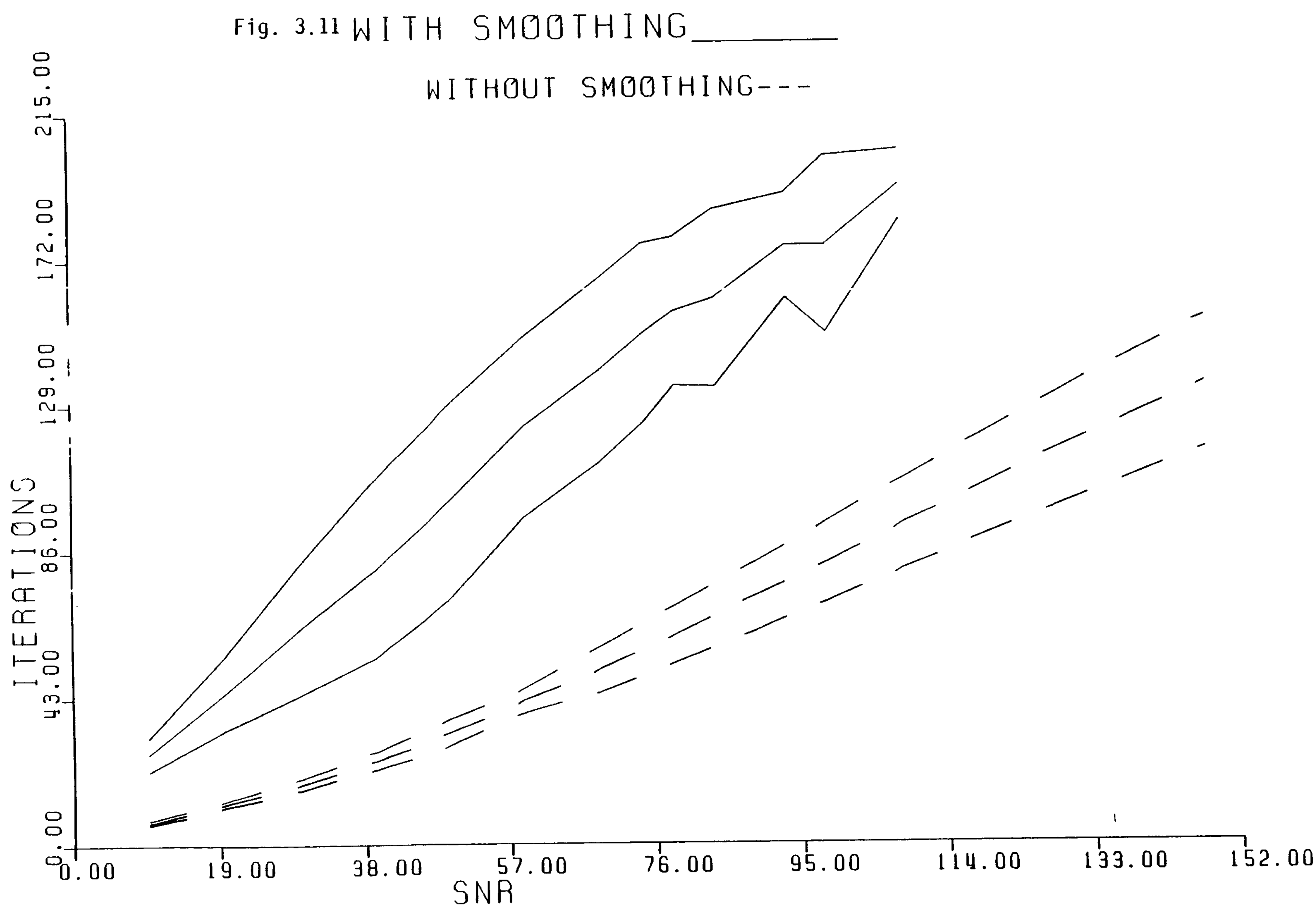


Fig 3.10 ITERATIONS VS SNR

WITHOUT SMOOTHING





WITH SMOOTHING
WITHOUT SMOOTHING---
215.00
172.00
129.00
86.00
43.00
0.00
ITERATIONS
0.00
19.00
38.00
57.00
76.00
95.00
114.00
133.00
152.00
SNR

Fig. 3.11

Fig. 3.12 SMOOTHING VS SNR

SMOOTHED SEISMIC DAT

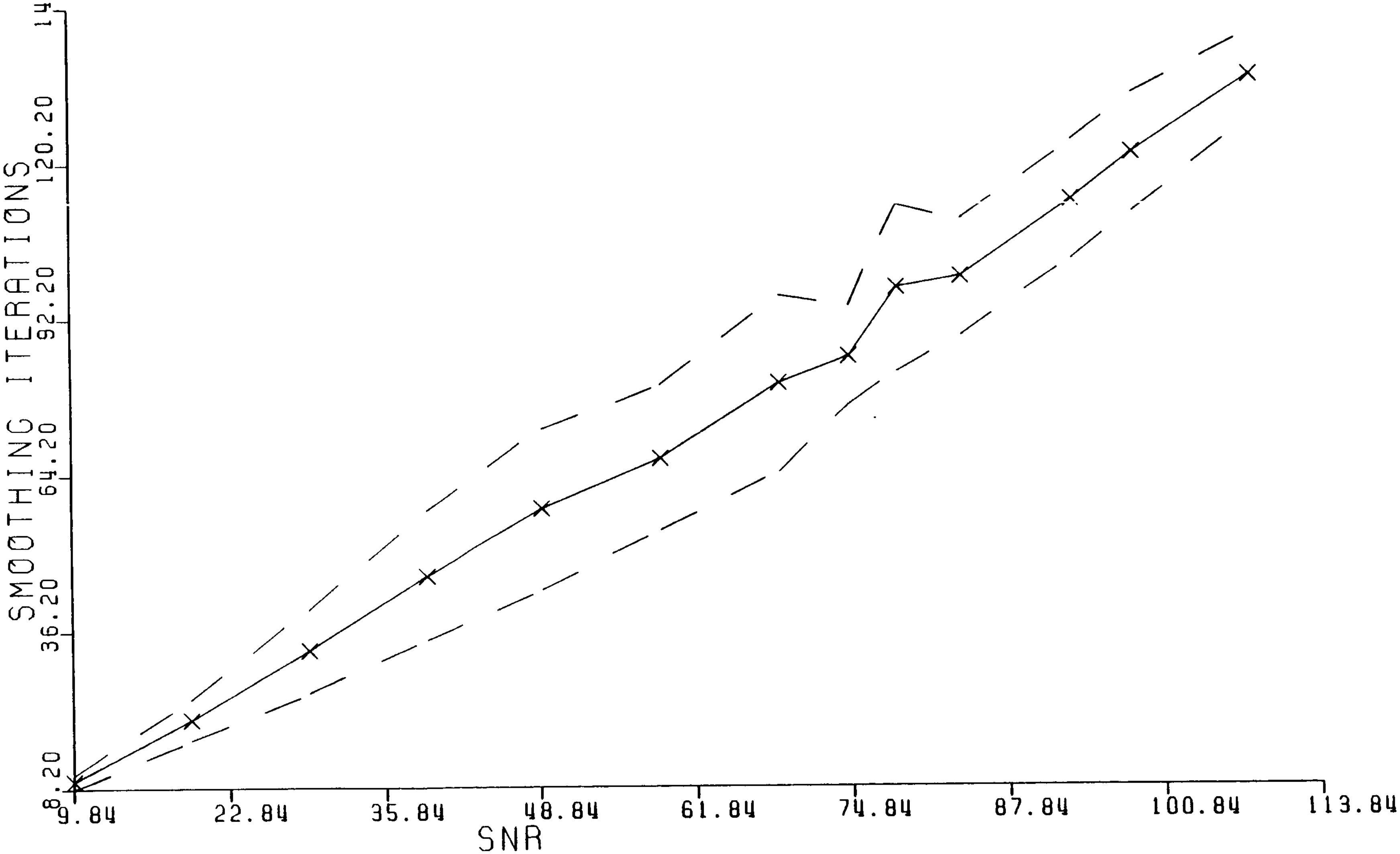


Fig. 3.13 Deconvolved result
Noise Free

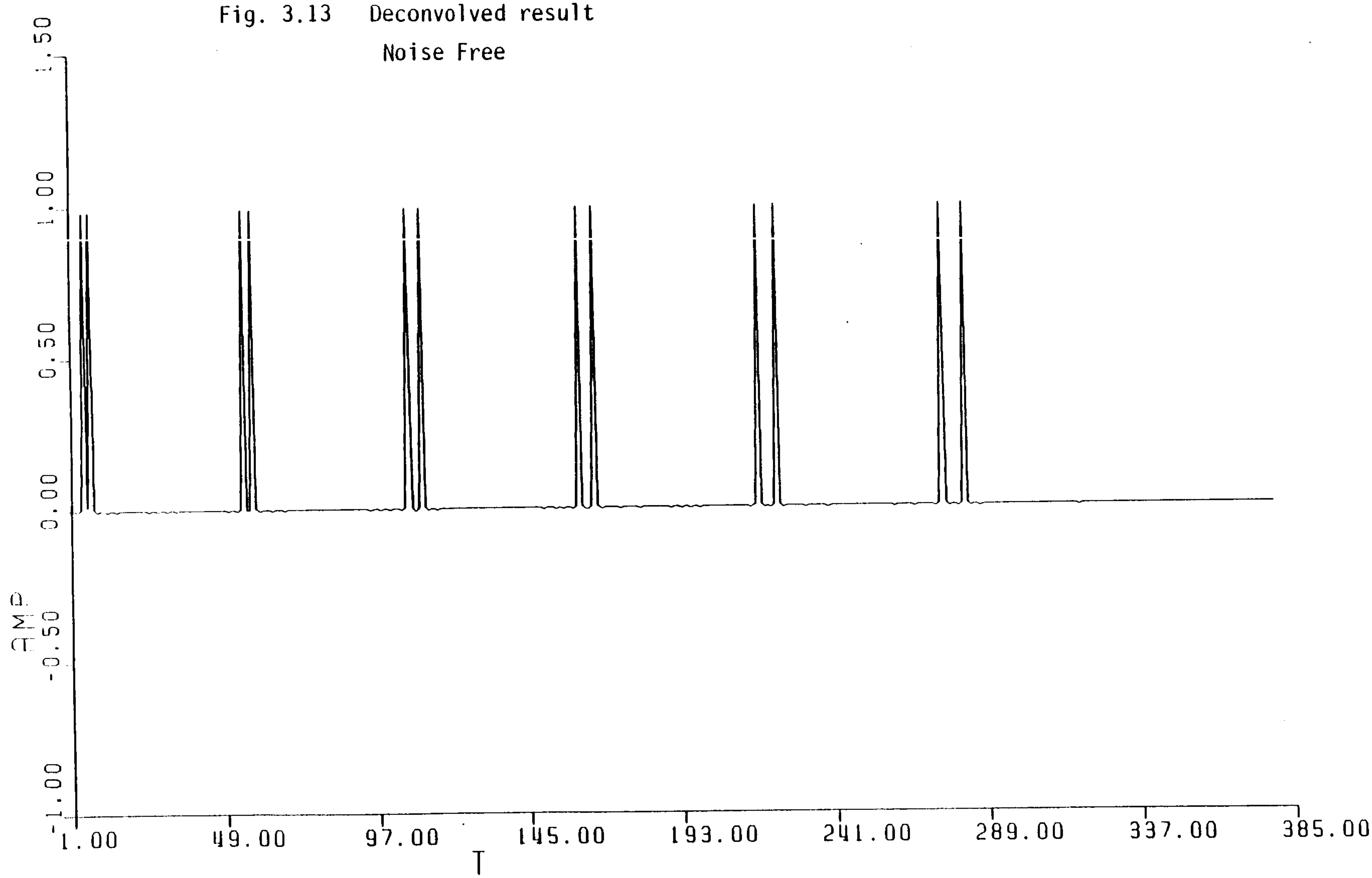


Fig. 3.14 NØISY DATA, H

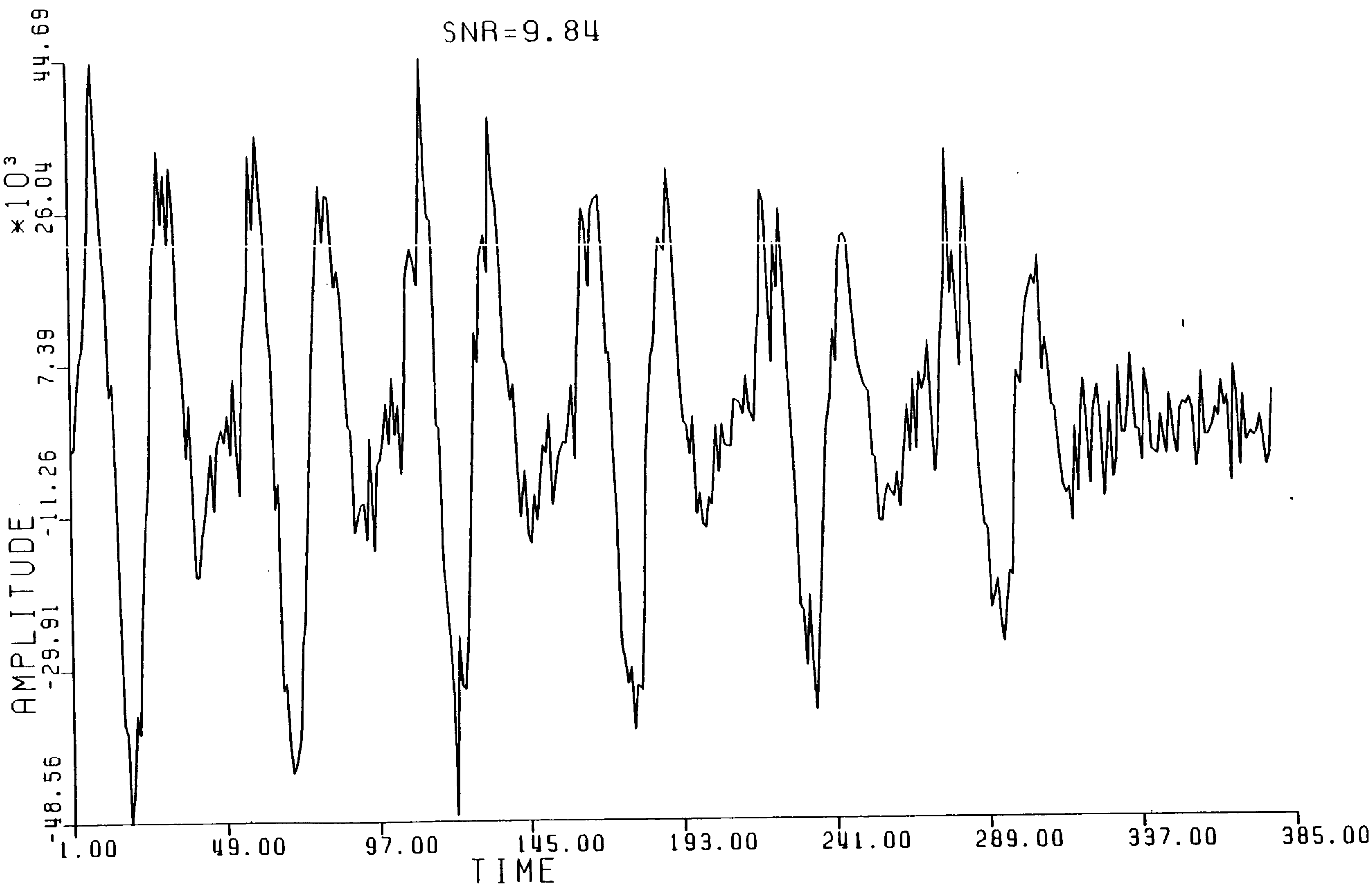


Fig. 3.15 SMOOTHED DATA

SNR=9.84

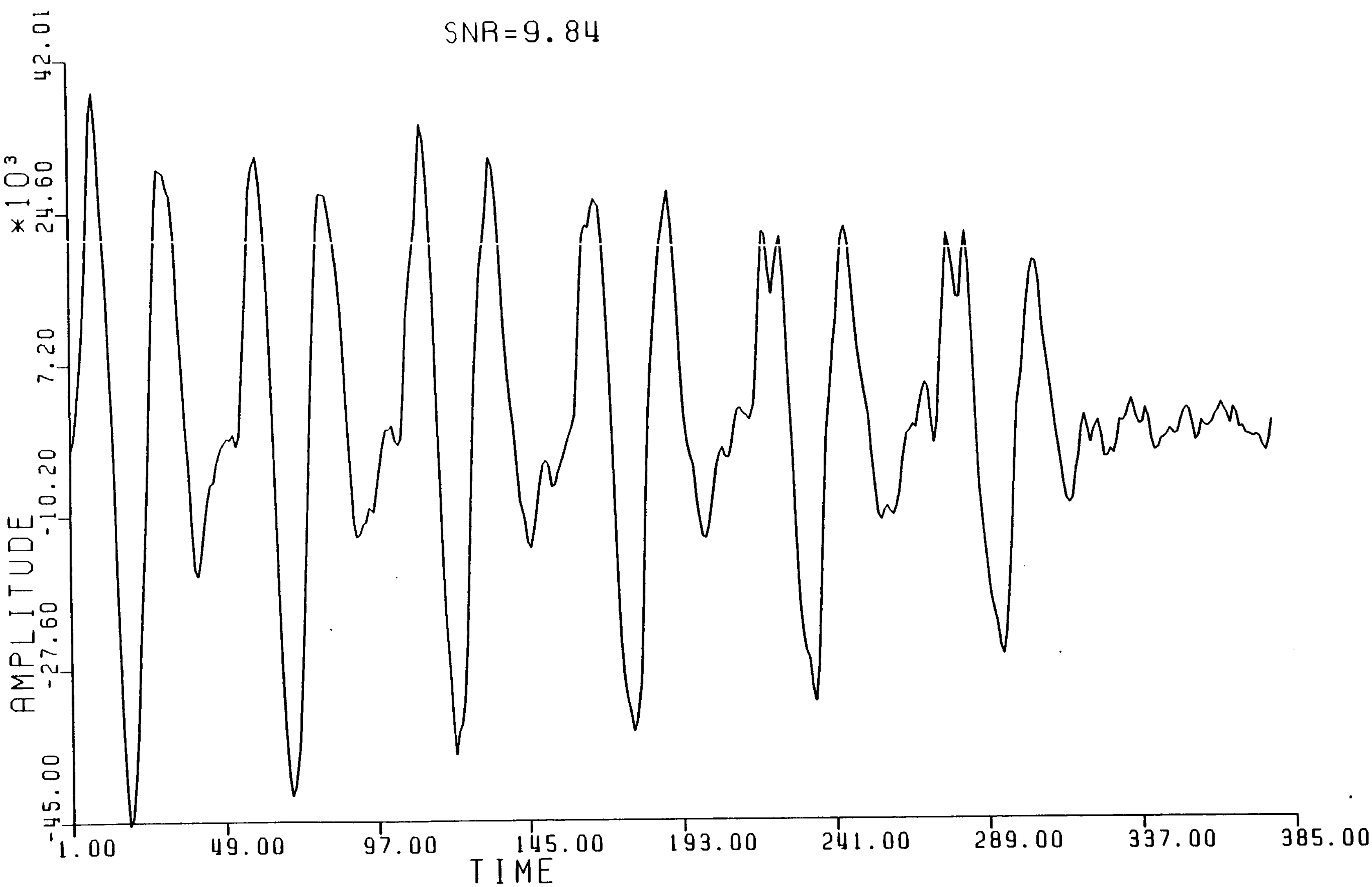


Fig. 3.16 DECONVOLUTION RESULT

SNR= 10 SMOOTHING=0

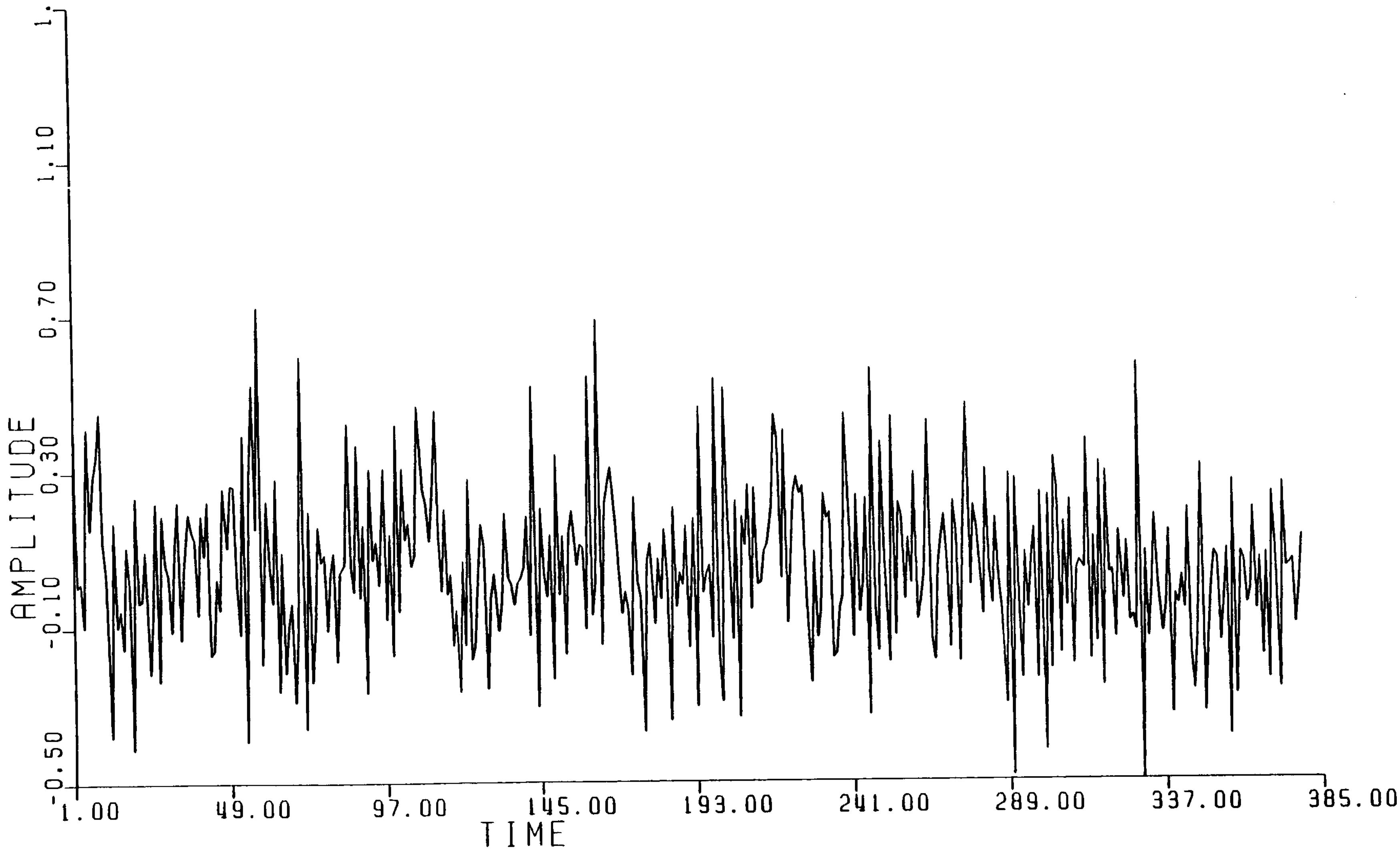


Fig. 3.17 DECONVOLVED RESULT

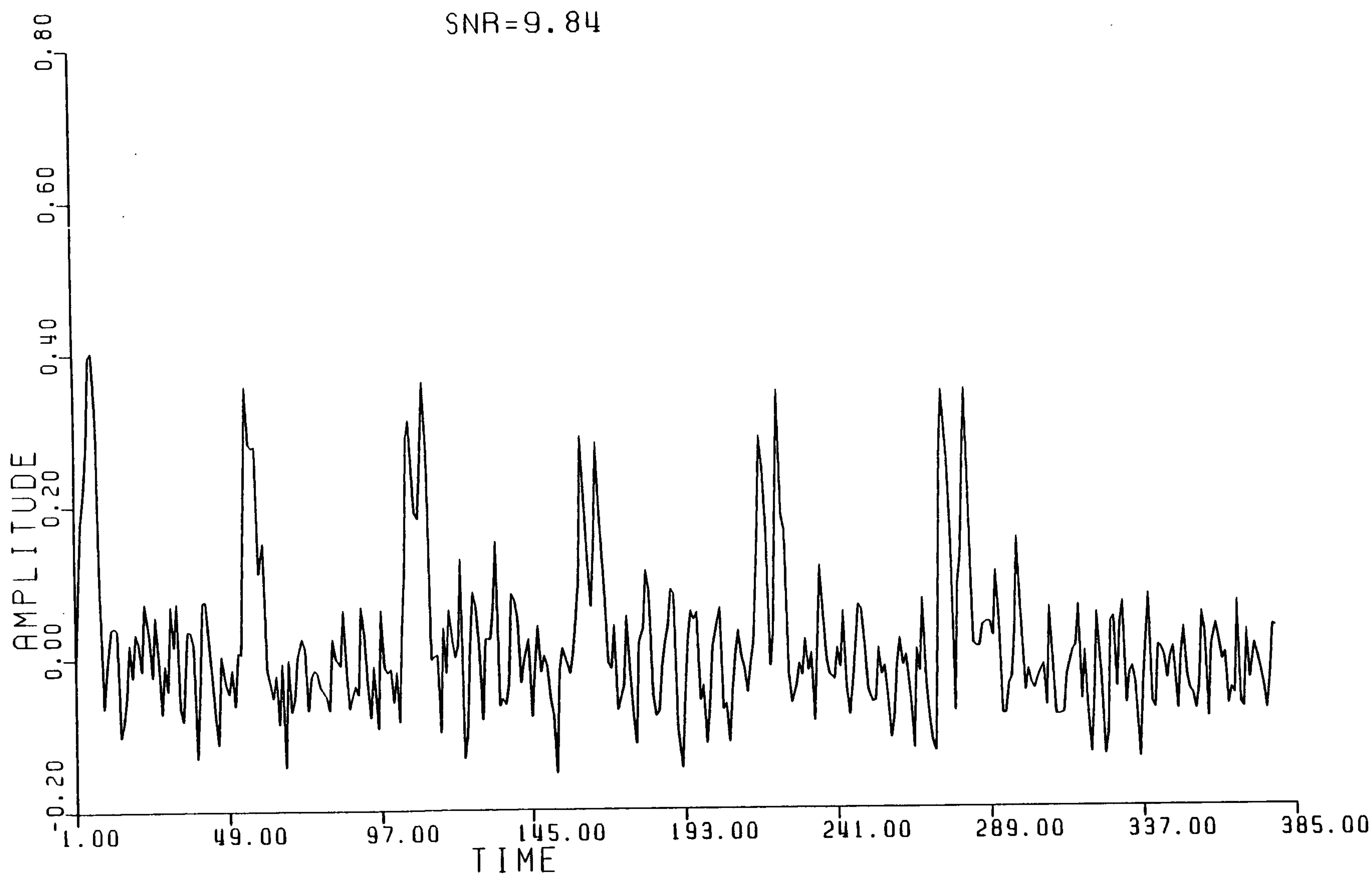


Fig 3.18

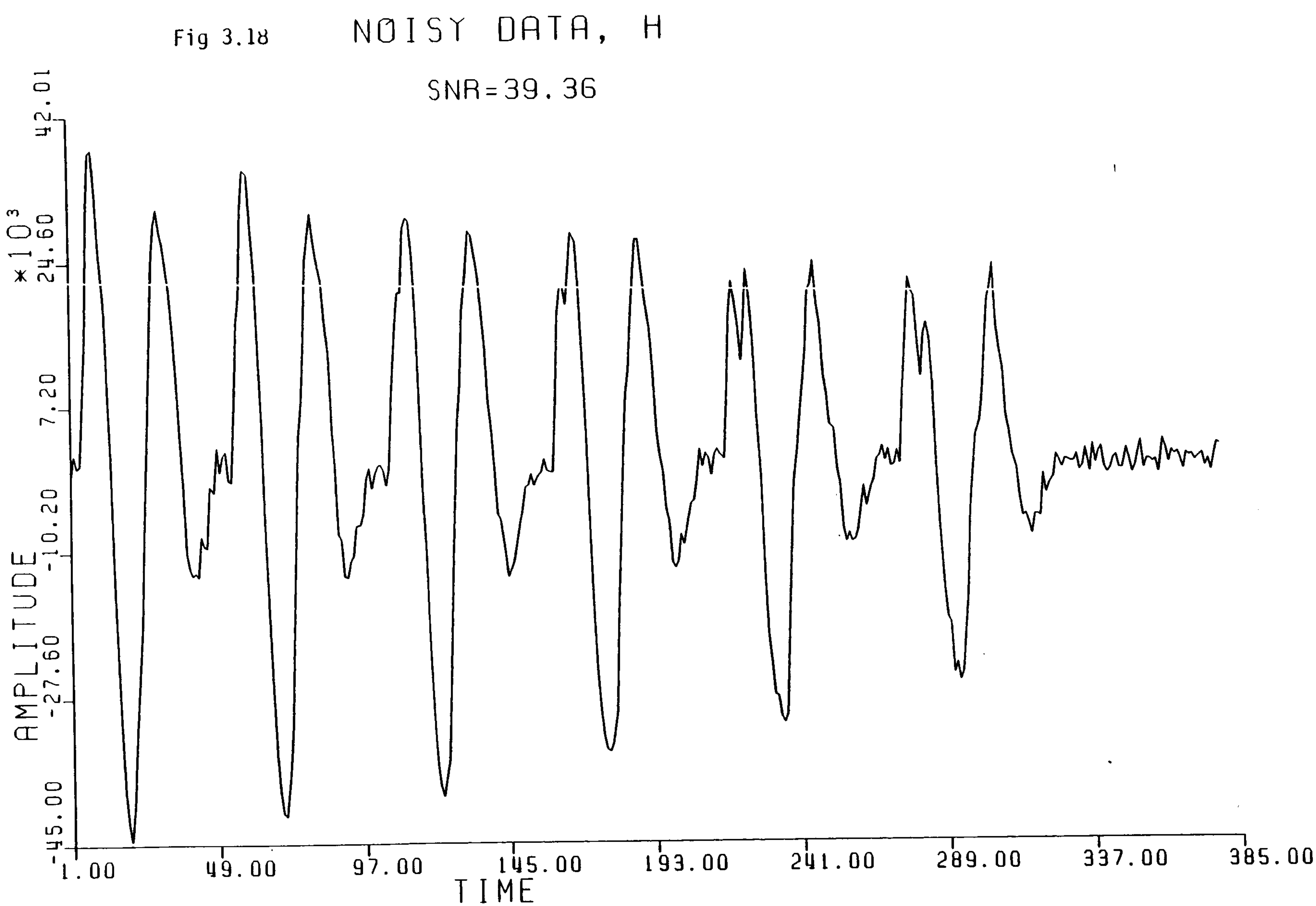

NOISY DATA, H
SNR=39.36
AMPLITUDE
$*10^3$
42.01
24.60
7.20
-10.20
-27.60
-45.00
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME

Fig. 3.19

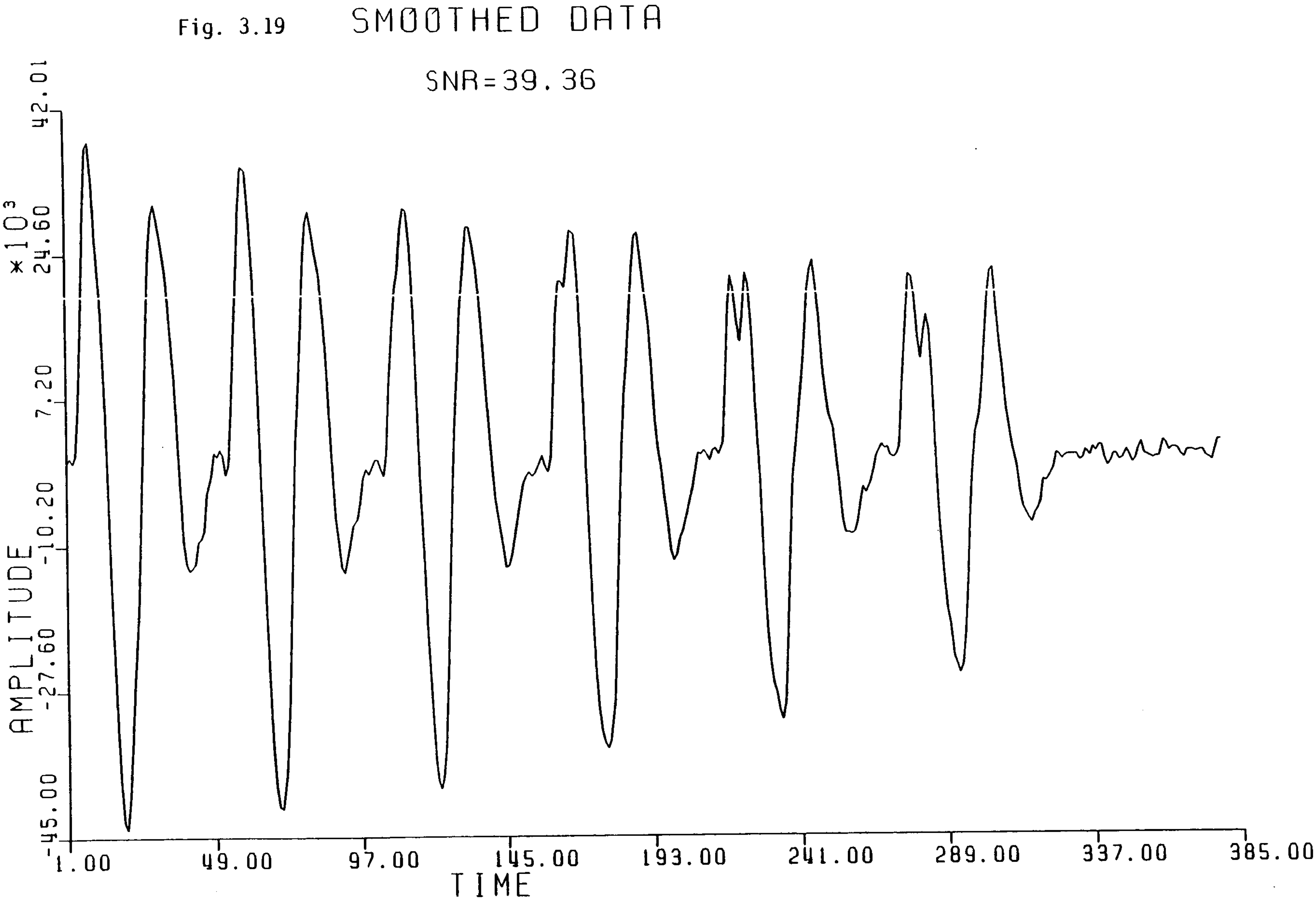
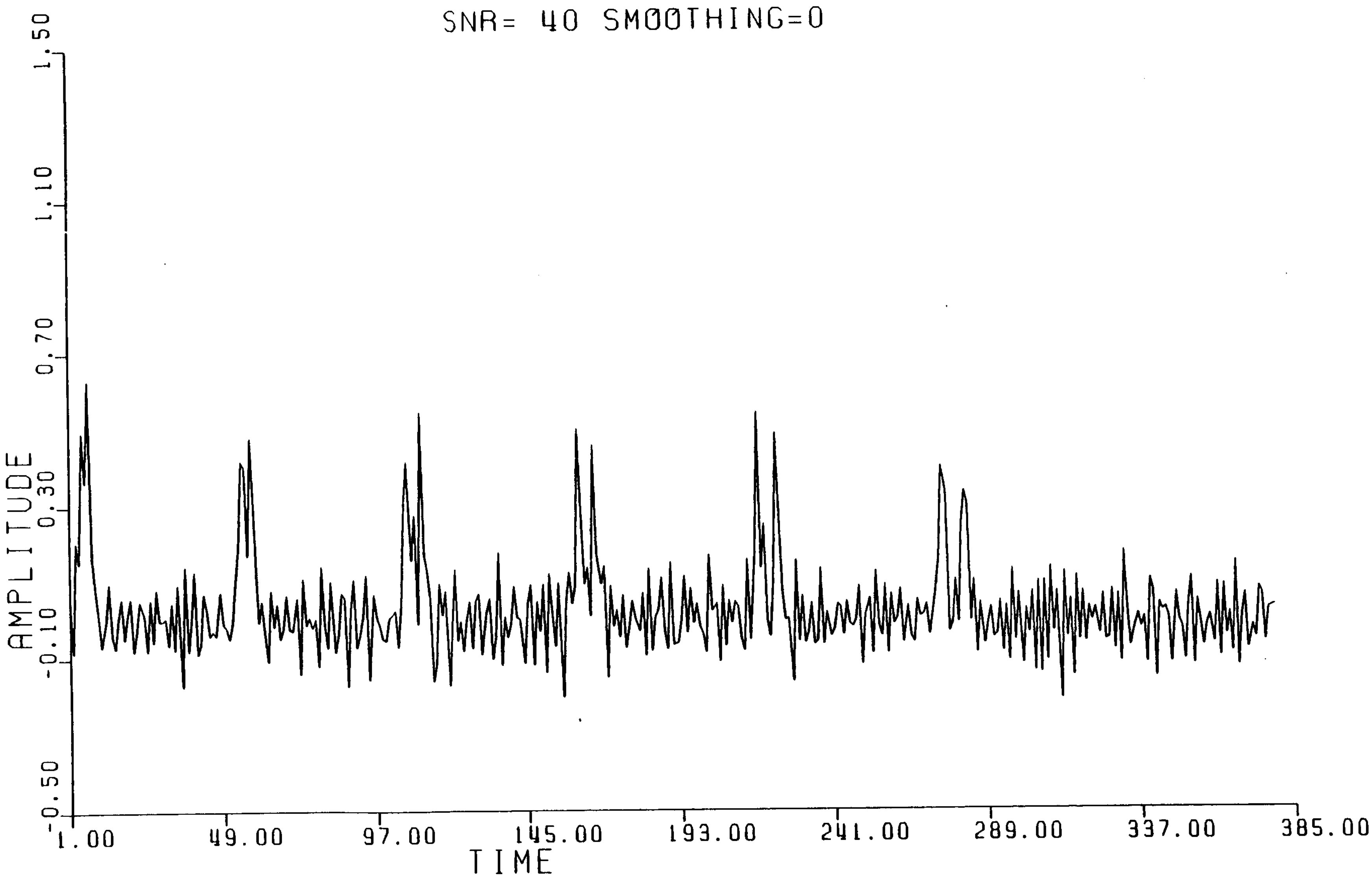

SMOOTHED DATA
SNR=39.36
AMPLITUDE
*10³
42.01
24.60
7.20
-10.20
-27.60
-45.00
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME

Fig. 3.20 DECONVOLUTION RESULT

SNR= 40 SMOOTHING=0



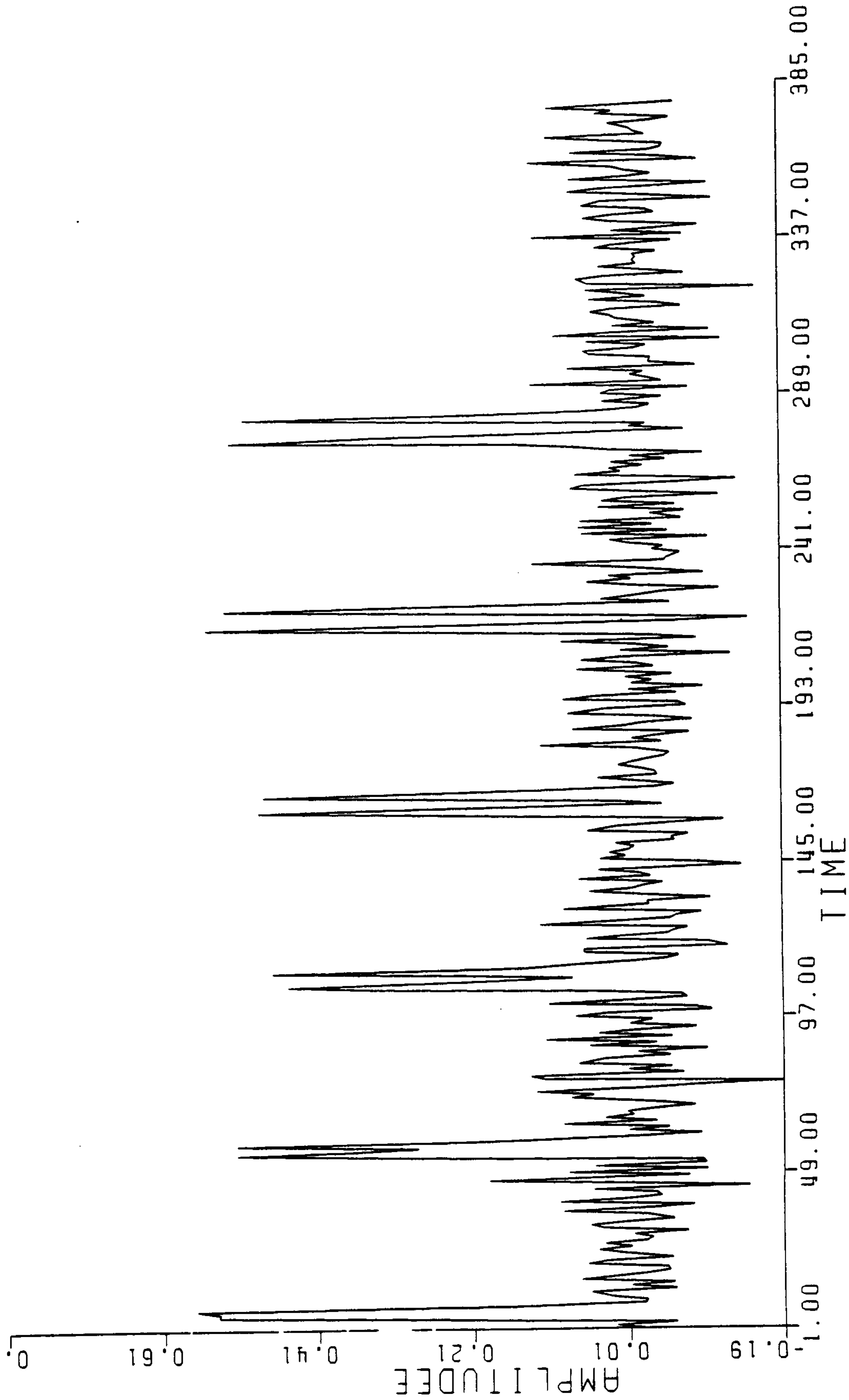


Fig. 3.21 DECONVOLVED RESULT

SNR=39.36

Fig. 3.22 H, WITHOUT SMOOTHING

SNR=147

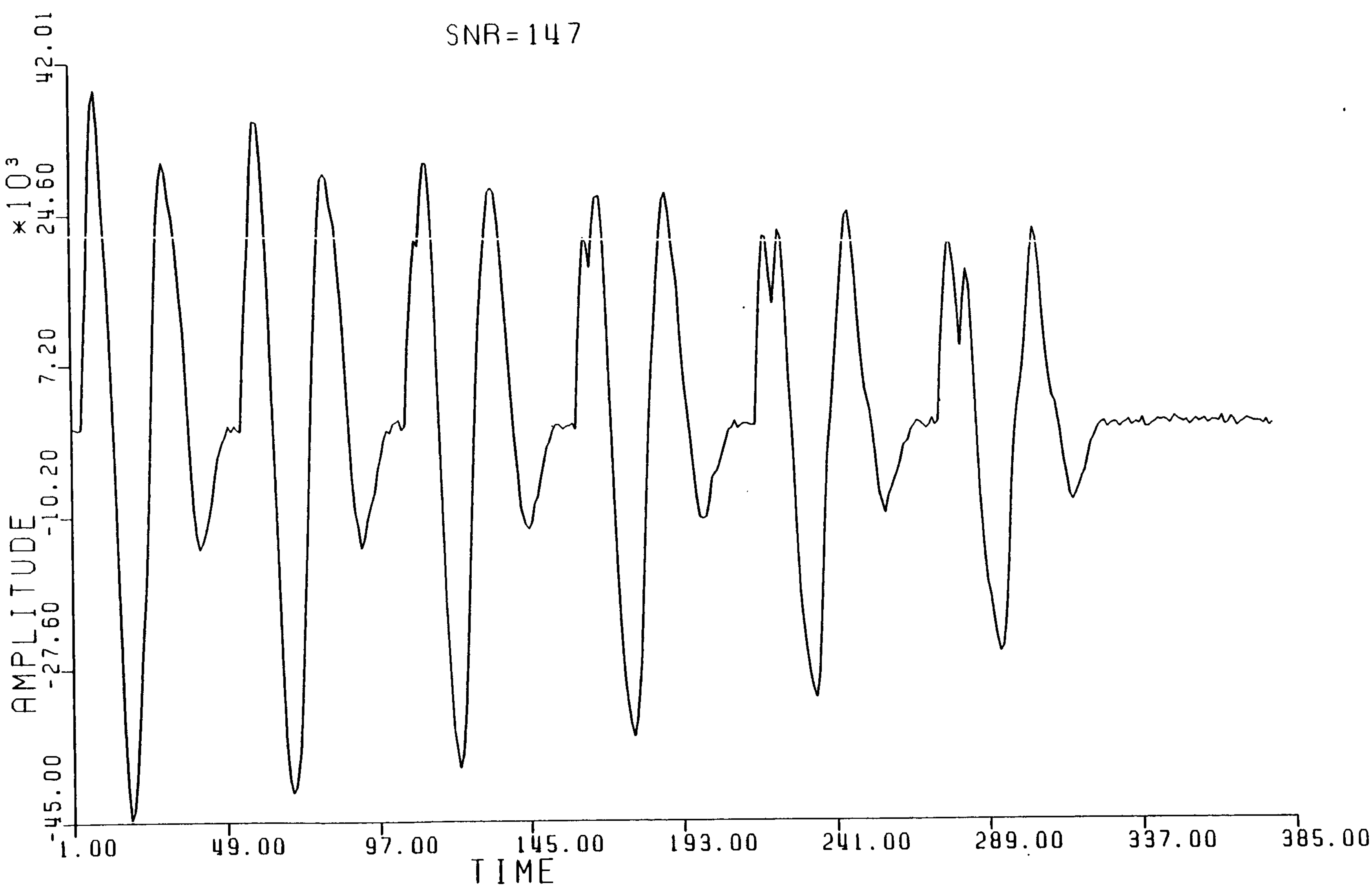


Fig 3.23

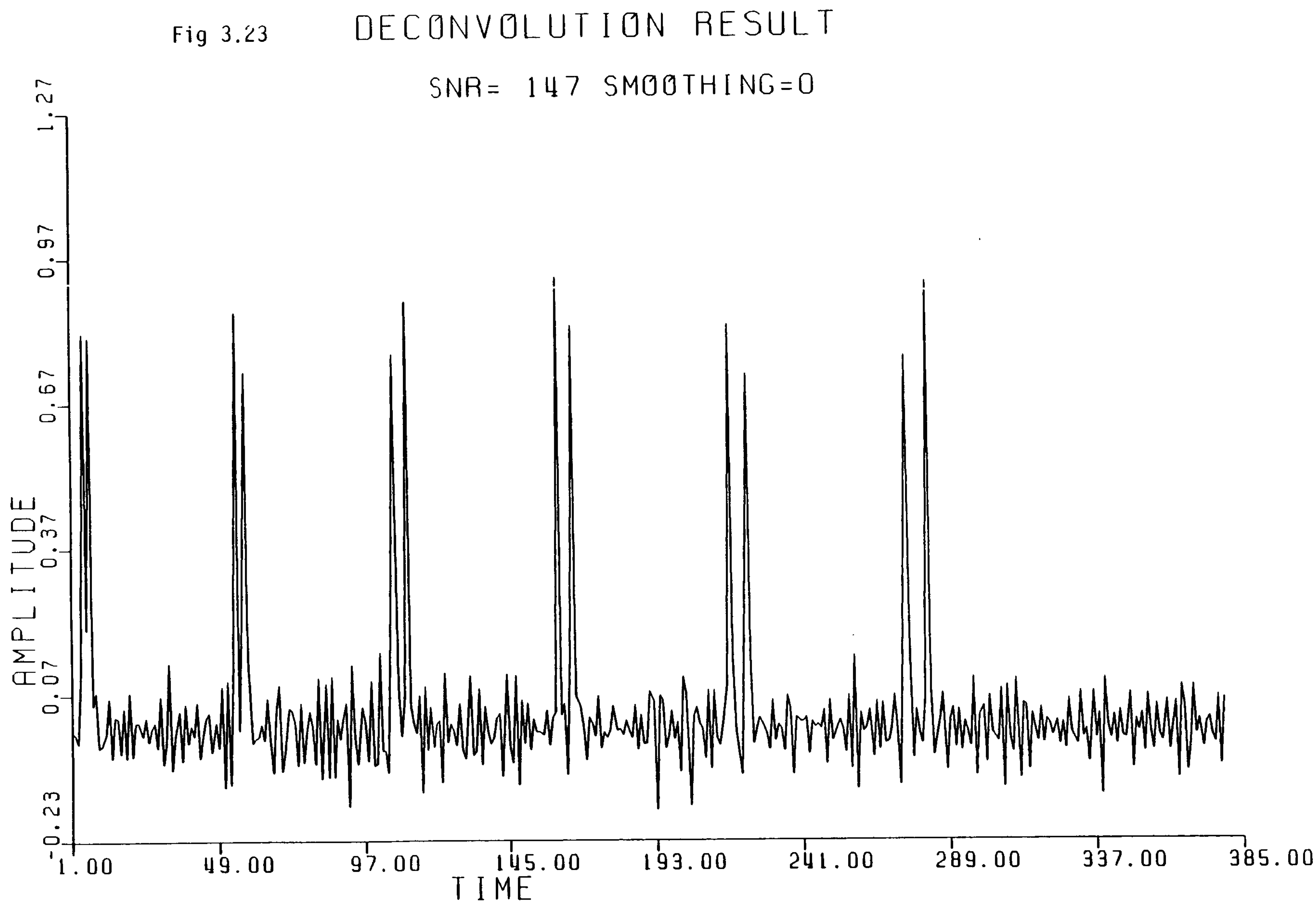

DECONVOLUTION RESULT
SNR= 147 SMOOTHING=0
AMPLITUDE
1.27
0.97
0.67
0.37
0.07
-0.23
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

Fig. 3.24 MSE VS SNR

REBLURRING PROCEDURE

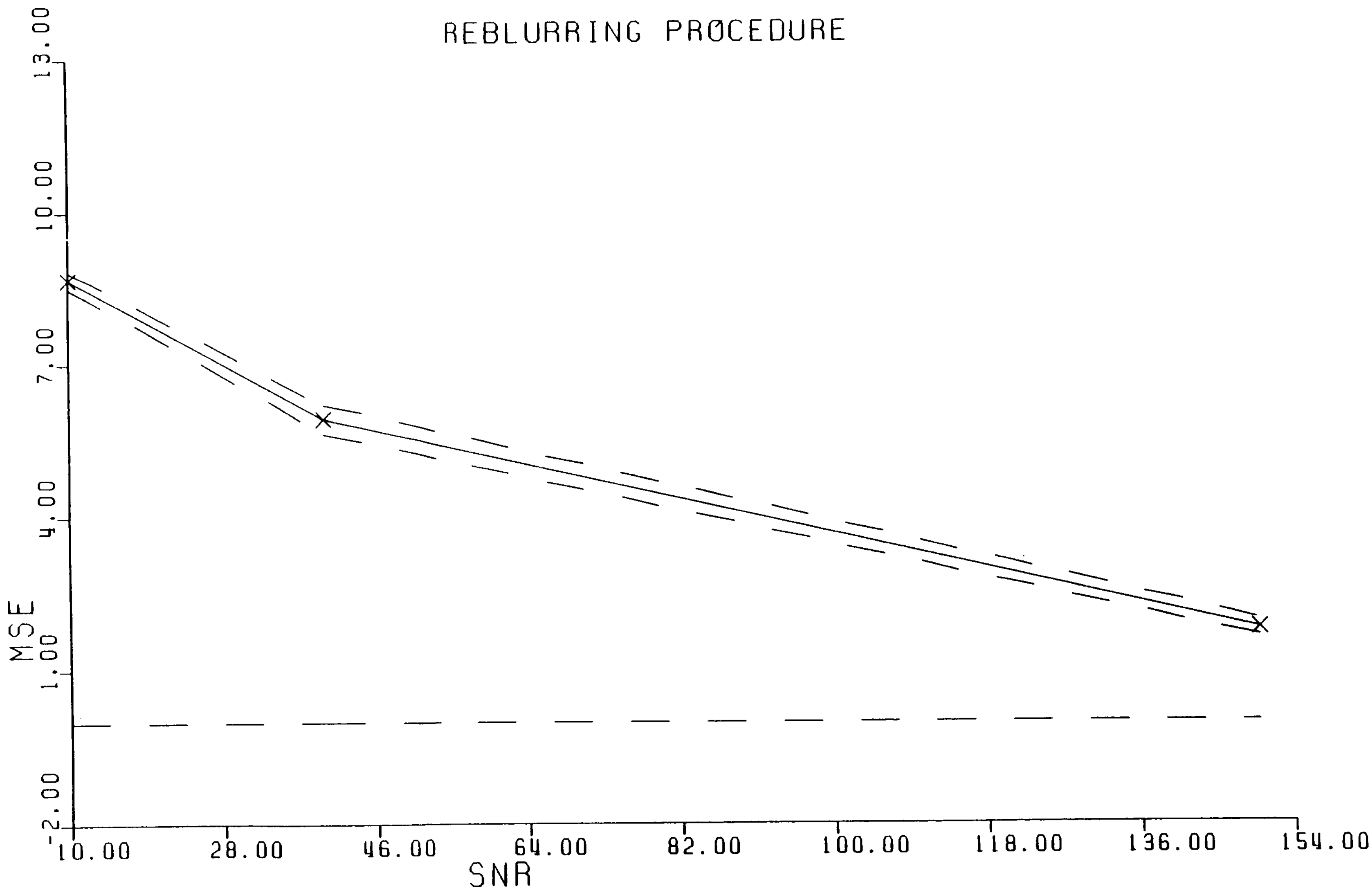


Fig. 3.25

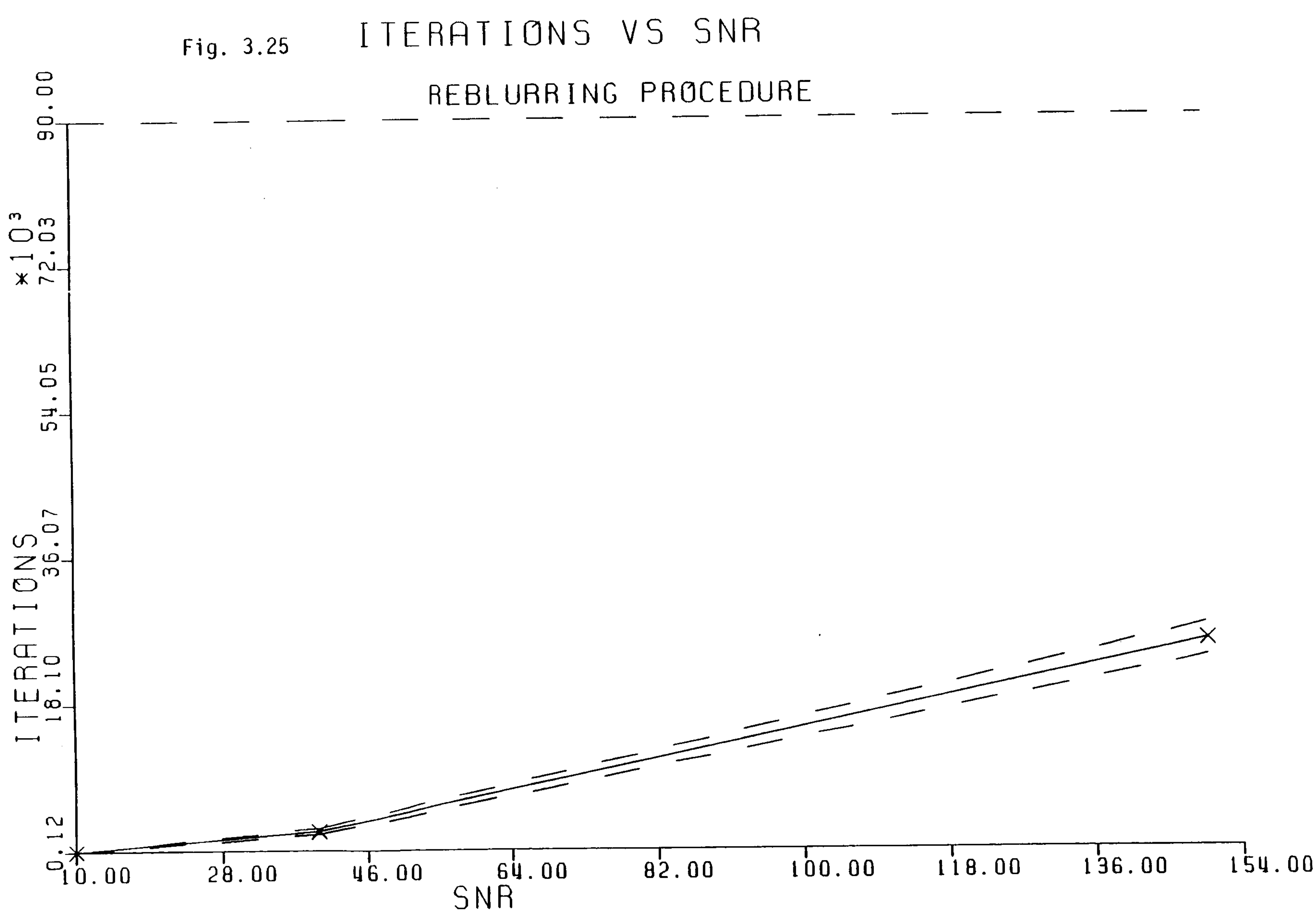

ITERATIONS VS SNR
REBLURRING PROCEDURE
ITERATIONS
*10³
90.00
72.03
54.05
36.07
18.10
0.12
10.00
28.00
46.00
64.00
82.00
100.00
118.00
136.00
154.00
SNR

Fig. 3.26 RB SNR=00

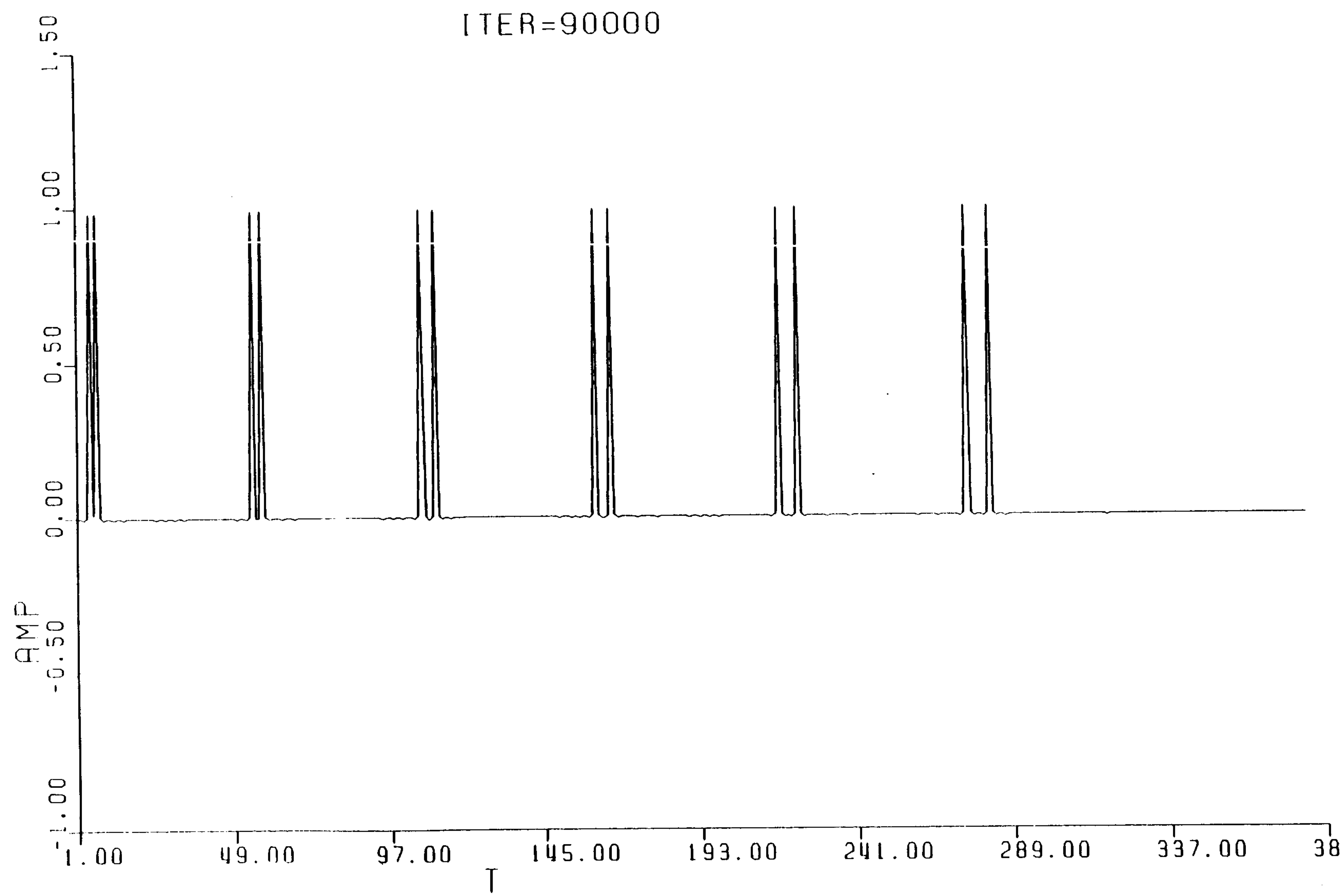


Fig. 3.2.7 DECONVOLVED RESULT

RB. SNR=10

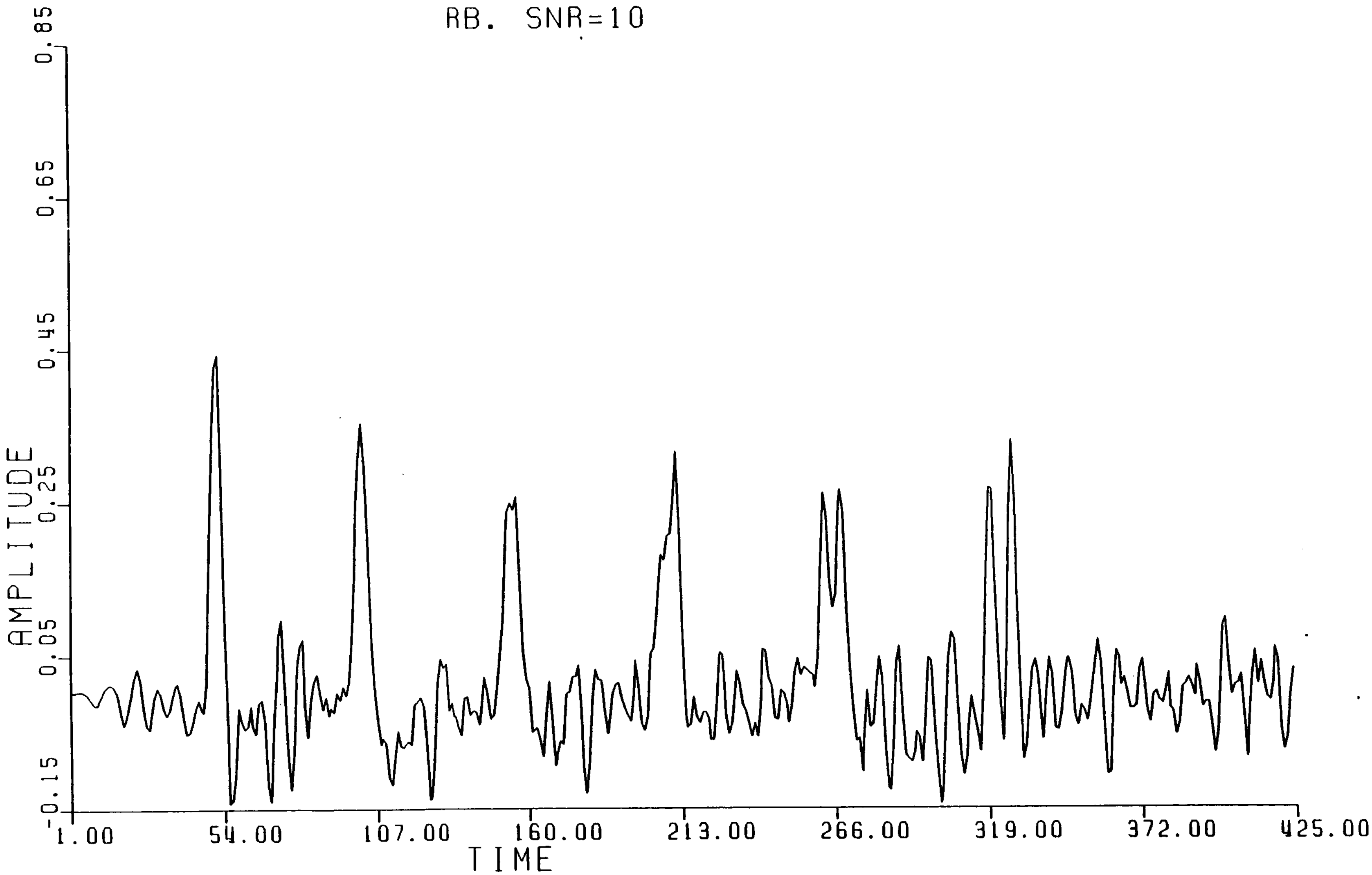


Fig. 3.28 DECONVOLVED RESULT

RB. SNR=40

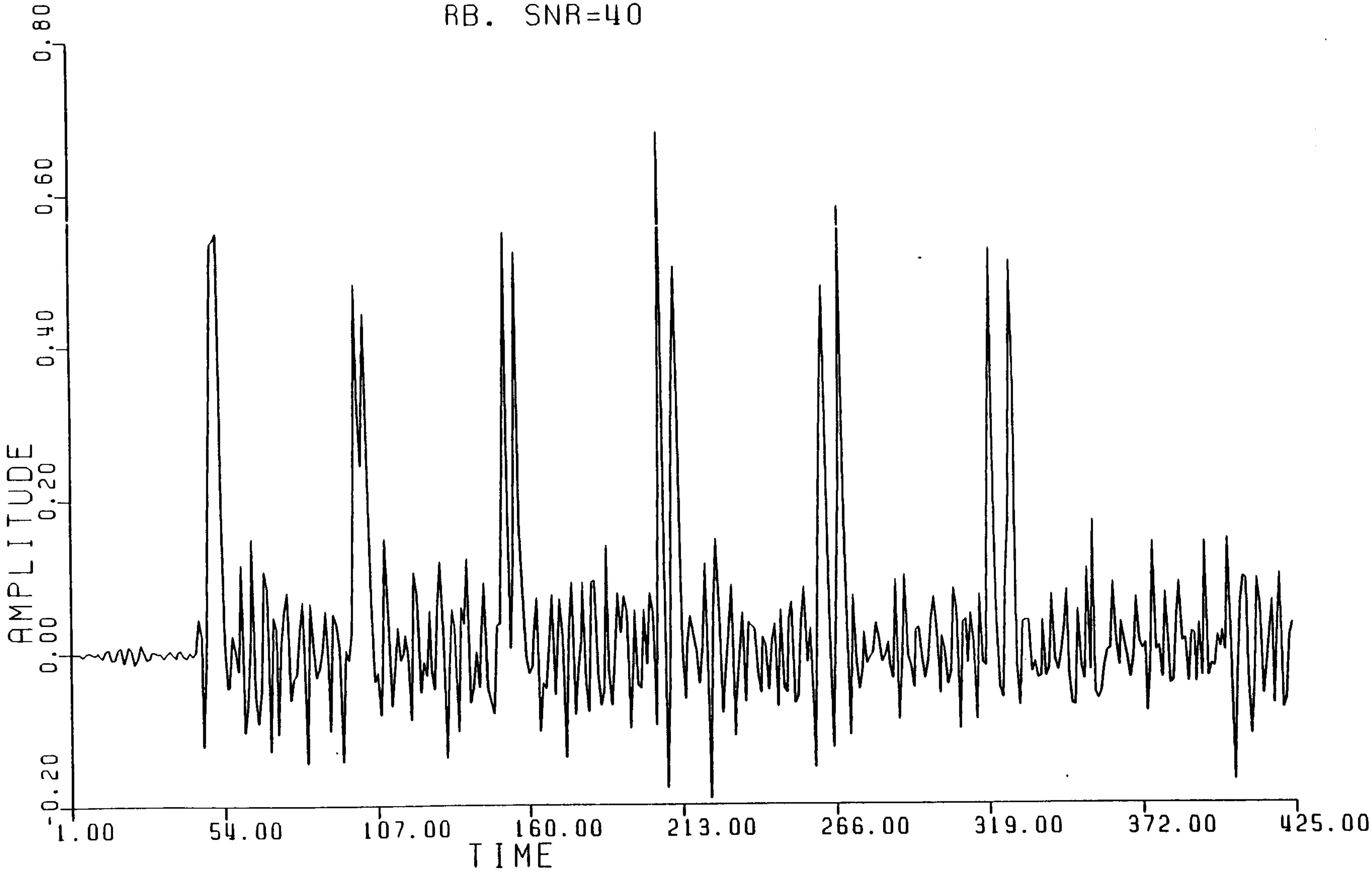


Fig. 3.29 DECONVOLVED RESULT

RB. SNR=150

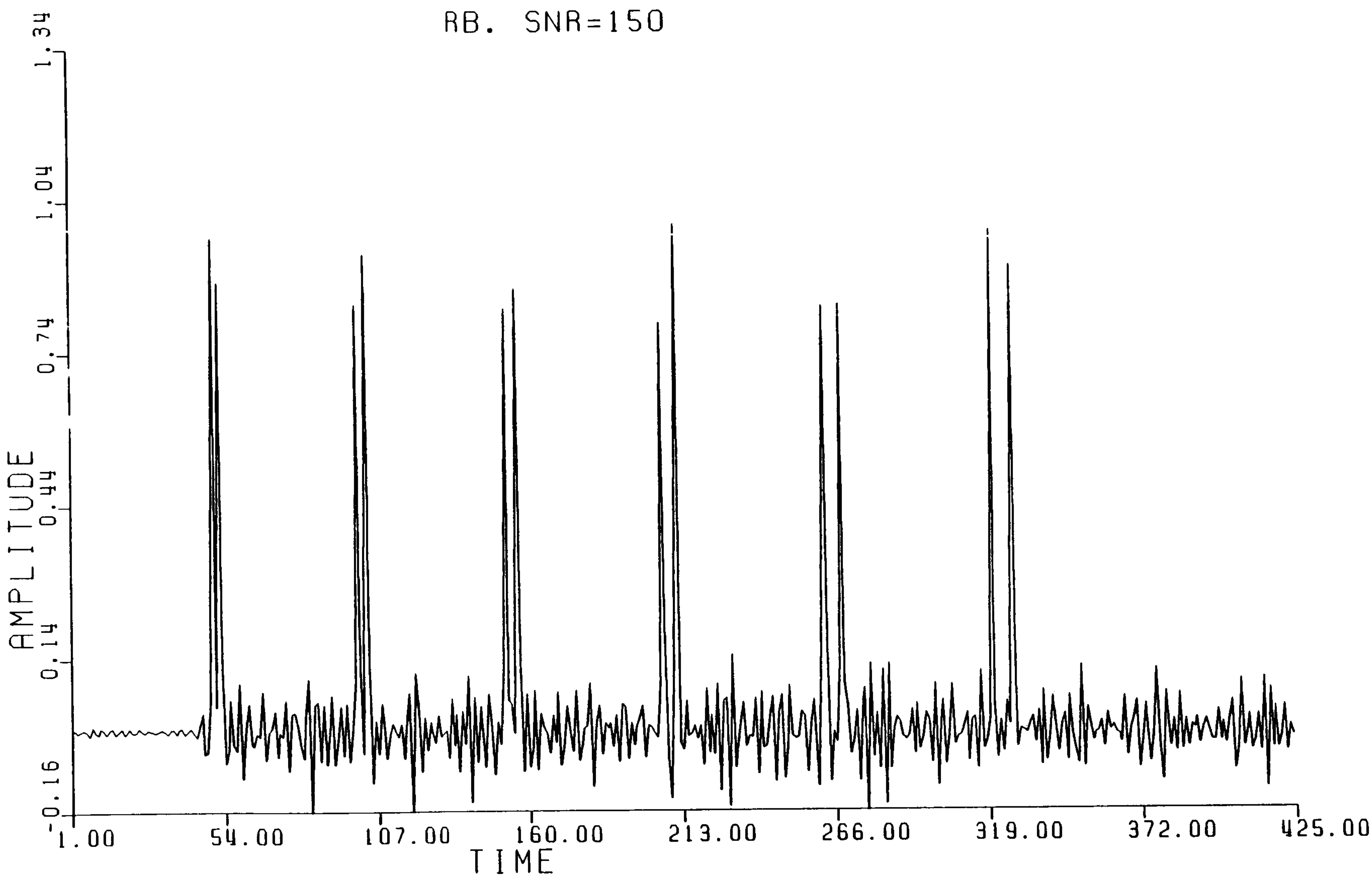
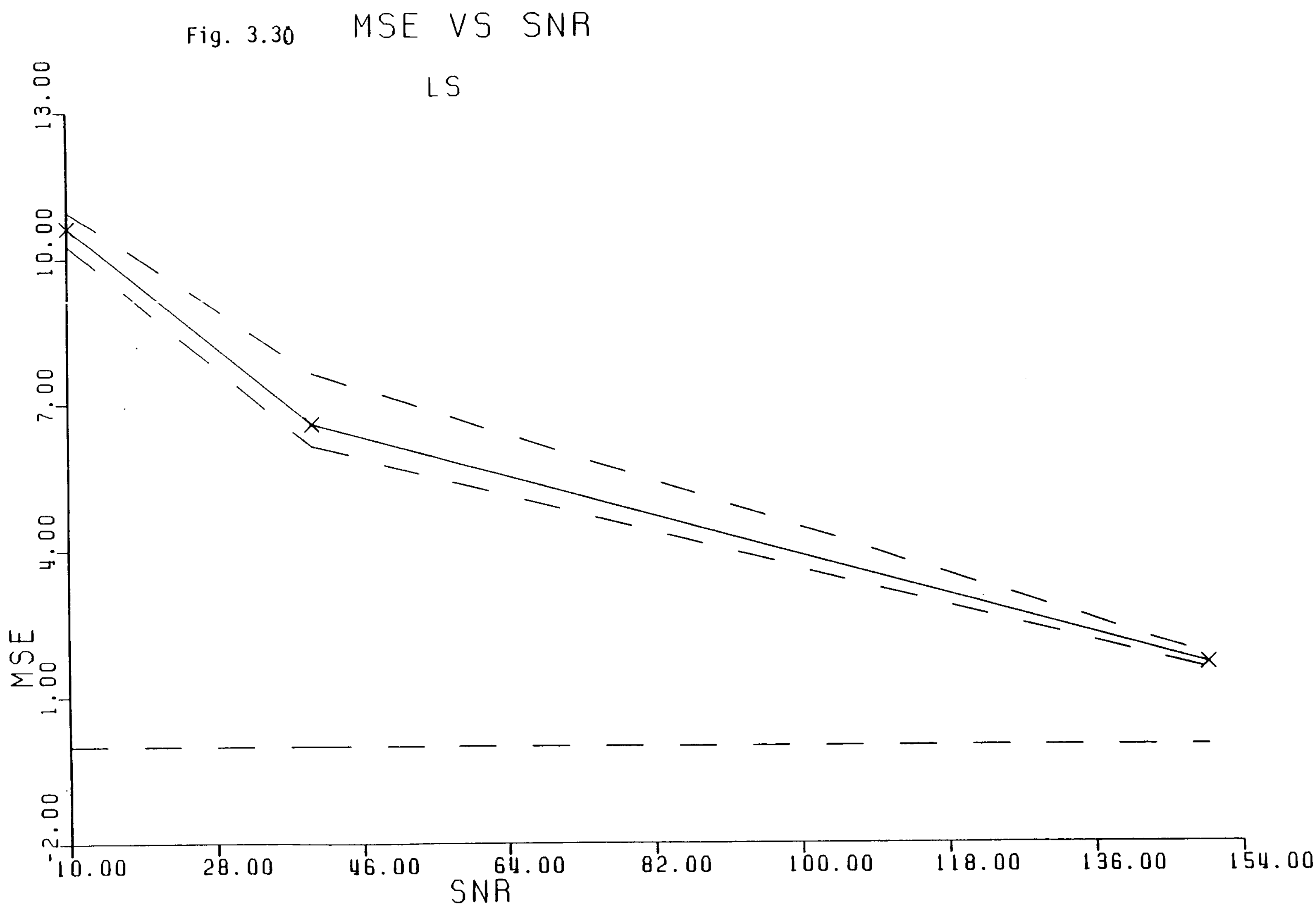


Fig. 3.30



MSE VS SNR
LS
MSE
13.00
10.00
7.00
4.00
1.00
-2.00
SNR
10.00
28.00
46.00
64.00
82.00
100.00
118.00
136.00
154.00

Fig. 3.31 LS INVERSE FILTERING

WITH NØ NØISE

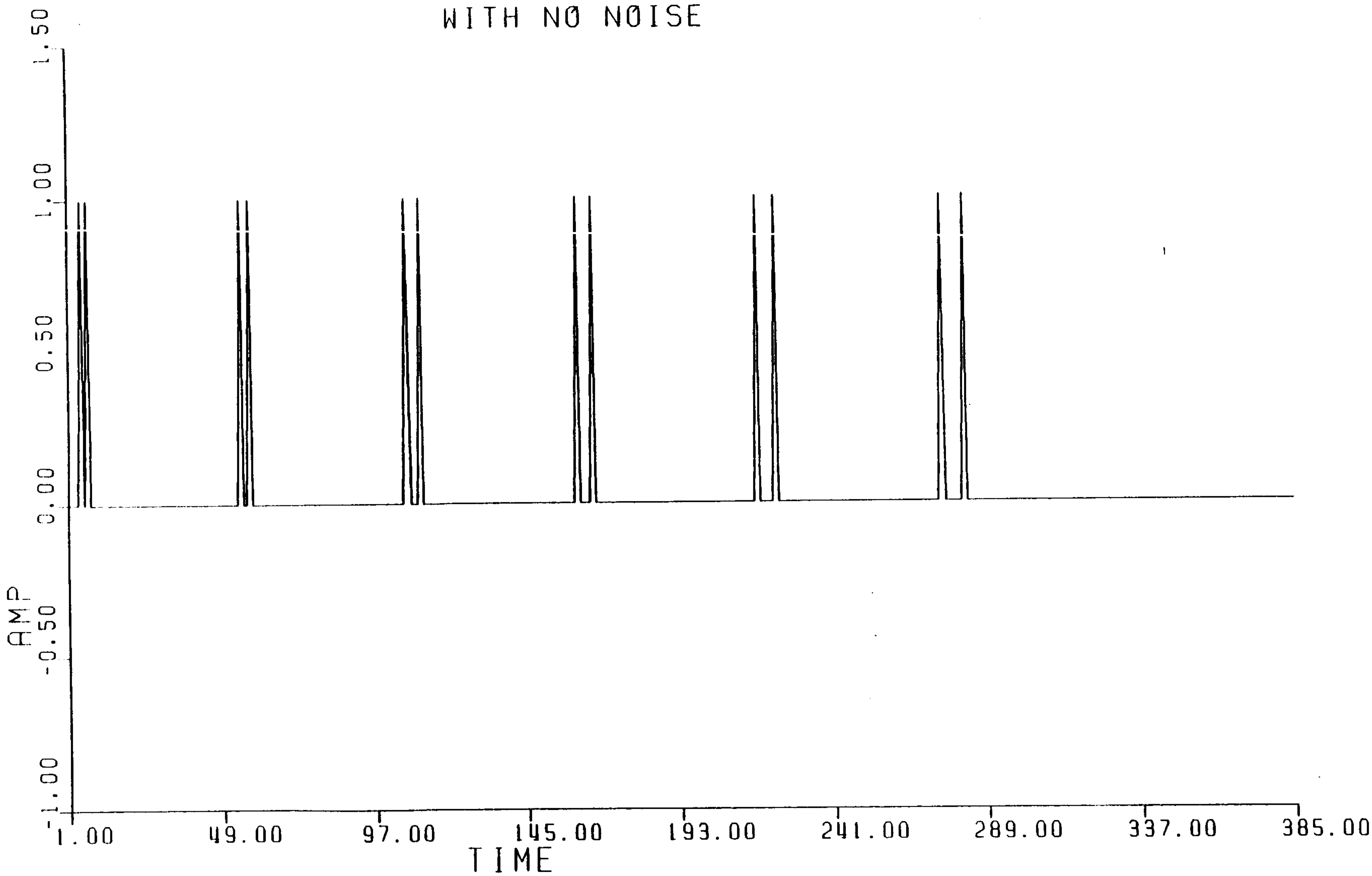


Fig. 3.32 LS SNR=10

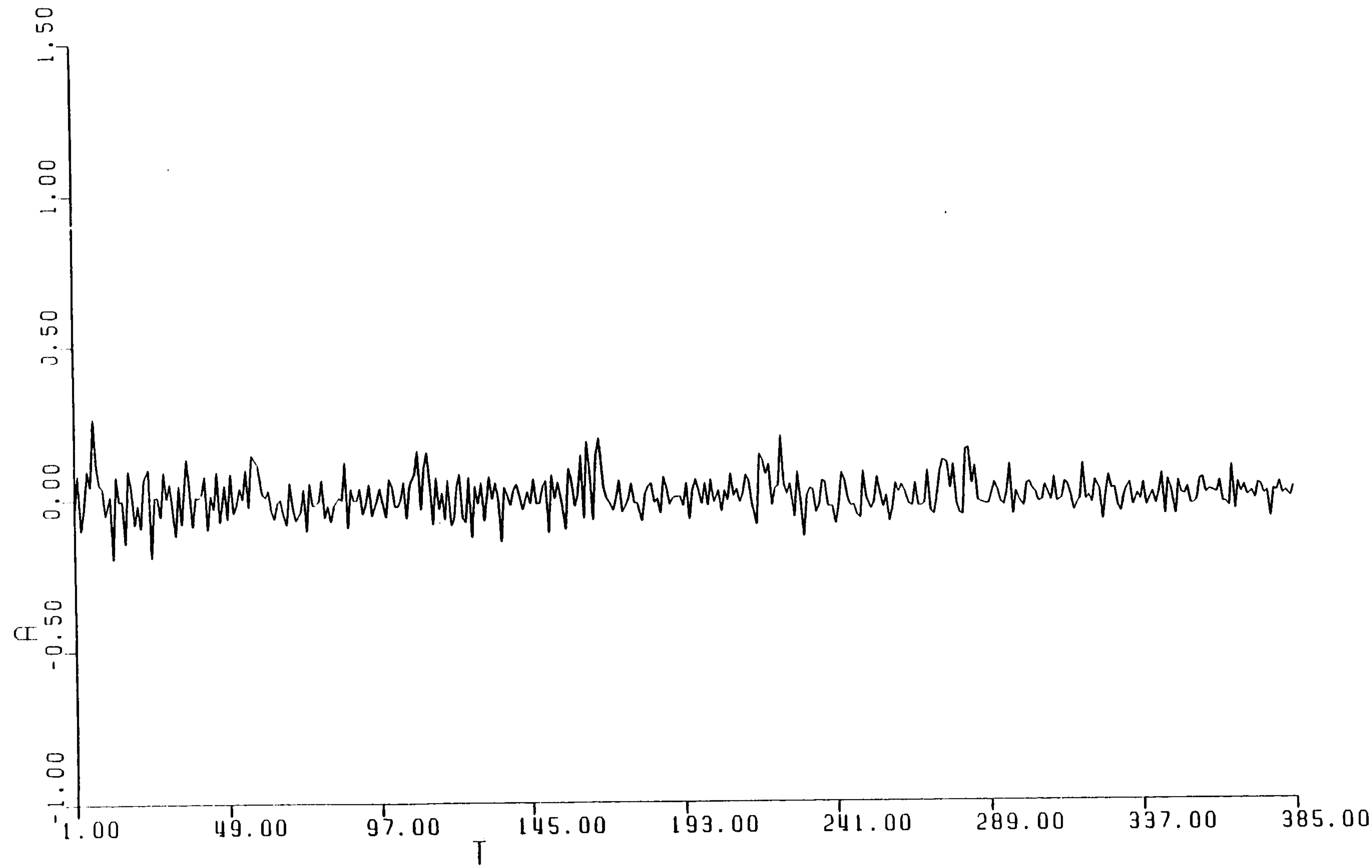


Fig. 3.33 LS SNR=40

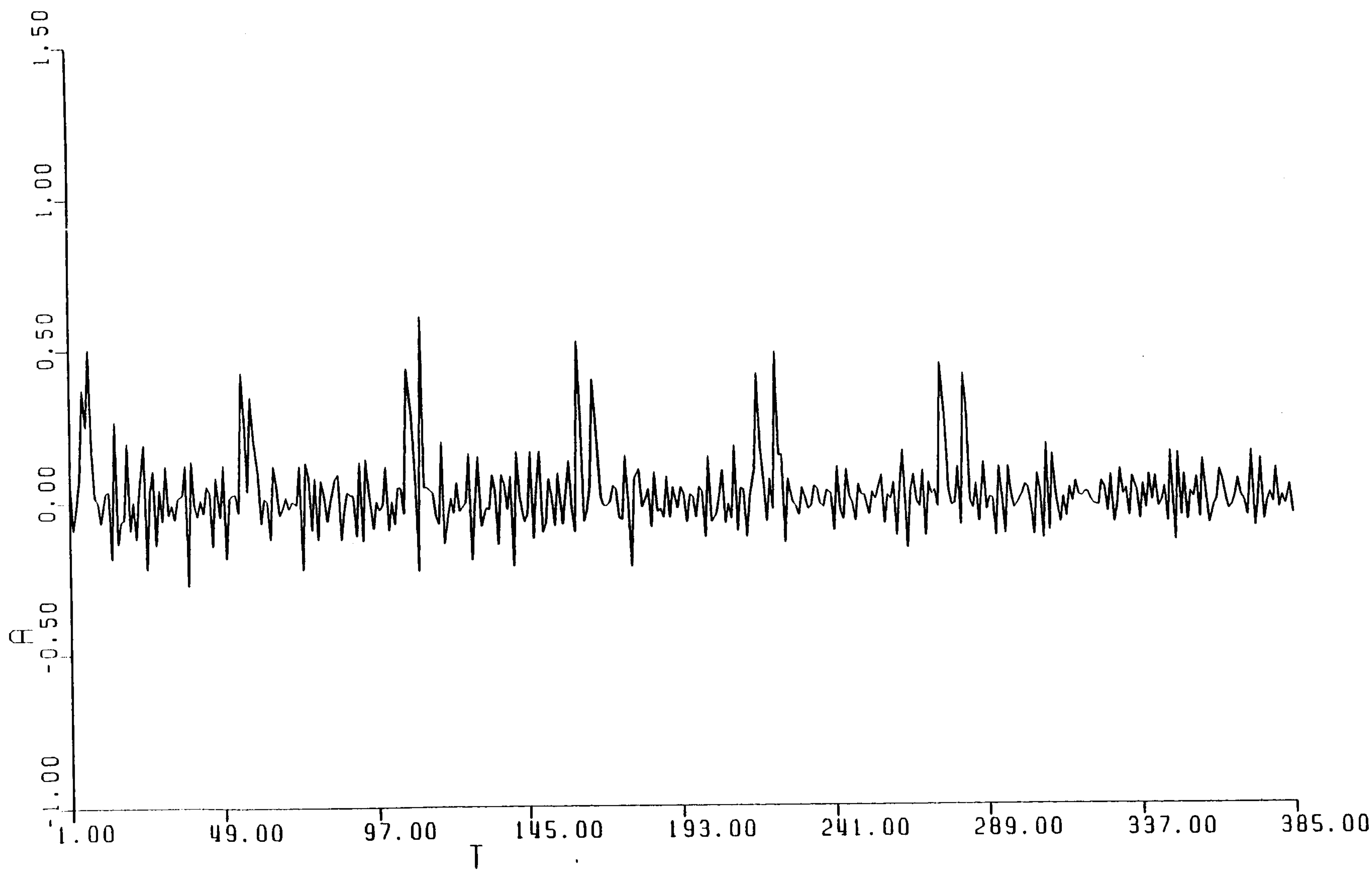


Fig. 3.34 LS SNR=150

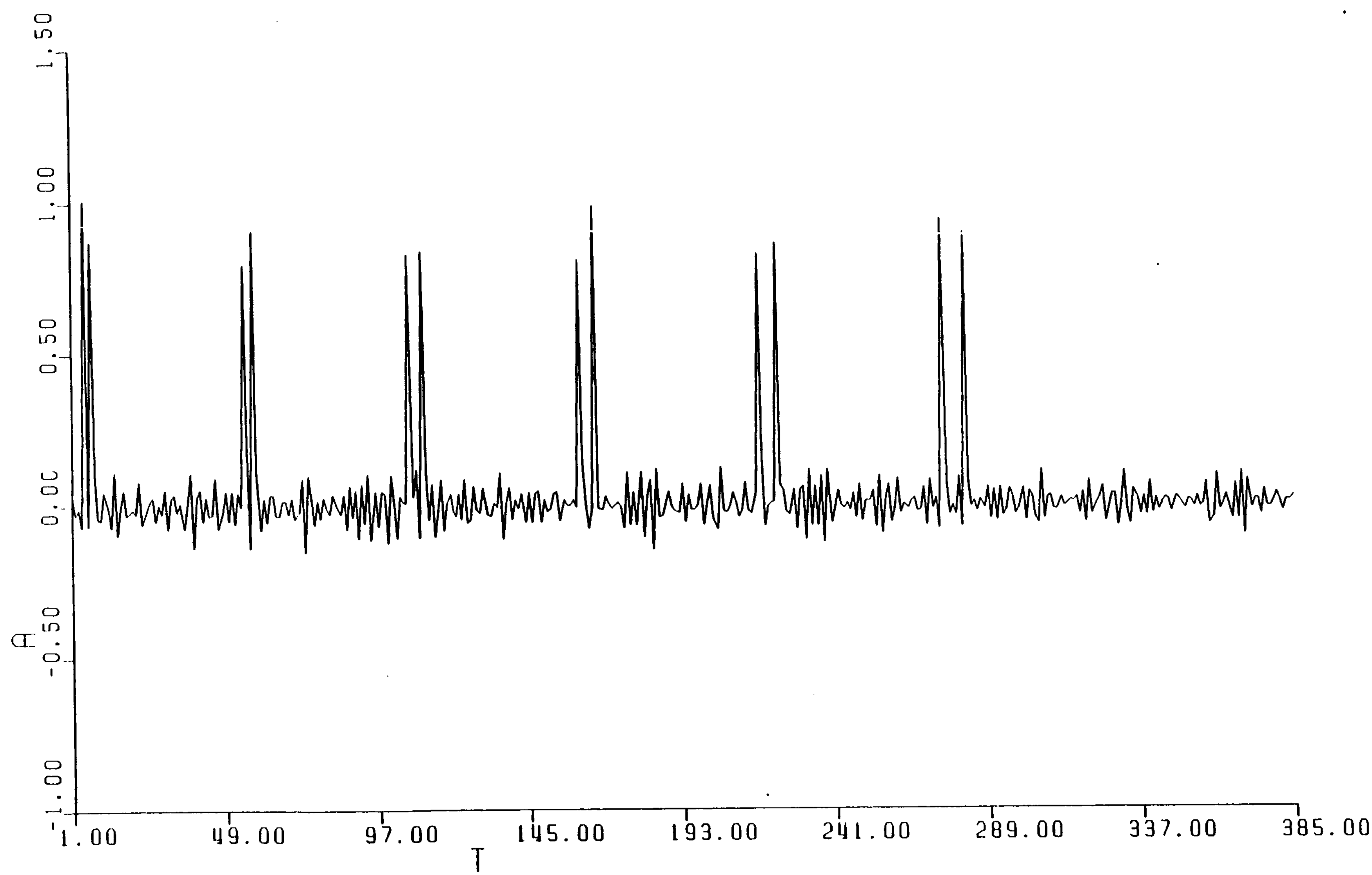


TABLE ( ) 3.1

SNR	AVERAGE MSE	STANDARD DEVIATION	AVERAGE MSE + SD	AVERAGE MSE - SD
9.841928	8.737156	0.2718737	9.009029	8.465282
19.68386	7.485857	0.3292042	7.815062	7.156653
29.52579	6.623653	0.4001058	7.023759	6.223547
39.36771	5.919385	0.4704656	6.389851	5.448919
49.20965	5.312435	0.5365910	5.849026	4.775844
59.05157	4.779438	0.6055247	5.384962	4.173913
68.89351	4.301651	0.6611241	4.962776	3.640527
74.72681	4.073354	0.7031566	4.776510	3.370197
78.73543	3.718730	0.2444320	3.963162	3.474298
84.06767	3.696341	0.7424178	4.438759	2.953923
93.40852	3.240202	0.2418046	3.482007	2.998398
98.41930	3.168524	0.7883208	3.956845	2.380203
108.2612	2.724073	0.2175720	2.941645	2.506501

TABLE ( ) 3.2

SNR	AVER. UNF. ITERATIONS	STANDARD DEVIATION	AVERAGE UNF.+SD	AVERAGE UNF.-SD
9.841928	26.64000	4.995037	31.63504	21.64496
19.68386	44.42000	10.57372	54.99372	33.84628
29.52579	63.32000	19.17649	82.49648	44.14352
39.36771	80.74000	25.88035	106.6203	54.85965
49.20965	100.2000	28.56361	128.7636	71.63638
59.05157	122.1800	26.43535	148.6154	95.74465
68.89351	138.6200	27.00140	165.6214	111.6186
74.72681	149.8400	26.41845	176.2585	123.4215
78.73543	156.1875	22.00914	178.1966	134.1784
84.06767	160.0600	26.22930	186.2893	133.8307
93.40852	175.7838	15.48344	191.2672	160.3003
98.41930	175.8000	26.11589	201.9159	149.6841
108.2612	193.2941	10.40794	203.7021	182.8862

TABLE ( ) 3.3

SNR	AVER. SMT. ITERATION	STANDARD DEVIATION	AVERAGE SMT.+SD	AVERAGE SMT.+SD
9.841928	9.580000	1.297536	10.87754	8.282464
19.68386	20.64000	3.735023	24.37502	16.90498
29.52579	32.82000	7.514493	40.33449	25.30551
39.36771	46.18000	11.65451	57.83451	34.52549
49.20965	58.10000	14.43780	72.53780	43.66220
59.05157	67.18000	12.96563	80.14563	54.21437
68.89351	80.44000	15.75838	96.19838	64.68163
74.72681	85.42000	8.856839	94.27684	76.56316
78.73543	97.50000	14.94155	112.4416	82.55845
84.06767	99.46000	10.41770	109.8777	89.04230
93.40852	113.2973	10.52889	123.8262	102.7684
98.41930	121.6400	10.66538	132.3054	110.9746
108.2612	135.4118	7.677767	143.0895	127.7340

TABLE ( ) 3.4

SNR	AVERAGE MSE	STANDARD DEVIATION	AVERAGE MSE+SD	AVERAGE MSE+SD
9.841928	21.79787	1.671903	23.46977	20.12596
19.68386	11.00536	0.8359824	11.84134	10.16937
29.52579	8.160901	0.7050129	8.865914	7.455888
39.36771	6.719419	0.6982867	7.417706	6.021133
49.20965	5.761693	0.7268140	6.488507	5.034879
59.05157	4.931045	0.3273007	5.258346	4.603745
68.89351	4.453925	0.8076731	5.261598	3.646252
78.73543	3.967191	0.8474249	4.814616	3.119766
88.57736	3.553317	0.8846793	4.437996	2.668637
98.41930	3.197412	0.9188012	4.116213	2.278610
108.2612	2.888947	0.9498125	3.838759	1.939134
118.1031	2.620376	0.9777507	3.598127	1.642625
127.9451	2.385688	1.002834	3.388522	1.382853
137.7870	2.180045	1.025338	3.205383	1.154707
147.6289	1.999334	1.045507	3.044841	0.9538268

TABLE ( ) 3.5

SNR	AVERAGE UNF. ITR	STANDARD DEVIATION	AVERAGE UNF.ITR+SD	AVERAGE UNF.ITR-SD
9.841928	6.700000	0.5744563	7.274456	6.125544
19.68386	12.04000	0.8935323	12.93353	11.14647
29.52579	17.90000	1.615549	19.51555	16.28445
39.36771	24.62000	2.682462	27.30246	21.93754
49.20965	32.64000	3.882061	36.52206	28.75794
59.05157	42.10345	3.467533	45.57098	38.63591
68.89351	51.12000	6.736884	57.85688	44.38311
78.73543	61.26000	8.361364	69.62136	52.89864
88.57736	71.82000	9.995378	81.81538	61.82462
98.41930	82.48000	11.63656	94.11657	70.84344
108.2612	93.26000	13.29934	106.5593	79.96066
118.1031	103.9400	14.87335	118.8133	89.06666
127.9451	114.4200	16.45976	130.8798	97.96024
137.7870	124.5600	17.99240	142.5524	106.5676
147.6289	134.3400	19.47985	153.8198	114.8602

TABLE 3.6 RB

SNR	AV. MSE	S.D	AV. MSE+SD	AV.MSE-SD
10	8.688261	0.1627080	8.850969	8.525553
40	5.925281	0.2801664	6.205447	5.645114
150	1.795615	0.1730083	1.968623	1.622607
	0.00276	0.0	0.0	0.0

TABLE 3.7

SNR	AV. ITRN	S.D	AV.ITRN+SD	AV.ITRN-SD
10	143.7000	22.65944	166.3594	121.0406
40	2524.480	398.3608	2922.841	2126.119
150	25496.70	1992.233	27488.93	23504.47
	90001	0.	0.	0.

TABLE 3.8 MSE FOR LS

CASE NO.	SNR=10	SNR=40	SNR=150
1	10.47158	6.385849	1.684585
2	11.26424	7.100804	1.780114
3	11.04425	7.121286	1.905267
4	10.81335	6.962879	1.808486
5	10.70359	6.971309	1.799288
6	10.93749	6.771500	1.690314
7	10.05189	5.851874	1.505212
8	10.35378	5.829002	1.400842
9	10.45517	6.484002	1.631310
10	10.31653	6.360021	1.570464

TABLE 3.9

SNR	AV. MSE	S.D
10	10.641192	0.3564589
40	6.583852	0.4571581
150	1.677588	0.1464324
1.0406679E-06	0.0	

CHAPTER 4

GAUSSIAN DATA

4.1 INTRODUCTION

This chapter concerns optimization of the AC method for two Gaussian impulse response functions, one narrow and one wide. The input consists of three narrow Gaussians selected to give some overlap after convolution with g (Wright, 1980; Leclere, 1984).

The purpose of this chapter is first to optimize the AC noise removal and unfolding iterations using the new impulse responses, i.e., the narrow and wide Gaussians; and second, to compare the results of the narrow and the wide Gaussian cases to see how they converge.

The method used to achieve the optimization is essentially the same as the one employed in Chapter 3 for seismic data, that is, finding the minimum MSE to optimize the noise removal and unfolding iterations for the two Gaussians.

Various plots of the MSE and iteration number vs SNR are given here and in Appendices B (narrow) and C (wide).

Section 2 contains a discussion of the data and section 3 gives the results.These are followed by conclusions, tables, and plots. As before tables of each SNR and some of the plots are given in Appendices B and C .

4.2 DISCUSSION OF THE DATA USED

Two Gaussians as impulse response functions are used for the work described in this chapter.They are referred to as the narrow (Fig. 4.2) and the wide (Fig. 4.27) Gaussians. The narrow Gaussian consists of 9 points and the wide one of 21 points.Convolution of each of these impulse response functions with the input (Fig. 4.1) is given in Fig. 4.3 (narrow case), and Fig. 4.28 (wide case).

Iterative methods of noise removal and deconvolution converge faster for impulse response functions where $|G(S)|$ is a number close to one for a given s, and slower in regions where $|G(S)|$ is not close to one for a given s.

The narrow Gaussian has a broad transform. Therefore its magnitude stays close to one for a larger portion of the frequency axis, if normalized to have maximum value of one. Thus it is a faster converging function. The wide Gaussian has a narrow transform. Therefore it is a slowly converging function. These conclusions are confirmed by the results of this chapter.

The reason for choosing to work with two Gaussian impulse response functions is because of the Central Limit Theorem which states that if a large number of functions are convolved together the resultant may be very smooth, and as the number increases indefinitely, the resultant approaches a Gaussian form. This behavior is exhibited by many physical systems (Bracewell, 1978). Also, many instrument impulse response functions have a Gaussian form. Therefore, two Gaussians, one slowly convergent (wide) and one rapidly convergent (narrow) are generated to cover approximately the limits of convergence.

A criterion is chosen to terminate the iterations when the difference between two consecutive MSE's is on the order of magnitude of 1.0E-04 (MSE improvement negligible) for the narrow case.For the wide case this number is increased to 1.0E-02, because of the slowness of convergence. This criterion may be called the tolerance.

To obtain a good statistical result as before for 15 SNR cases, 50 noisy data sets each with a SNR close to the one of interest are generated. The optimum noise removal and deconvolution iteration number is found for each set. These iteration numbers as well as the MSE are averaged to be used for various plots vs SNR.

4.3 RESULTS

4.3.1 THE NARROW GAUSSIAN

Tables 4.1 through 4.5 summarize the average MSE and the average unfolding and noise removal iteration results for each SNR case. Tables 4.3 and 4.5 are the average MSE and the average number of unfolding iteration results without applying the noise removal iterations. The first column of each table is the average SNR (average of 50) followed by either the average MSE or the average number of iterations (unfolding or smoothing). The third column is the standard deviation, and the last two columns are the mean iteration number minus and plus the standard deviation. These tables are used to produce the plots of Fig.'s 4.4 through 4.13 . Fig. 4.4 is the average MSE vs SNR when noise removal is used. To see the details better a plot of the natural logarithm of the MSE (Ln(MSE)) and Ln(SNR) is produced in Fig. 4.5. The dashed line corresponds to the standard deviation, and data points are marked with x . This plot is well behaved and it can be used for prediction of the MSE by either interpolation or extrapolation. Fig. 4.6 is the same as above without applying the noise removal iterations. Fig. 4.7 is used to demonstrate improvements achieved by applying the noise removal iterations. This figure has been produced by plotting Fig.'s 4.5 and 4.6 on the same axes.Fig. 4.8 is the same as Fig.4.7 without plotting the standard deviations. This helps in avoiding a possible confusion of interpretation of Fig. 4.7. Fig. 4.8 indicates that applying the noise removal iterations to noisy data sets with SNR SNR higher than about 30 ($e^{3.4}$) does not provide any improvement in MSE. The MSE even gets worse if noise removal is applied to data with SNR higher than 500 ($e^{6.2}$).

The next four sets of figures (4.9 through 4.12) show the results for the unfolding iterations. From these sets of plots the following can be inferred: (1) unlike the seismic case the number of unfolding iterations tends to stay constant rather than increasing as SNR is increased, (2) as before, applying the noise removal iterations increases the number of unfolding iterations (Fig. 4.9). This increase is almost independent of SNR and does not necessarily lead to a better MSE (see Fig. 4.8). Fig. 4.13 shows the number of noise removal iterations vs SNR. It also tends to stay constant as the SNR is increased.

The MSE for noise free data (SNR infinite) is 8.09E-09 at the optimum iteration number of 62.This iteration number can be thought of as an asymptote to the unfolding iteration number vs SNR plot as SNR increases (as the level of noise is lowered). Applying the noise removal iterations to noisy data sets for which the SNR is high (less noise) would cause the unfolding iterations to go beyond this number (the asymptote). This behavior can be explained by considering the mechanism by which the noise removal iterations work. They smooth the data first and then restore them back to the original form. After the noise removal iterations have been applied, the data have less resolution and take more unfolding iterations to reach a given resolution improvement level. From the above arguments it can be inferred that with smoothing, the maximum number of unfolding iterations should not be allowed to exceed that for noise free data (in this case 62) no matter what the SNR is. If they do, the noise removal iterations do not give any improvement and should not be applied.

The rest of the plots in this chapter are examples of deconvolution with and without application of the noise removal iterations for SNR's of 11,36, and 135 (Fig.'s 4.14 through 4.26). Appendix B contains tables and plots of some other SNR cases.

4.3.2 THE WIDE GAUSSIAN

Tables (4.6 through 4.10) and plots (4.27 through 4.51) arranged exactly in the same way as for the narrow Gaussian case and contain the same information (the average MSE,etc.). The only difference is in the absissca, where the value of the average MSE is used instead of Ln(MSE) (Fig.'s 4.30 through 4.38).

As mentioned before, the wide Gaussian has a narrow transform and therefore converges slowly. In consideration of the computer time needed for simultaneous optimization of 15 average SNR cases, 50 noisy data sets each, for a slowly convergent function, an upper bound of 2500 is set for the number of unfolding iterations. This causes a problem. The results are incomplete but consistent.For some sets the optimum iteration number is reached well below the limit (2500) and for some no optimum is found by that limit. Also, an upper bound of 122 is used for the number of noise removal iterations. For some of these cases after 122 noise removal iterations (the limit), no optimum deconvolution was reached. This means that more than 122*2500=305000 total iterations are needed for optimization. If 10 of the 50 noisy data sets for a given SNR behave this way (actually the number is more than 10, as shown in the tables in Appendix C), more than 305000*10=3050000 iterations are required to optimize just 10 cases. For a reasonably fast system like the VAX 8600 this could take more than a week (just for 10 of the 50 noisy data sets). Therefore, for a complete optimization of 15 SNR cases at least 15 weeks of elapsed time is required.

An additional reason for this difficult behavior is the use of an exact Gaussian rather than a rounded form.Another case of inconsistent behavior is the relatively large tolerance on MSE (1.0E-2).

The AC method uses the principal solution as its goal for the deconvolution iteration comparison (Chapter 2). This could be a problem for the wide Gaussian impulse response function or any function which has very many small values in its transform.Since the noise is also divided by these small numbers, this leads to a large change in F_p ($F_p = (H+N)/G$) { s : G(s)=/0 }), where F_p is the principal solution and N the noise. That is why the noise removal gives much greater improvement for the wide case than for the narrow case.

The general shapes of the number of iterations vs SNR for both the wide and the narrow Gaussian appear to be the same (approximately constant) with some variation at low SNR.

For the noise free case, 10000 iterations are used and yet no minimum MSE is reached. The MSE obtained at that iteration is 2.109948. Therefore, unlike the narrow case, no asymptote can be drawn.

As in the case of the narrow Gaussian, some examples of deconvolution with and without noise removal applied are shown here (Fig.'s 4.39 through 4.51) and in Appendix C .

4.4 CONCLUSION

The work in this chapter includes successful optimization for the narrow Gaussian and partial optimization for the wide Gaussian using the AC method. For the rapidly convergent narrow Gaussian impulse response function (wide transform), applying the noise removal iterations to noisy data at SNR's greater than about 30 does not give any improvement. Applying the noise removal iterations to the slowly convergent wide Gaussian impulse response function (narrow transform), however, seems to give great improvement. For very slowly convergent Gaussians (like the wide one used here) computer time makes the iterative methods unattractive, unless the SNR is very low. Since perfect Gaussians are not expected for experimentally determined response functions, however, this will not be a problem in general. Methods are being developed to deal more effectively with responses having transforms with very small values.

Fig. 4.1 ØRIGINAL INPUT, F

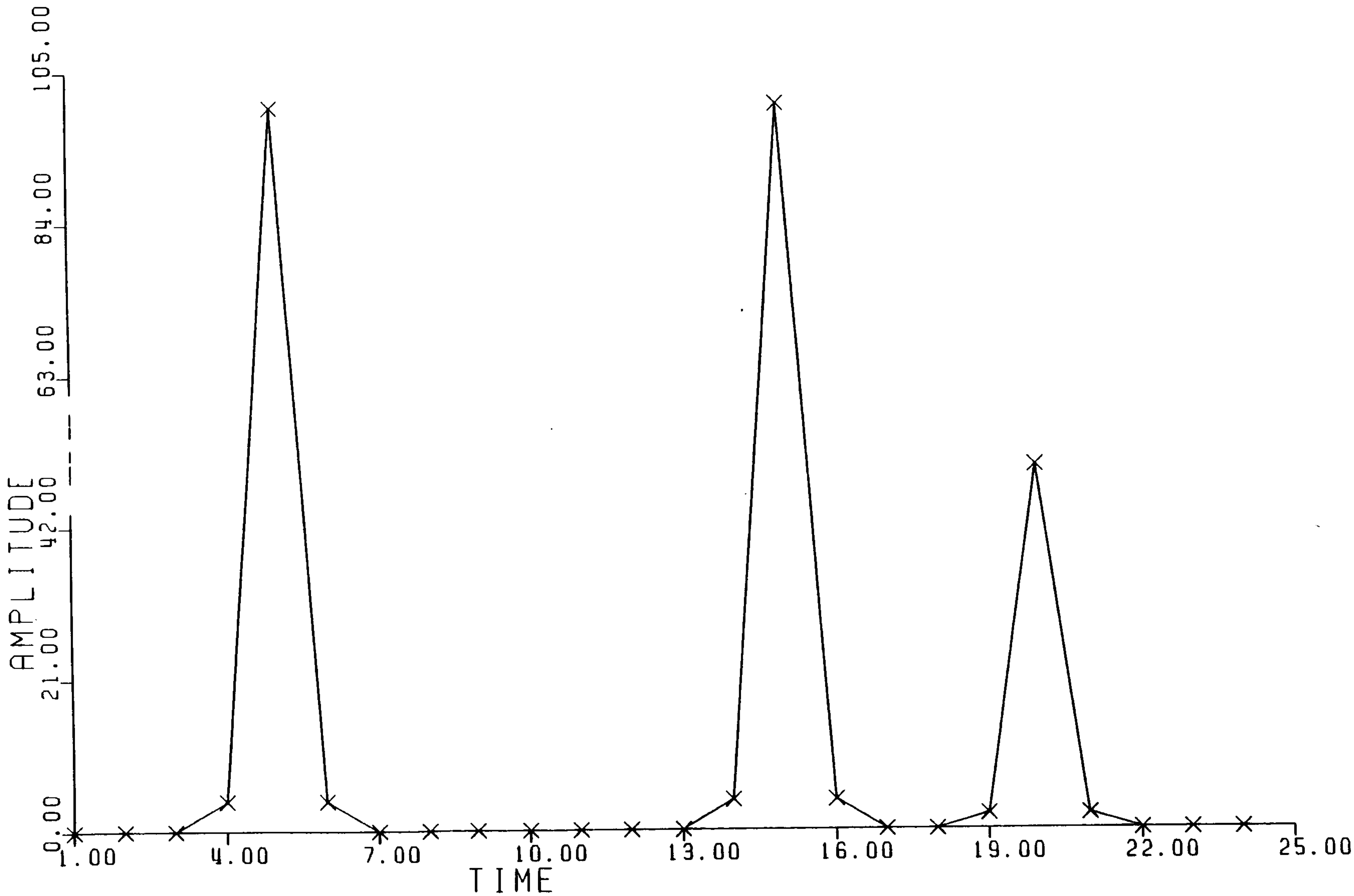


Fig. 4.2 IMPULSE RESPONSE

NARROW GAUSSIAN

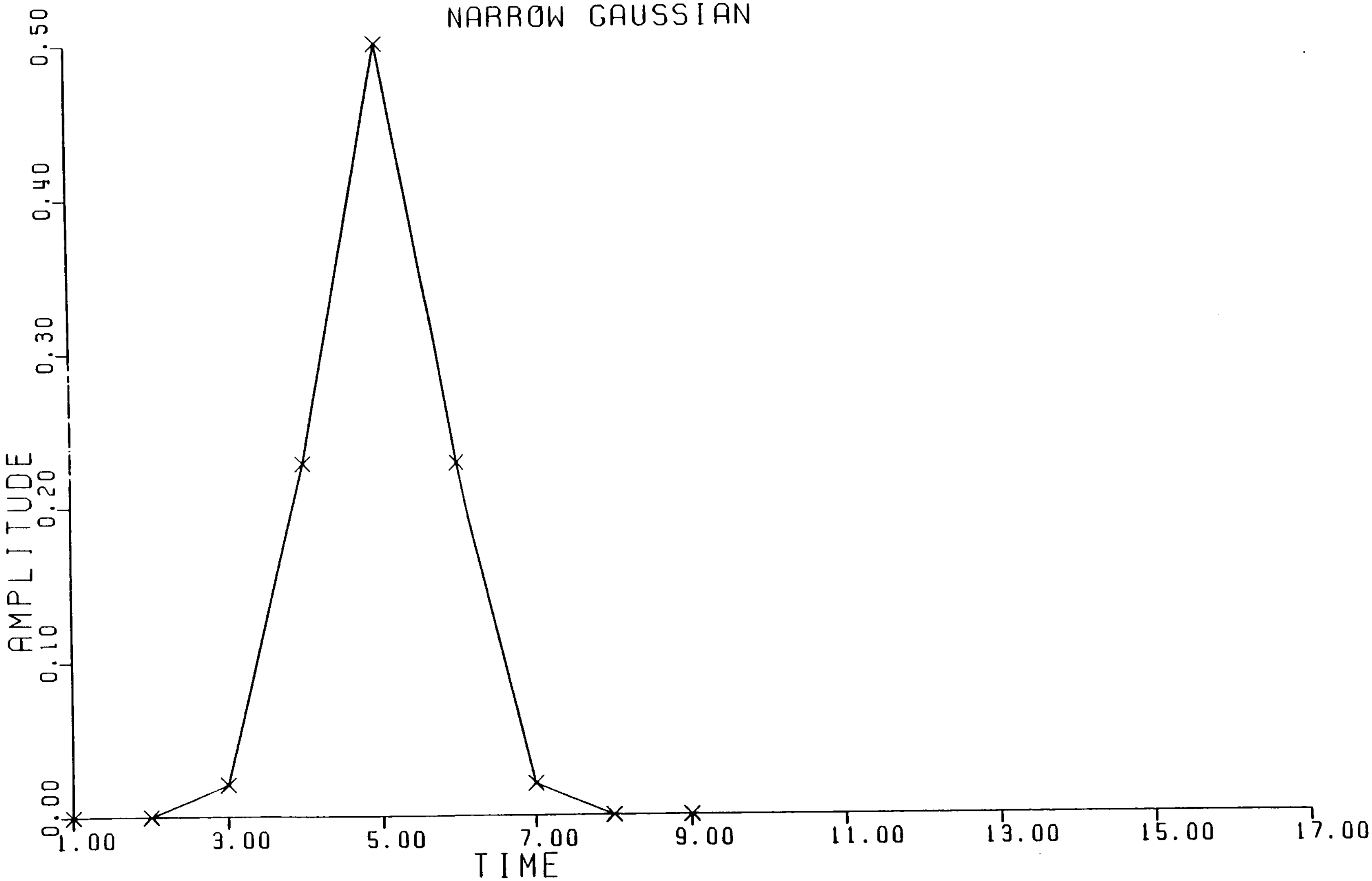


Fig. 4.3 CONVOLUTION H=F*G

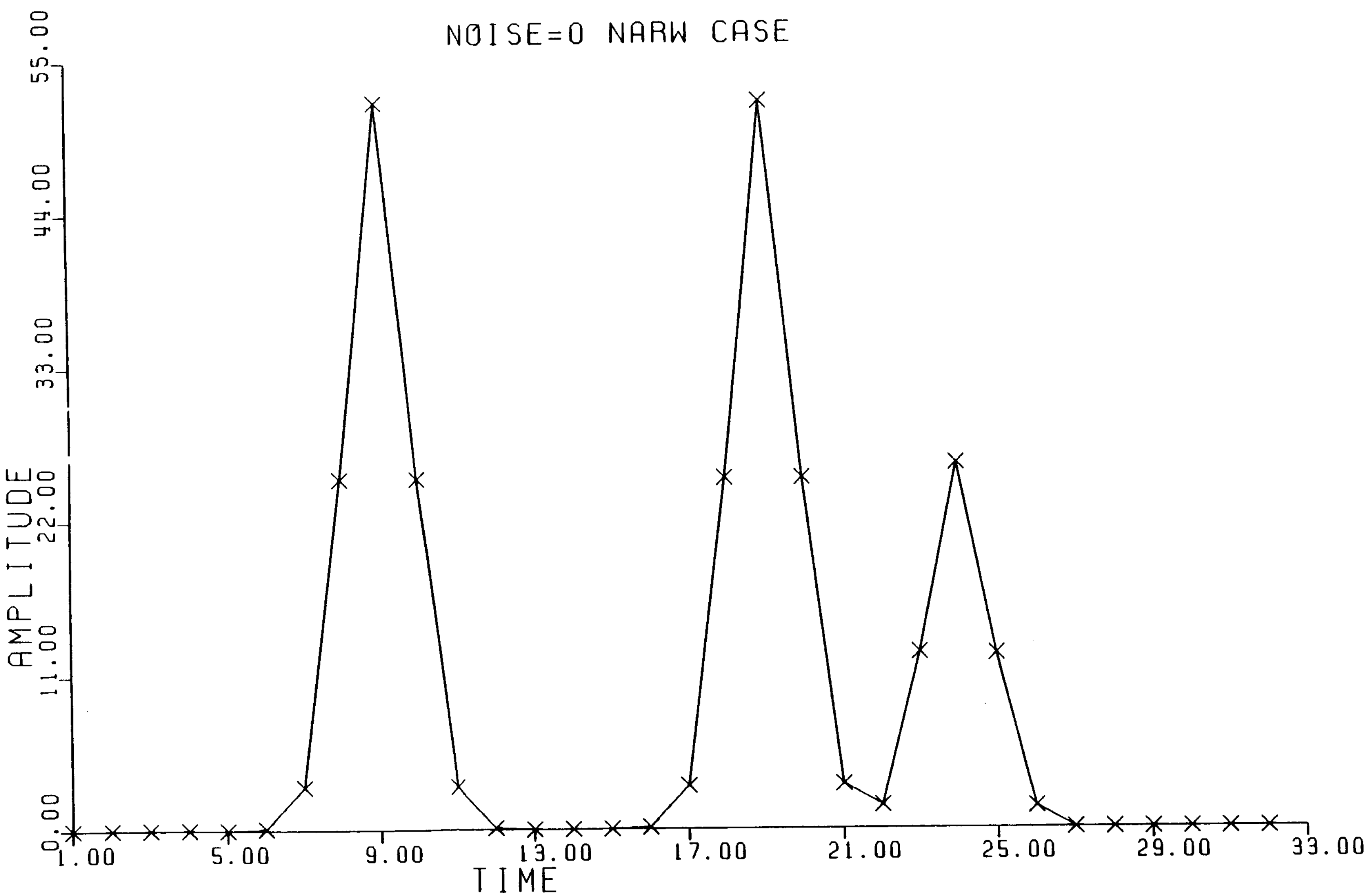


Fig.4.4 MSE VS SNR

NARW CASE

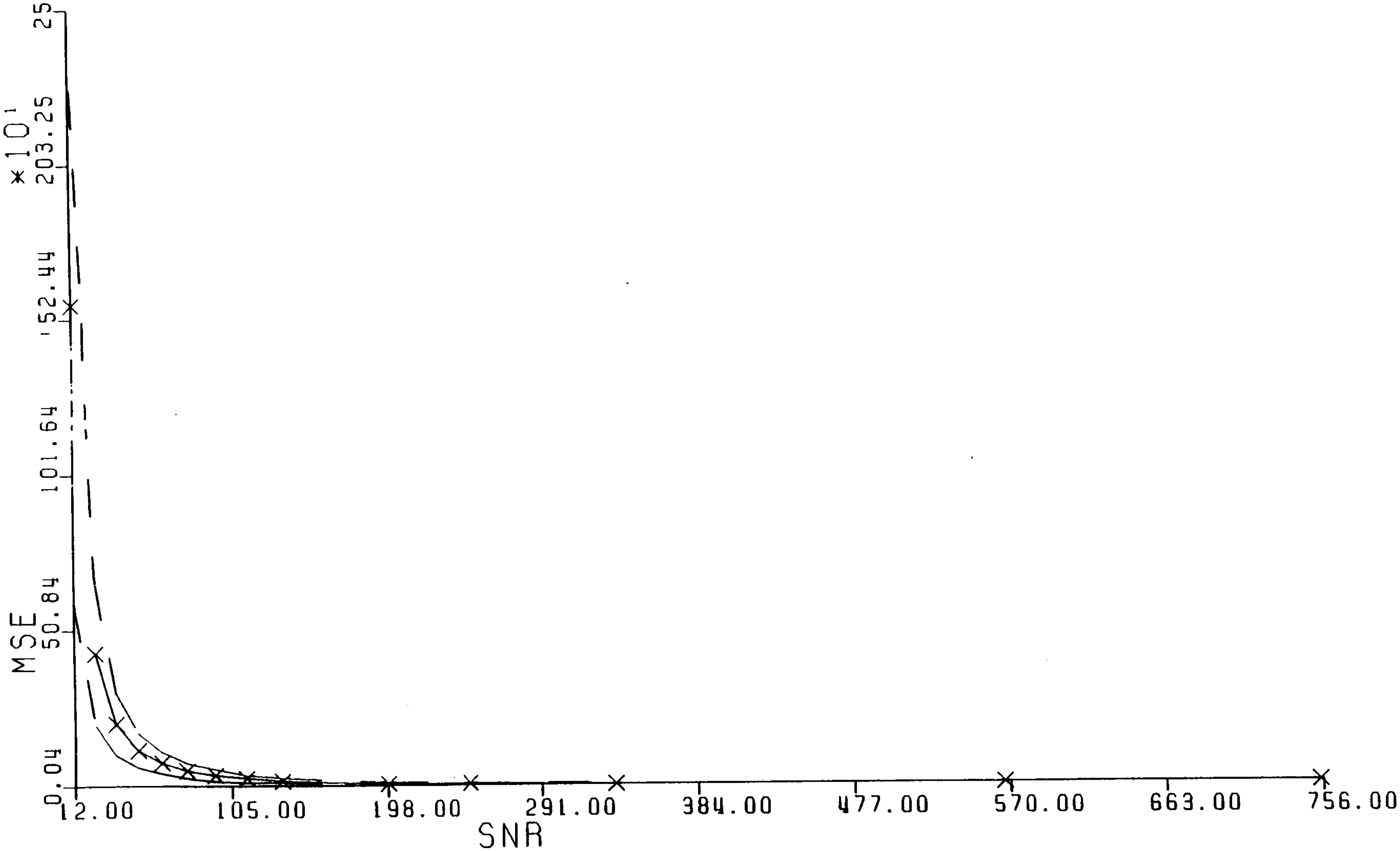


Fig. 4.5 LN(MSE) VS LN(SNR)

NARROW GAUSSIAN

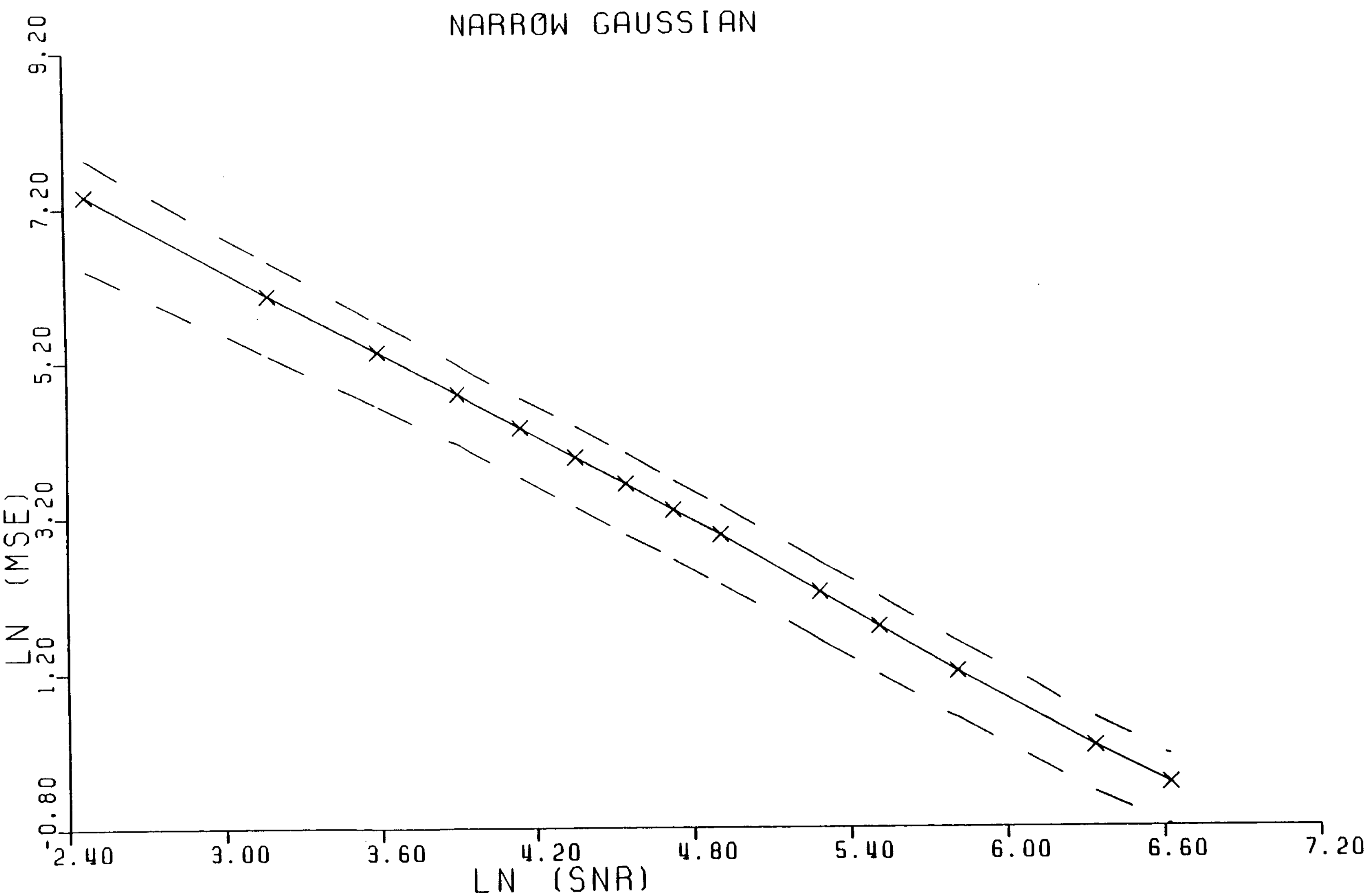


Fig. 4.6

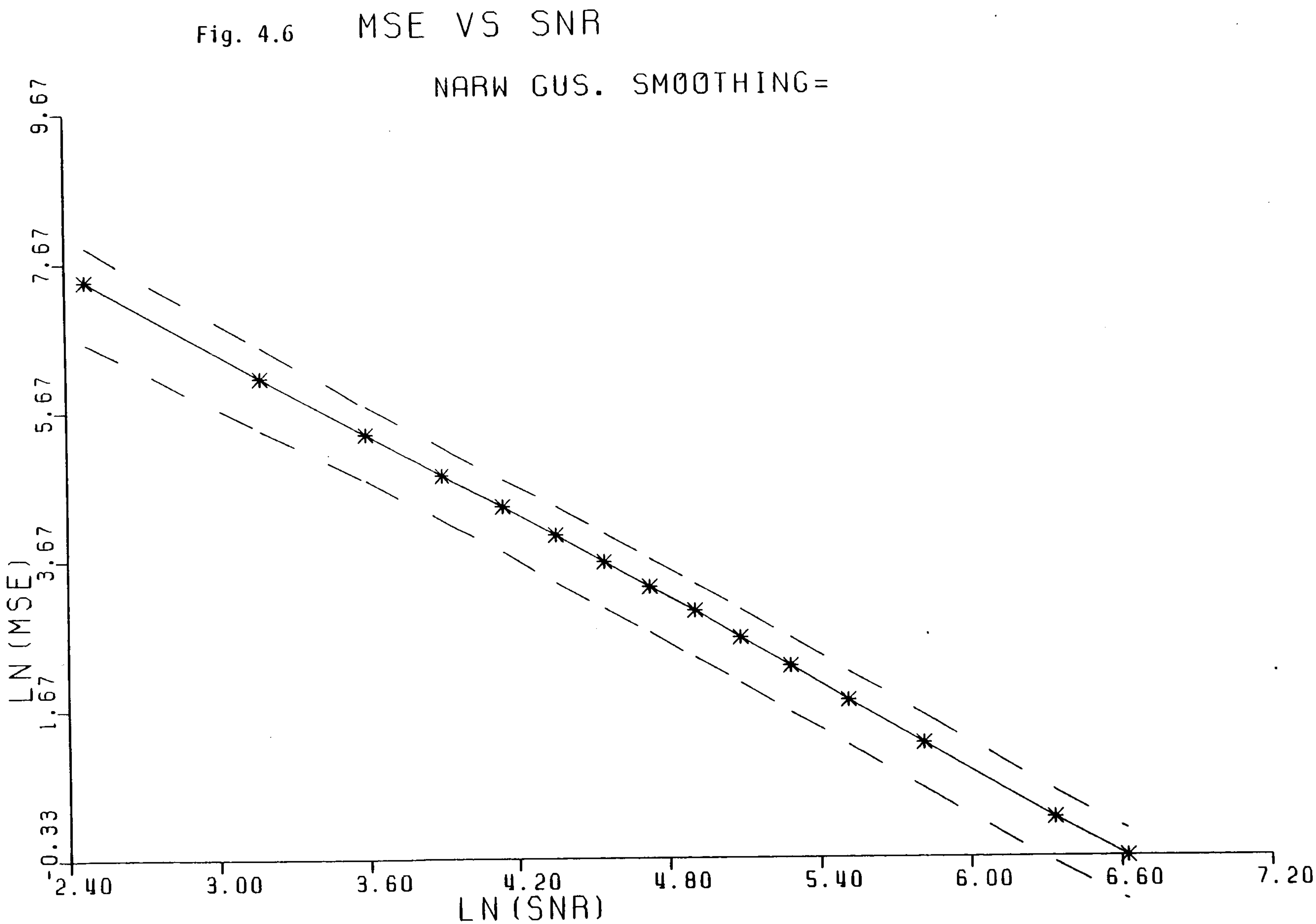

MSE VS SNR
NARW GUS. SMOOTHING=
LN(MSE)
9.67
7.67
5.67
3.67
1.67
-0.33
LN(SNR)
2.40
3.00
3.60
4.20
4.80
5.40
6.00
6.60
7.20

Fig. 4.7 WITH SMOOTHING

WITHOUT SMOOTHING

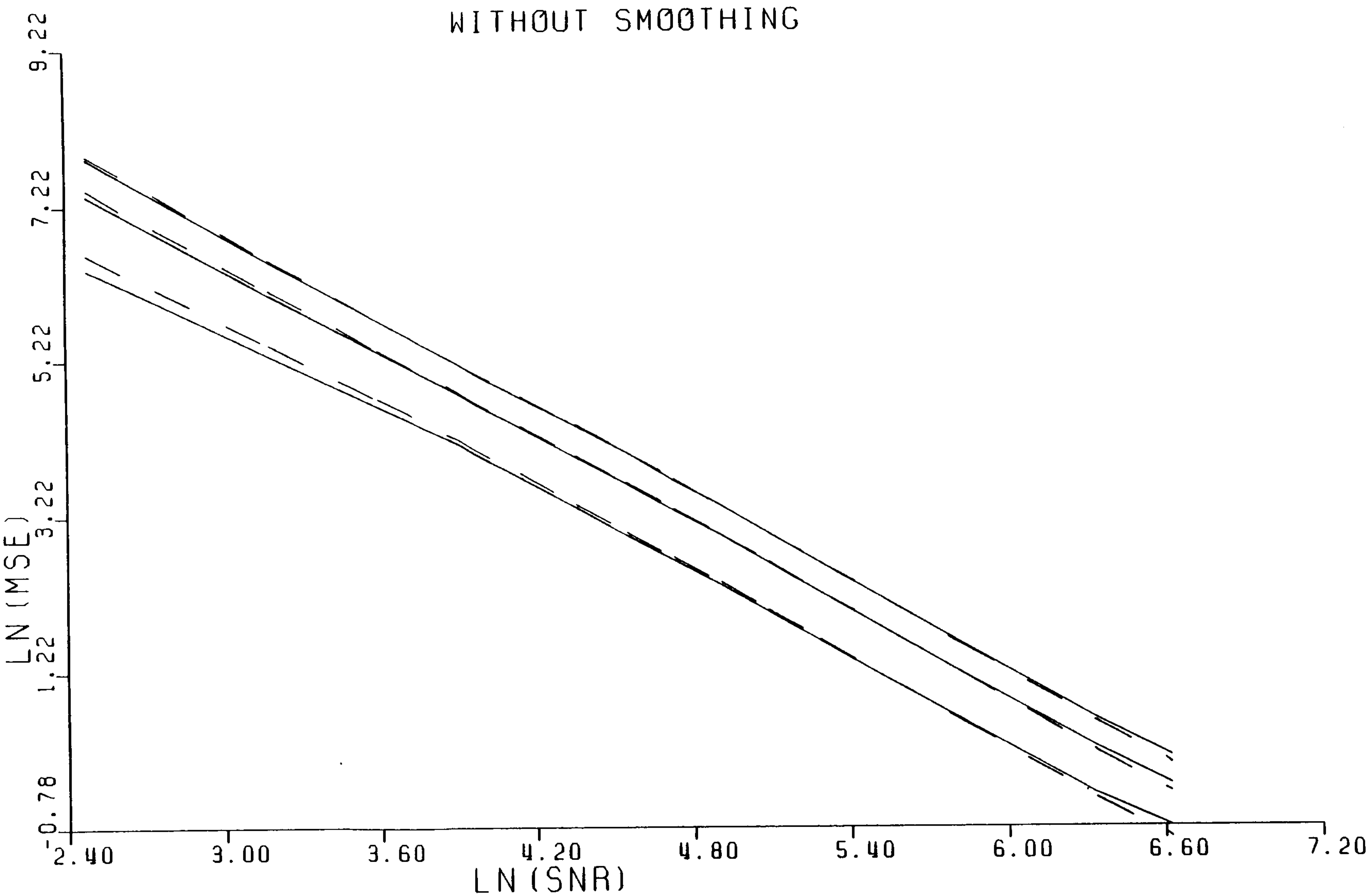


Fig. 4.8 WITH SMOOTHING______ WIHTOUT SMOOTHING

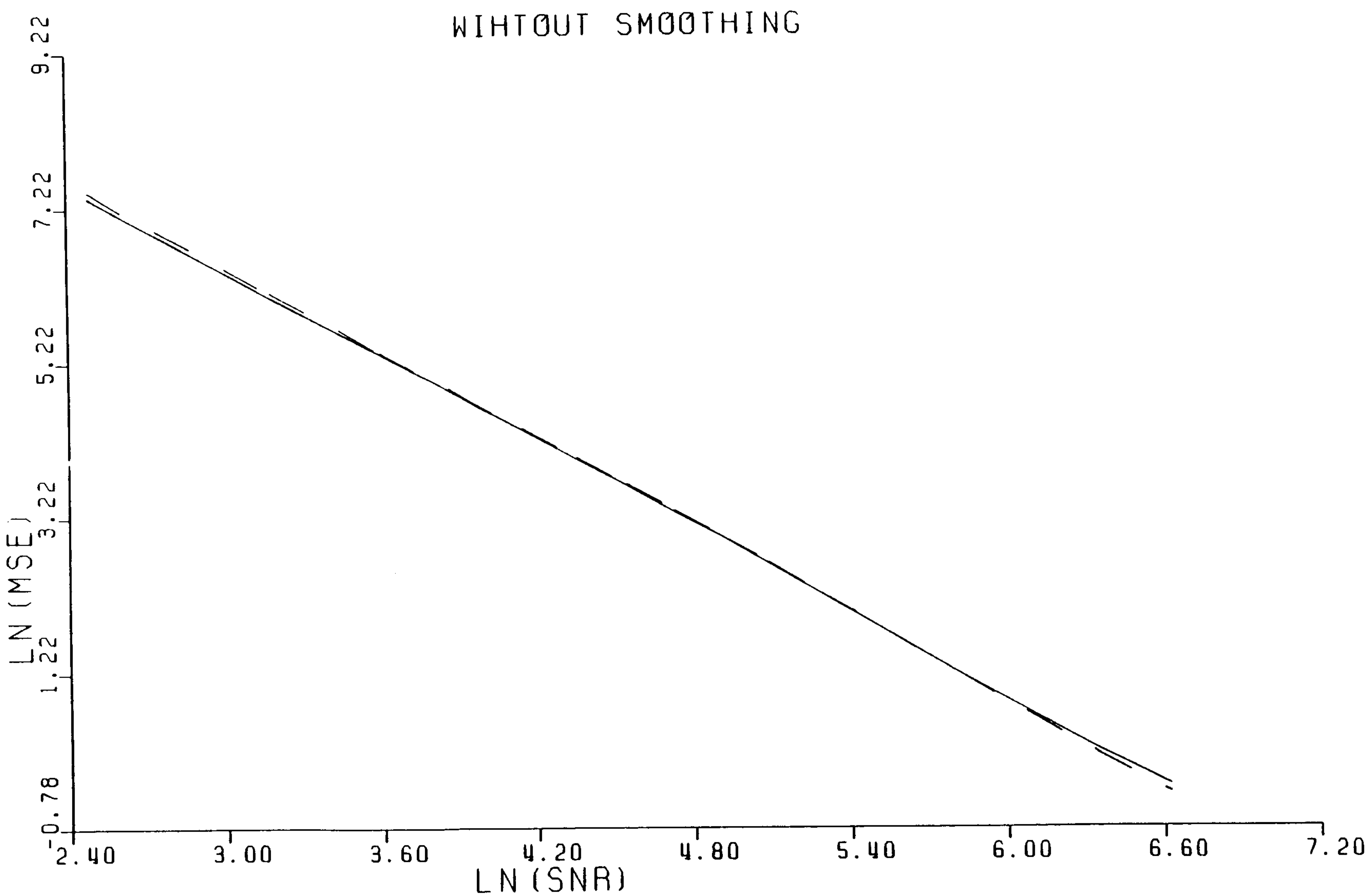


Fig. 4.9 UNF. ITRNS. VS SNR

NARROW GAUSSIAN

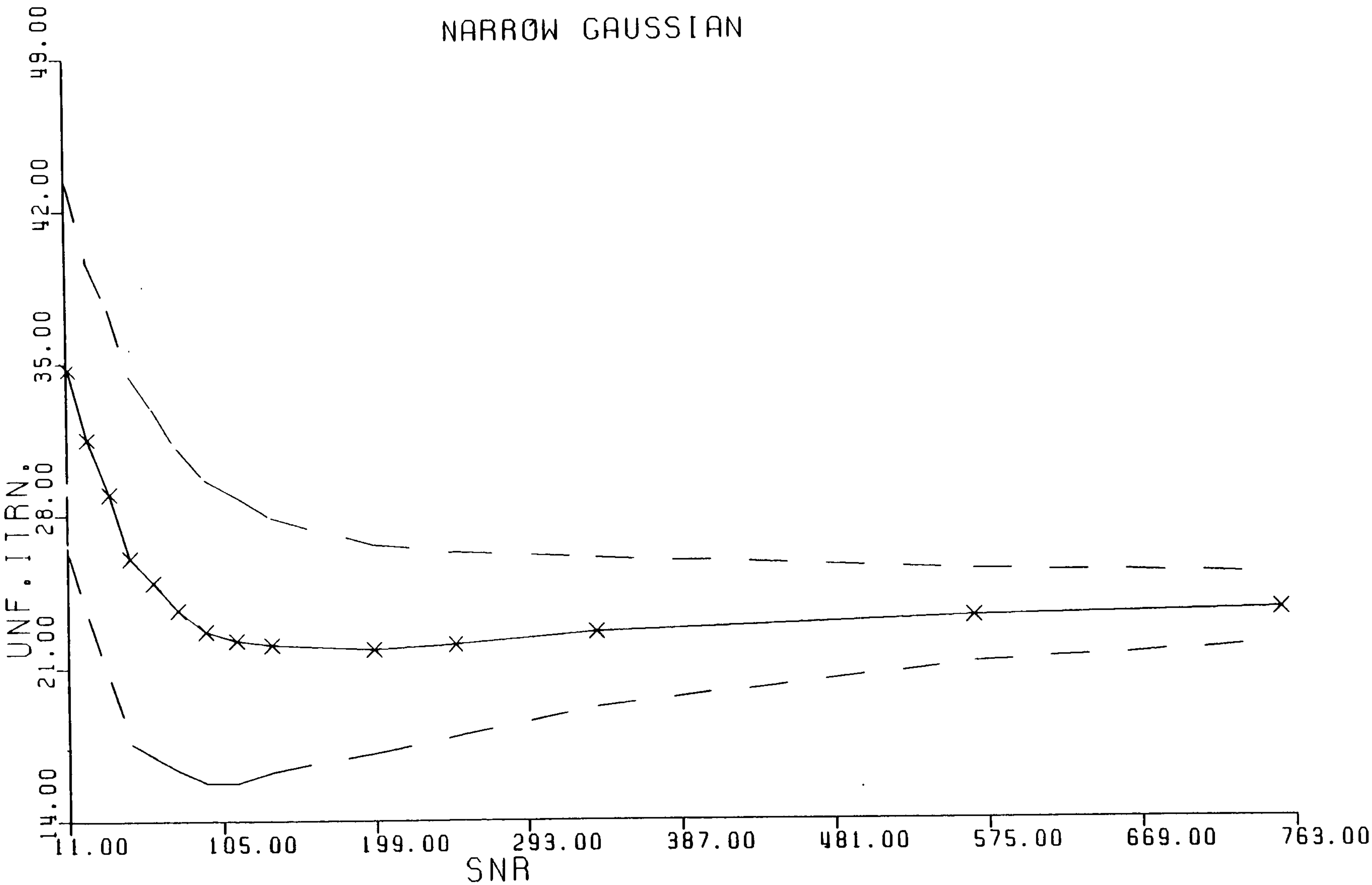


Fig. 4.10 UNF. VS SNR SMOOTHIN = 0.

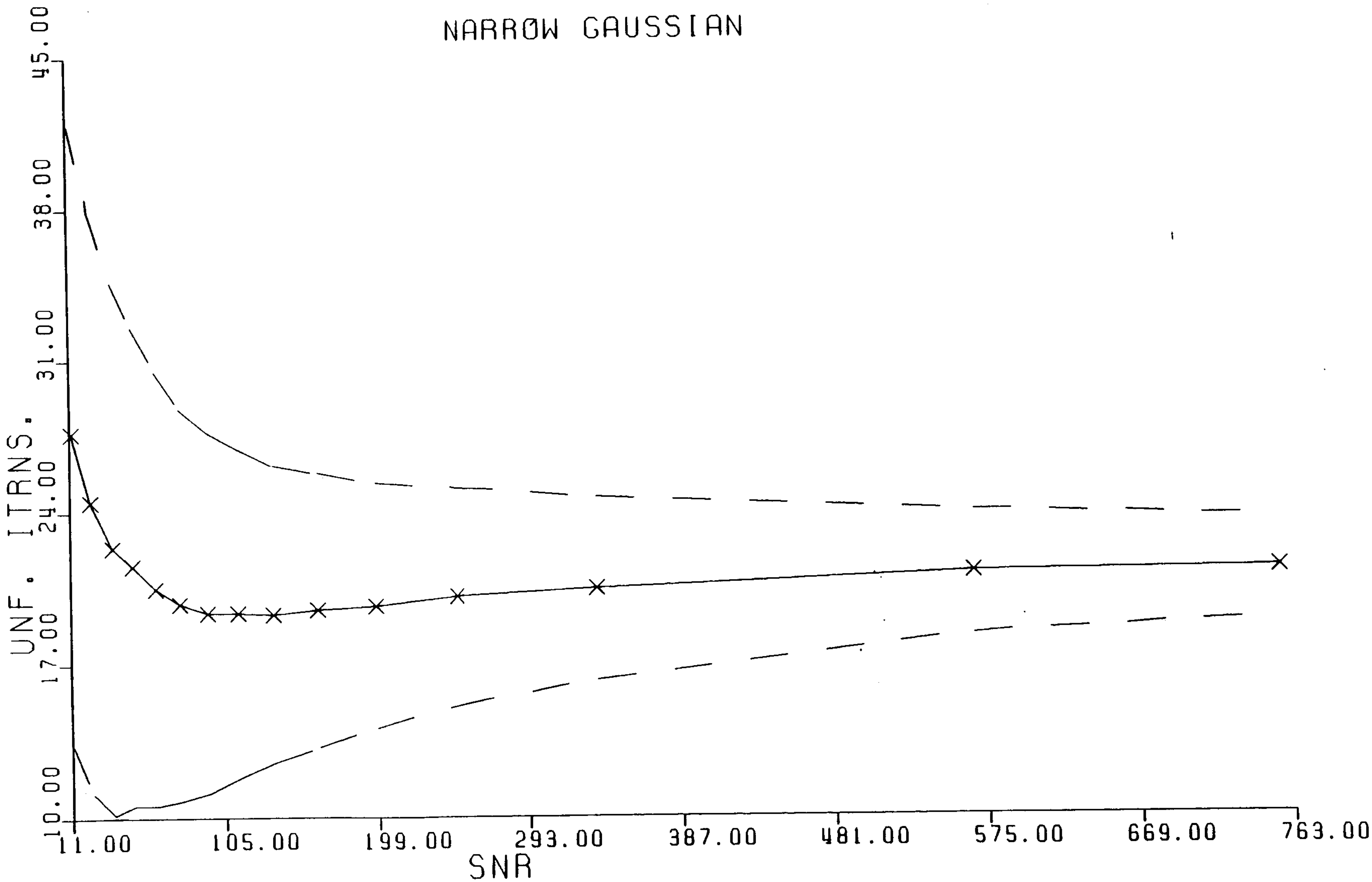


Fig. 4.11 WITH SMOOTHING______

WITHOUT SMOOTHING---

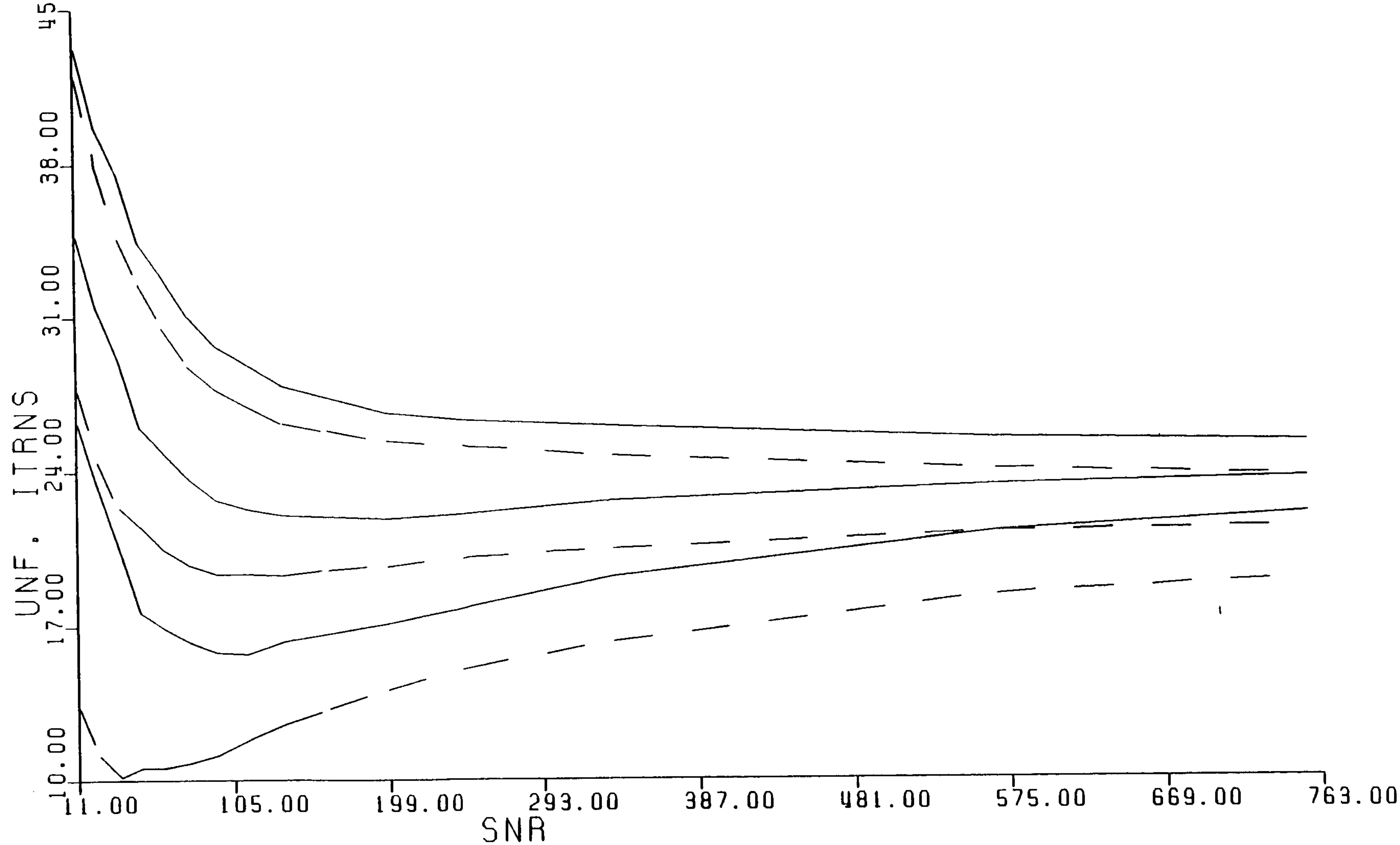


Fig. 4.12

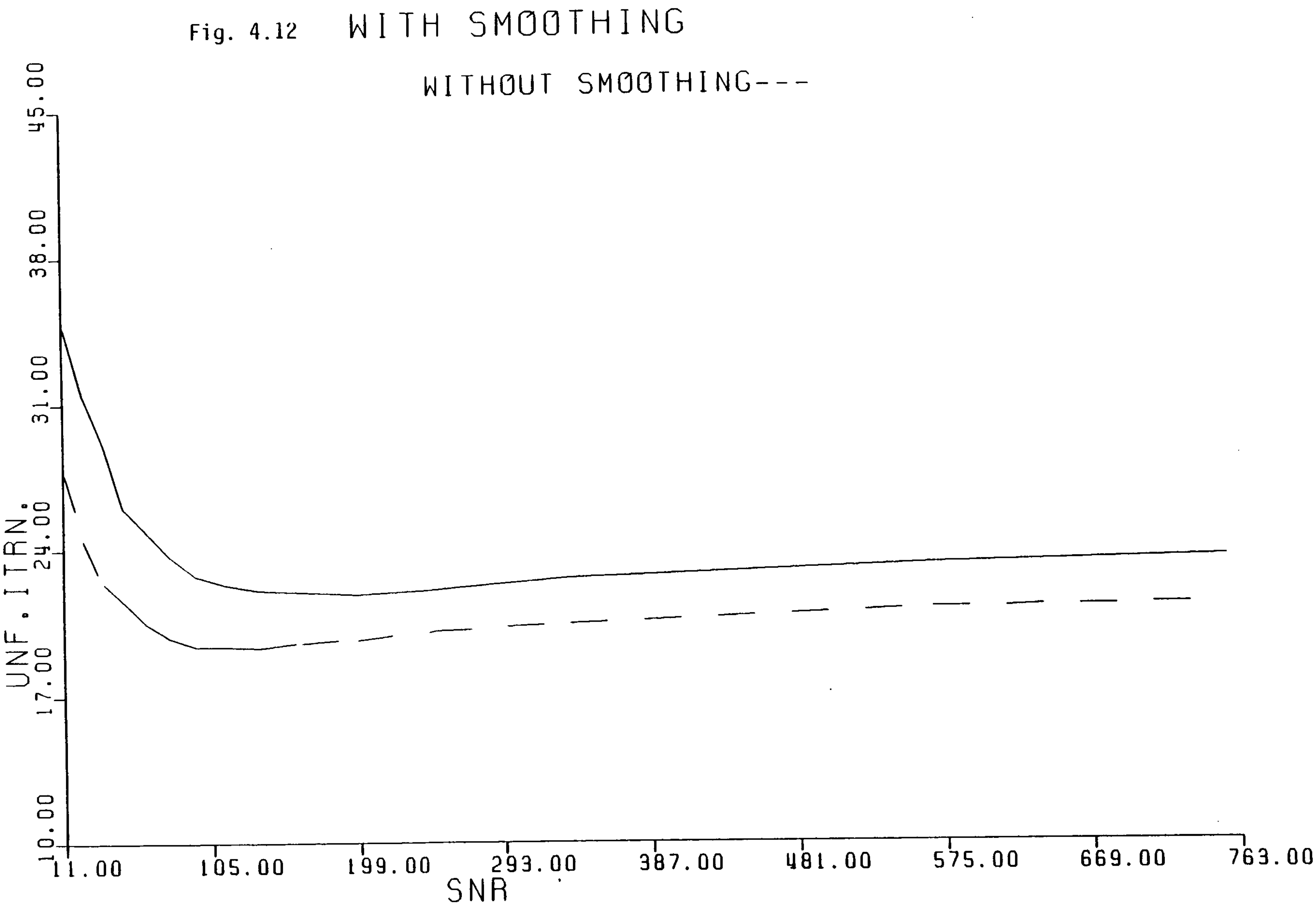

WITH SMOOTHING
WITHOUT SMOOTHING---
45.00
38.00
31.00
24.00
17.00
10.00
UNF. ITRN.
11.00
105.00
199.00
293.00
387.00
481.00
575.00
669.00
763.00
SNR

Fig. 4.13 SMTH. ITRNS. VS SNR

NARROW GAUSSIAN

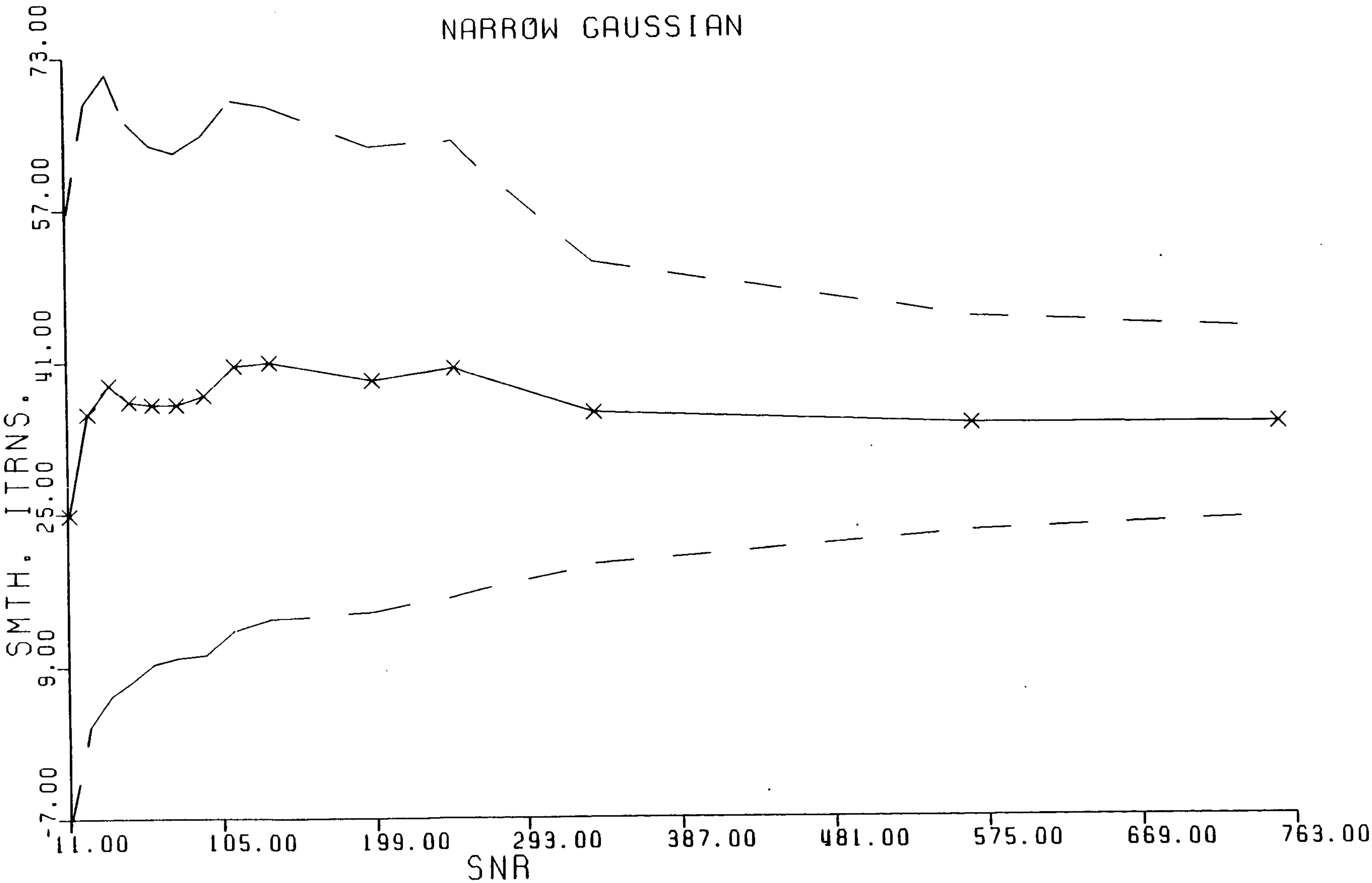


Fig. 4.14

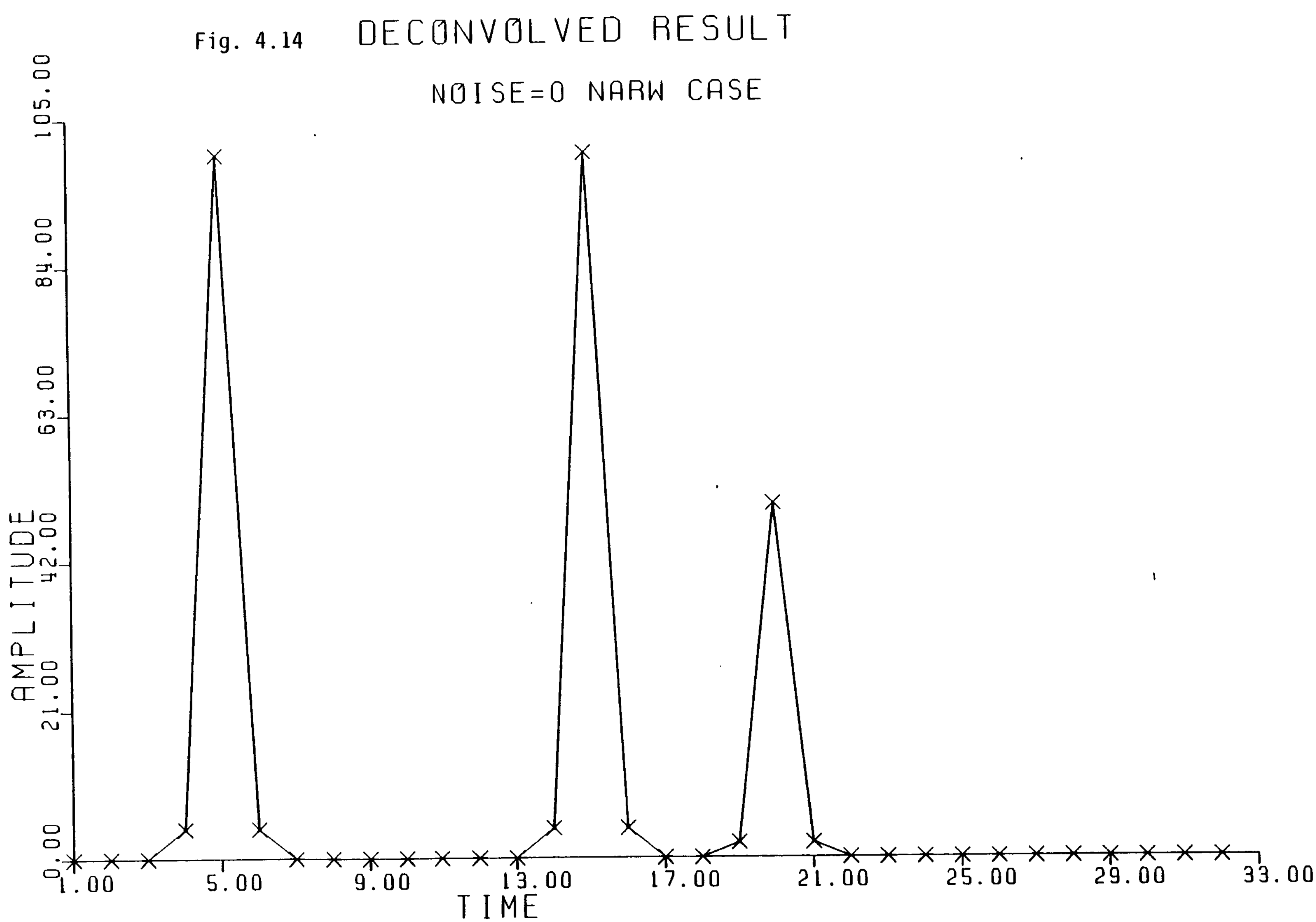

DECONVOLVED RESULT
NOISE=0 NARW CASE
AMPLITUDE
105.00
84.00
63.00
42.00
21.00
0.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME

Fig. 4.15

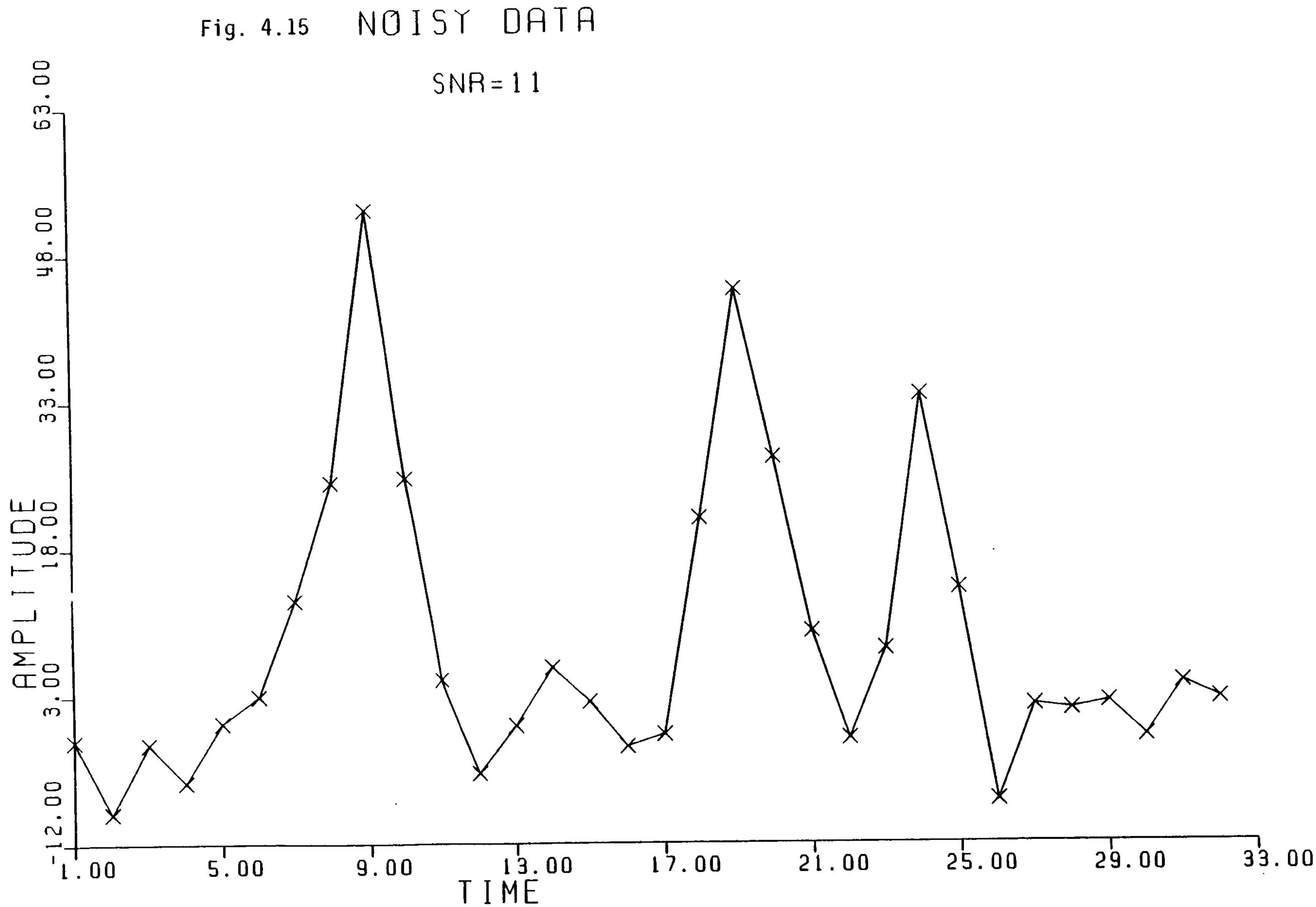

NØISY DATA
SNR=11
AMPLITUDE
63.00
48.00
33.00
18.00
3.00
-12.00
TIME
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00

Fig. 4.16 SMOOTHED DATA

SNR= 11

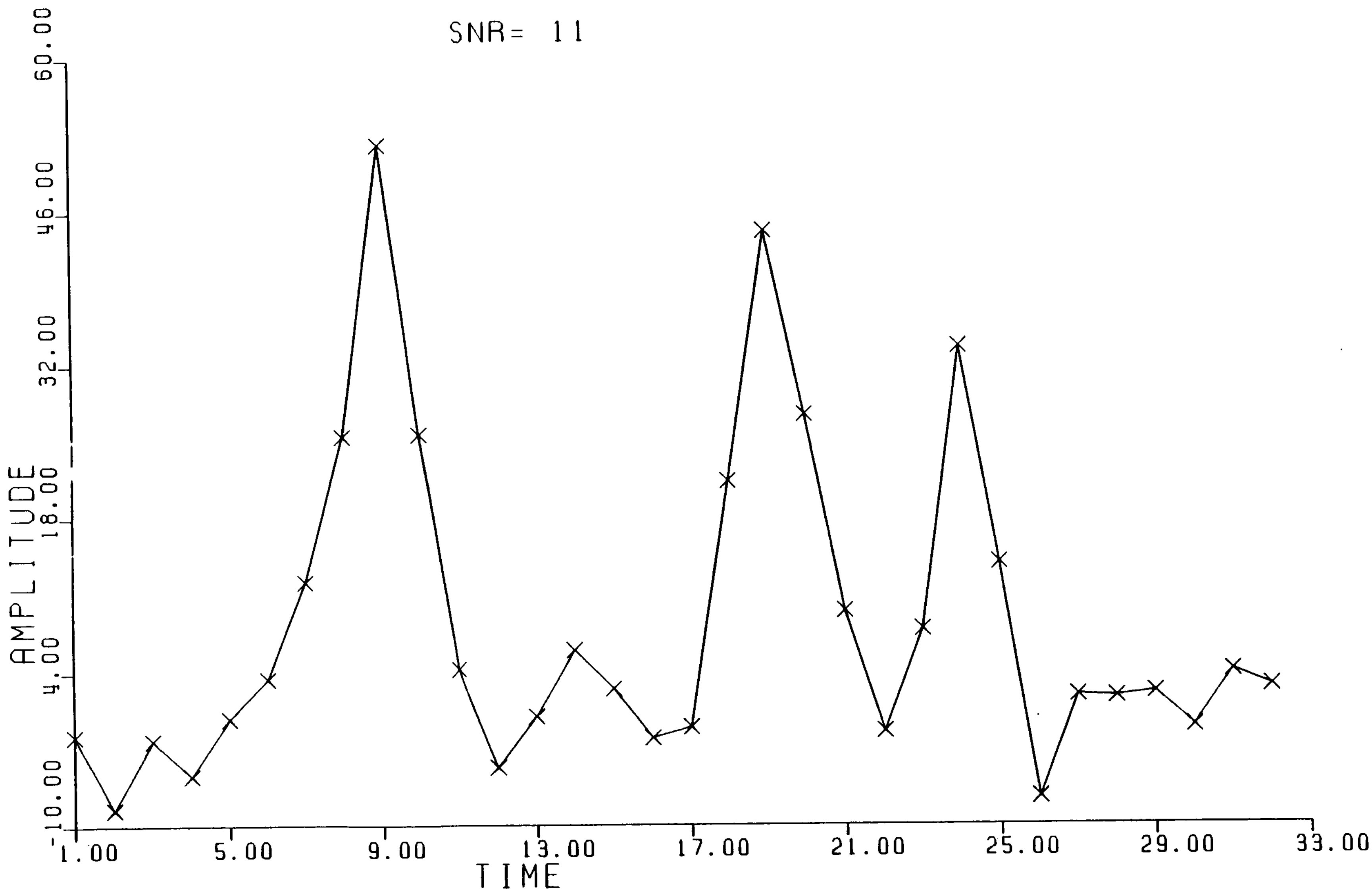


Fig. 4.17

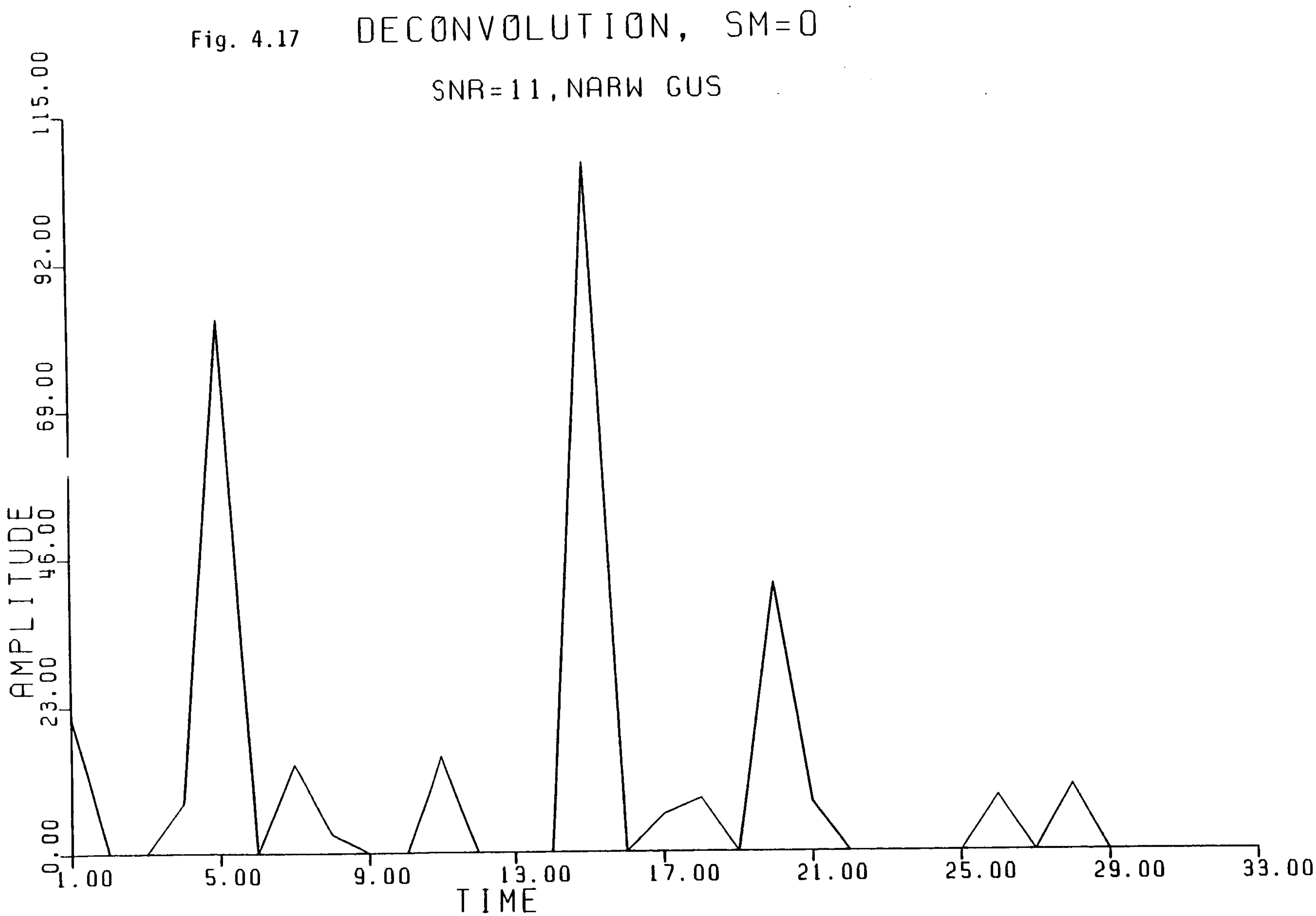

DECONVOLUTION, SM=0
SNR=11, NARW GUS
AMPLITUDE
0.00
23.00
46.00
69.00
92.00
115.00
TIME
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00

Fig. 4.18 DECONVOLVED RESULT

SNR=11,NARW GUS

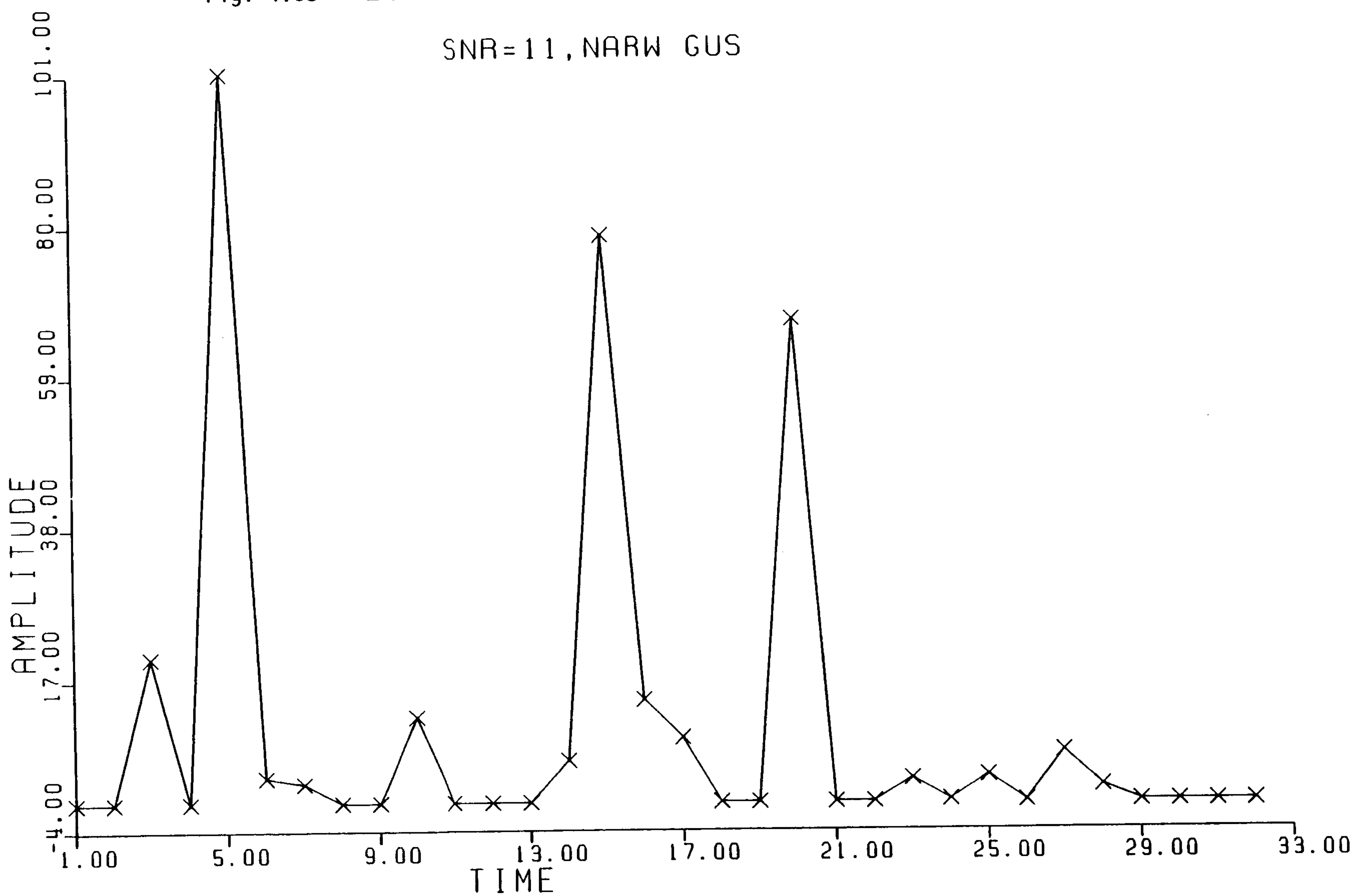


Fig. 4.19

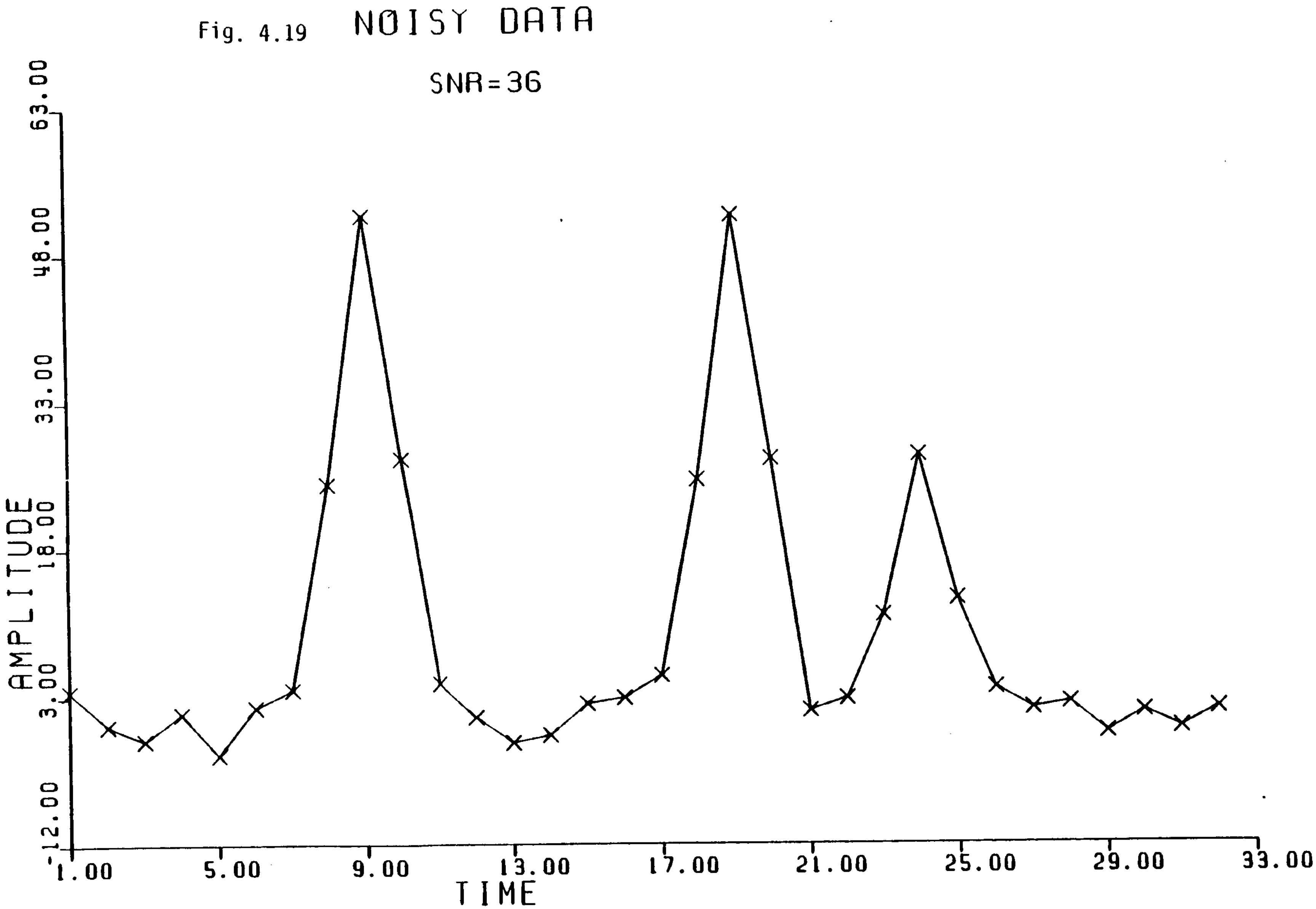

NØISY DATA
SNR=36
AMPLITUDE
63.00
48.00
33.00
18.00
3.00
-12.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME

Fig. 4.20

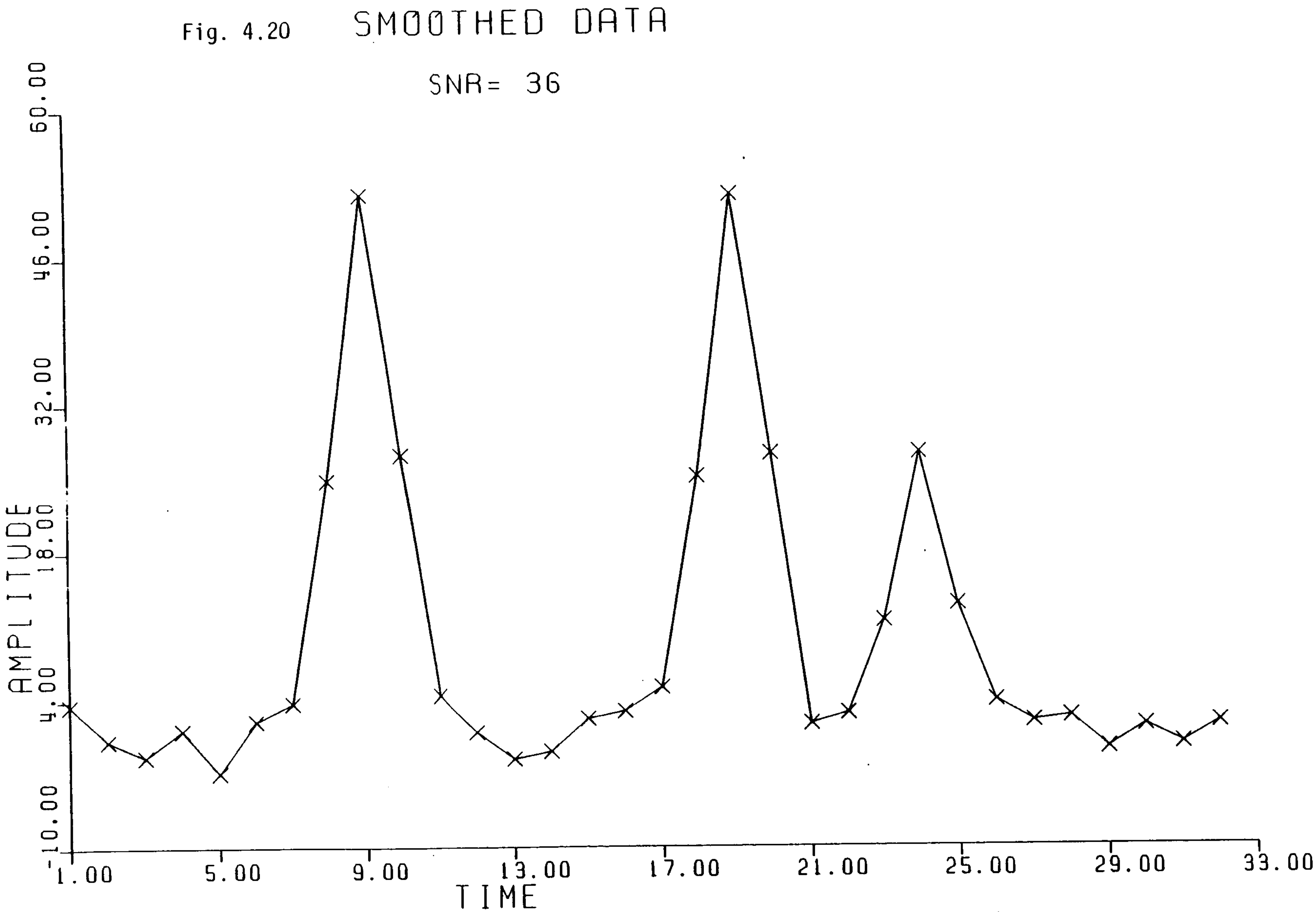

SMOOTHED DATA
SNR= 36
AMPLITUDE
60.00
46.00
32.00
18.00
4.00
-10.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME

Fig. 4.21 DECONVOLUTION, SM=0

SNR=36, NARW GUS

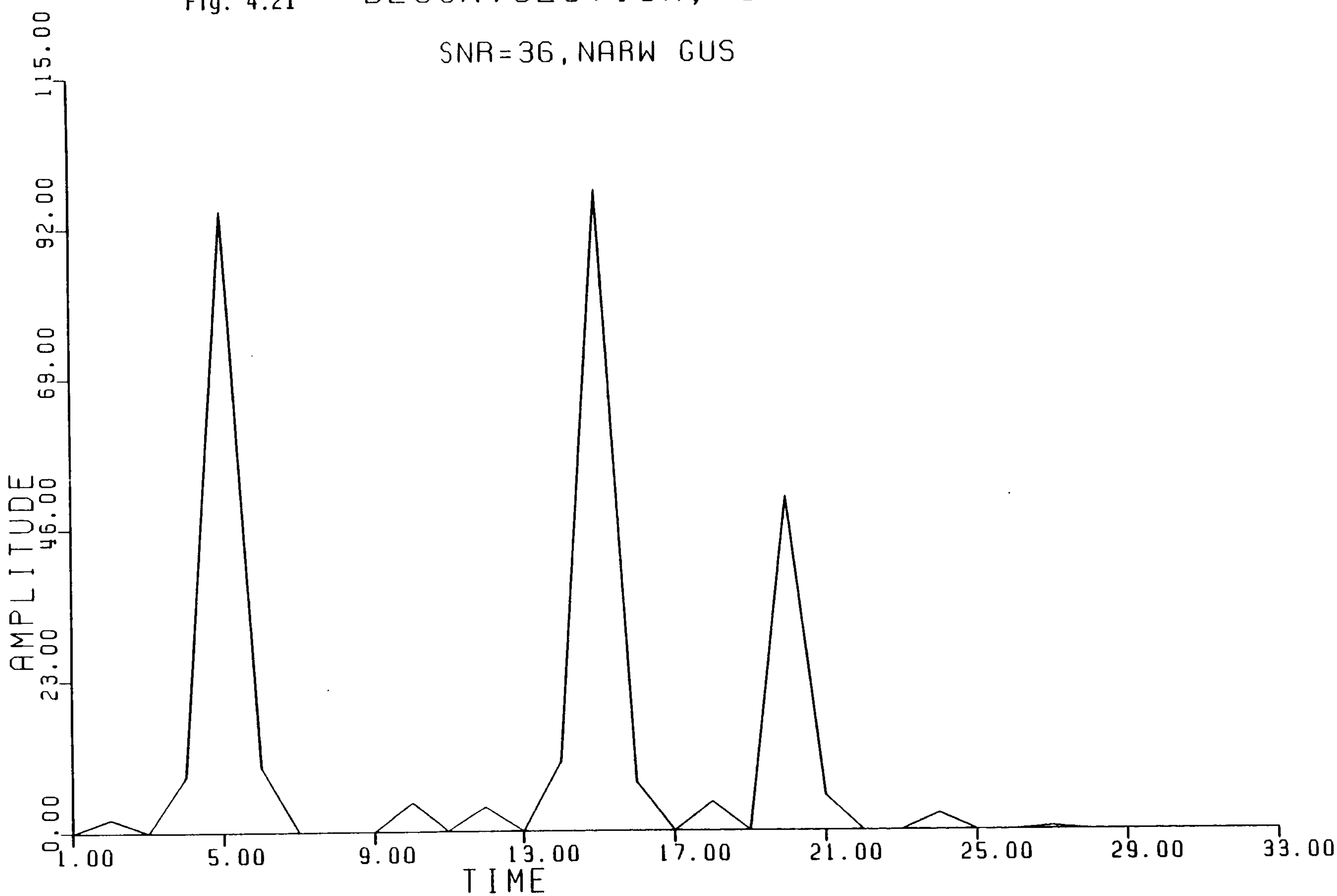


Fig. 4.22

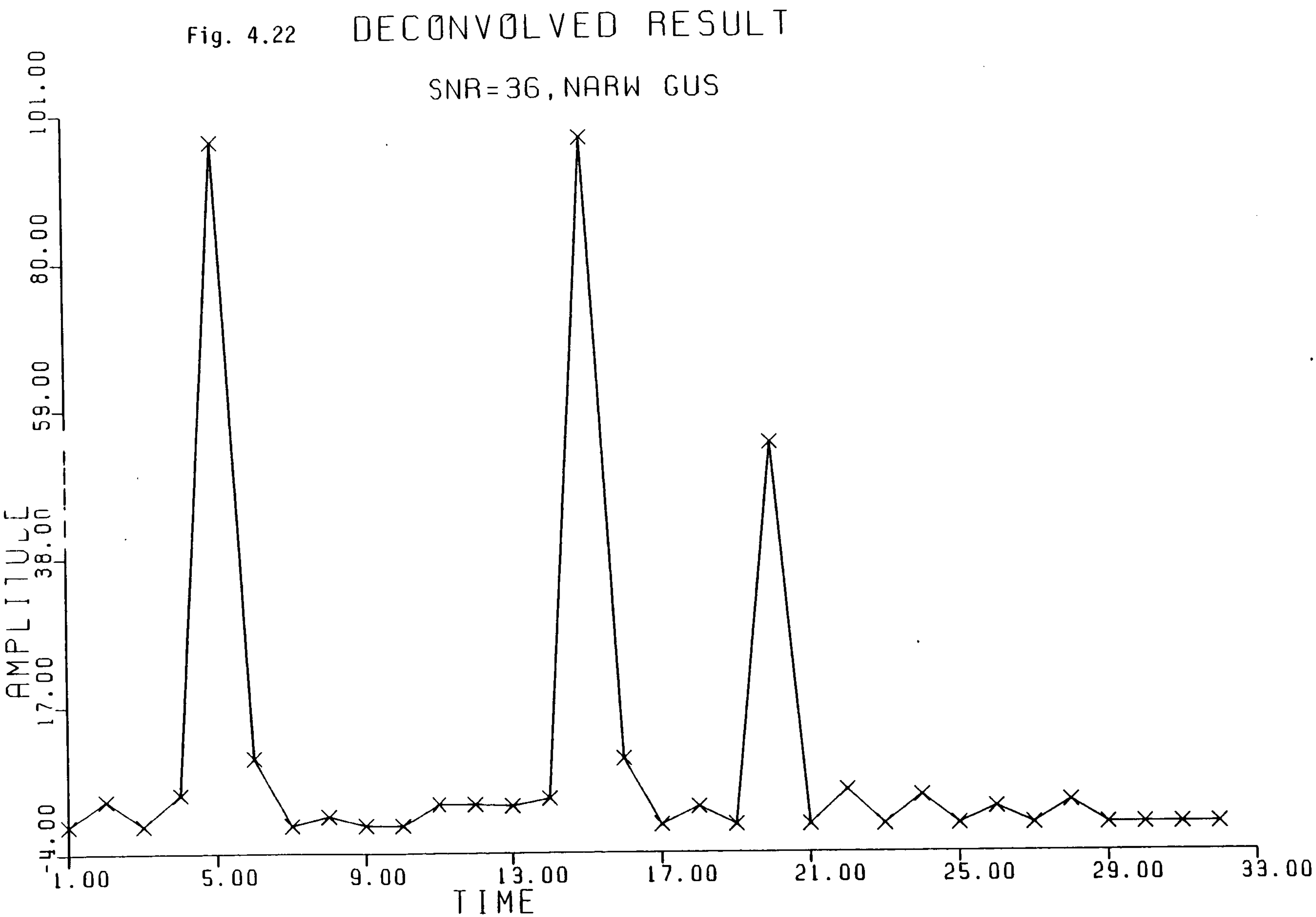
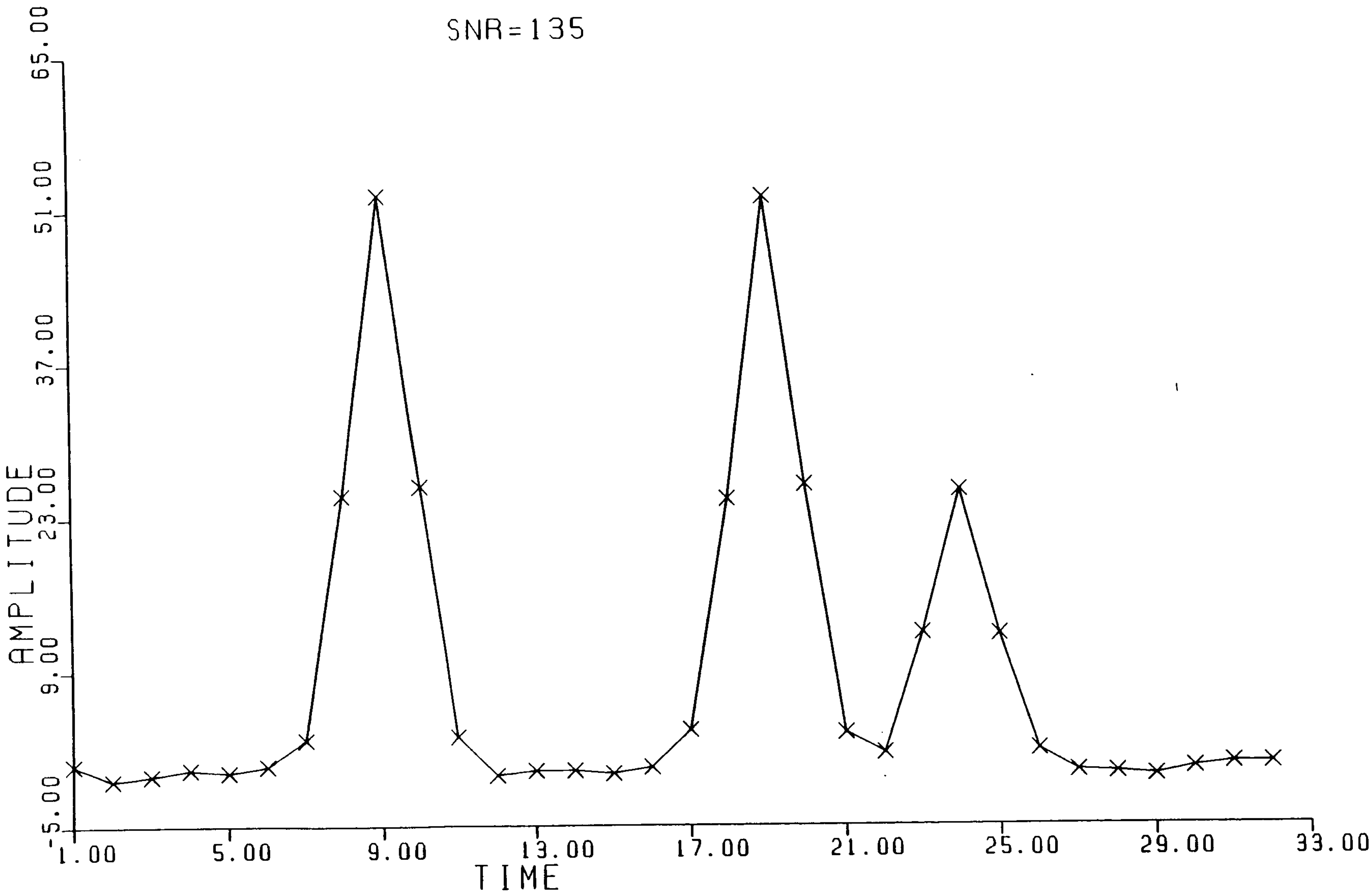

DECONVOLVED RESULT
SNR=36, NARW GUS
AMPLITUDE
101.00
80.00
59.00
38.00
17.00
-4.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME

Fig. 4.23 NØISY DATA

SNR=135



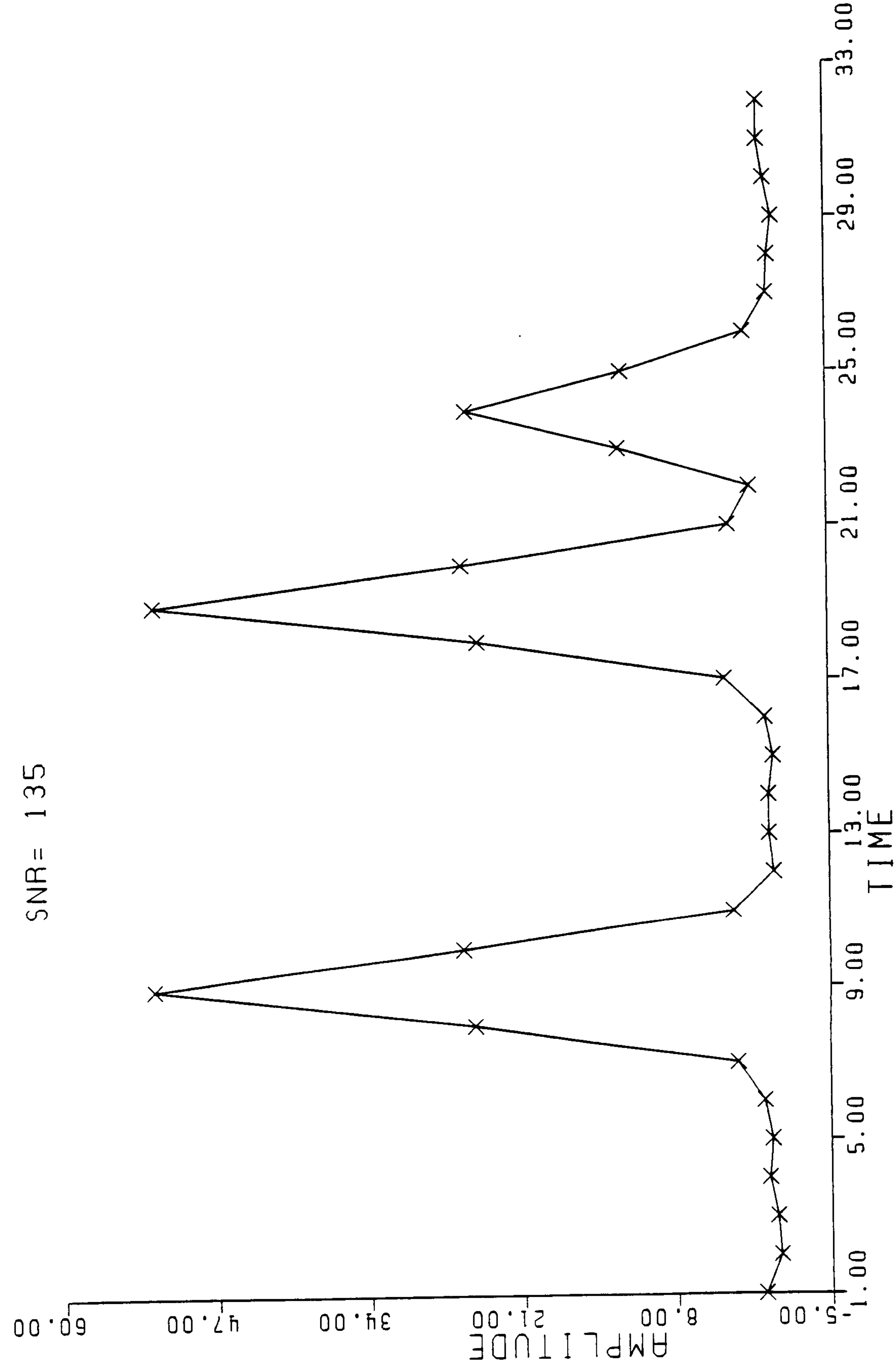

SMOOTHED DATA
SNR= 135
TIME
AMPLITUDE
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
-5.00
8.00
21.00
34.00
47.00
60.00

Fig. 4.24

Fig. 4.25

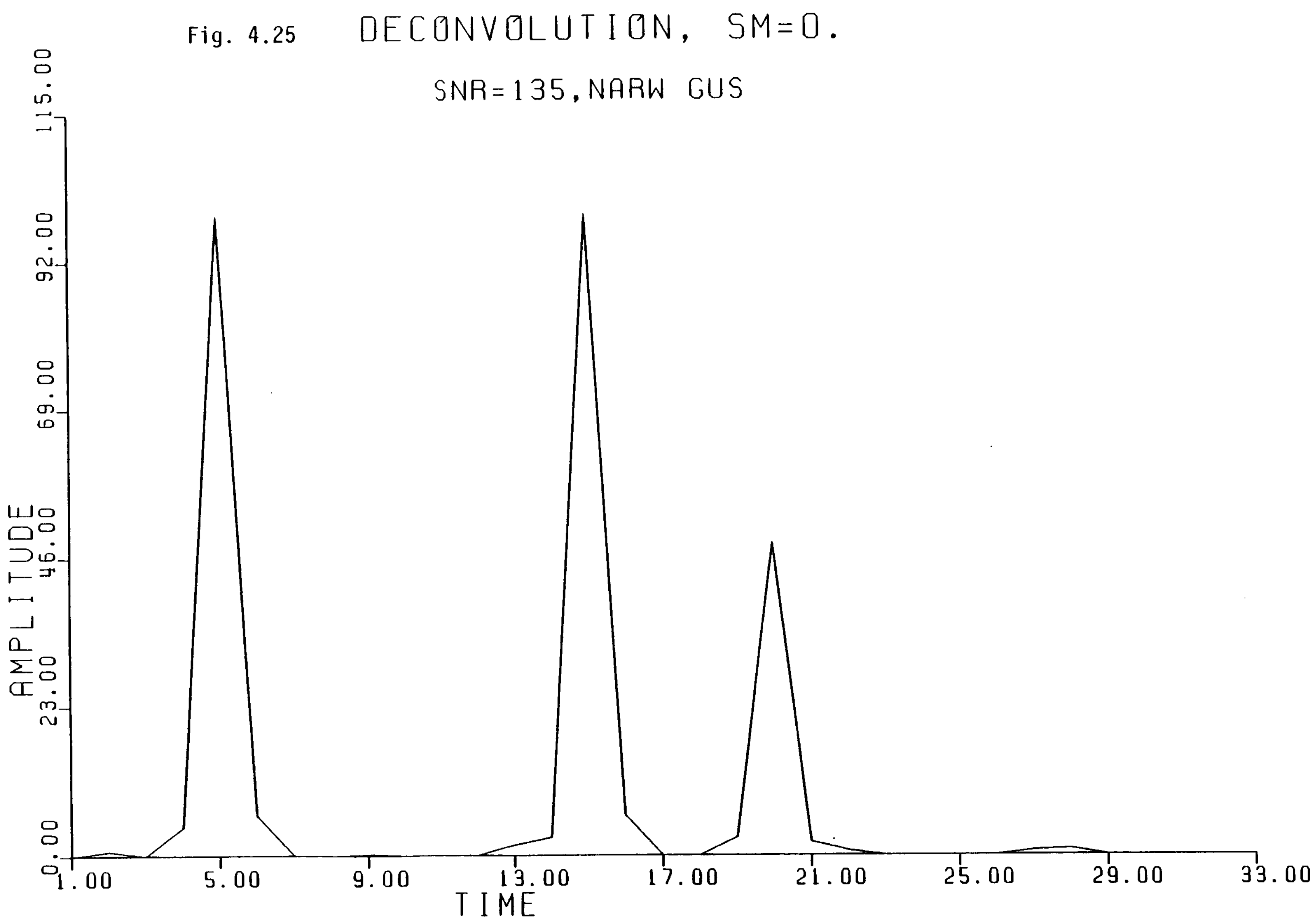

DECONVOLUTION, SM=0.
SNR=135,NARW GUS
AMPLITUDE
0.00
23.00
46.00
69.00
92.00
115.00
TIME
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00

Fig. 4.26

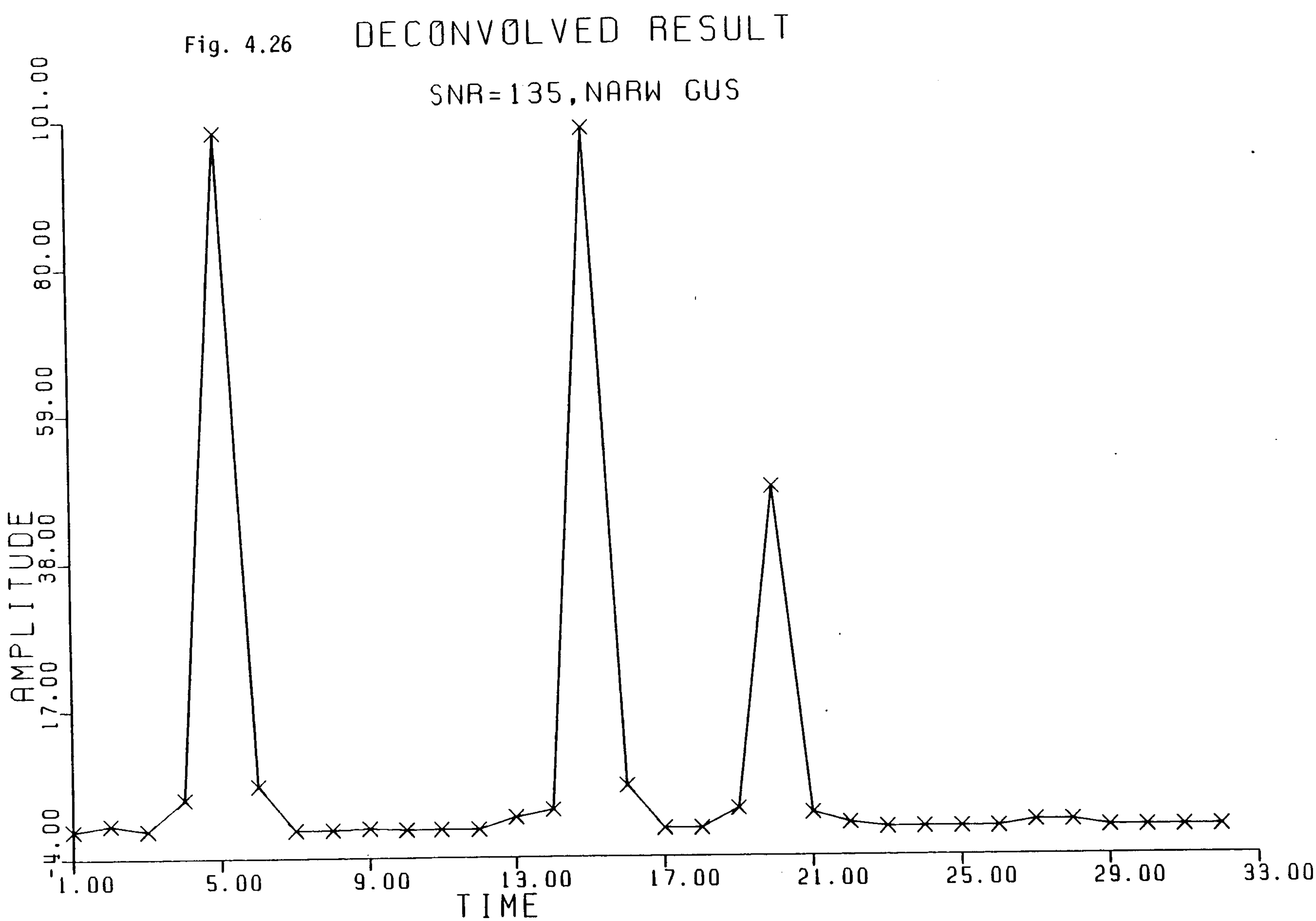

DECONVOLVED RESULT
SNR=135,NARW GUS
AMPLITUDE
101.00
80.00
59.00
38.00
17.00
-4.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME

Fig. 4.27 WIDE GAUSSIAN

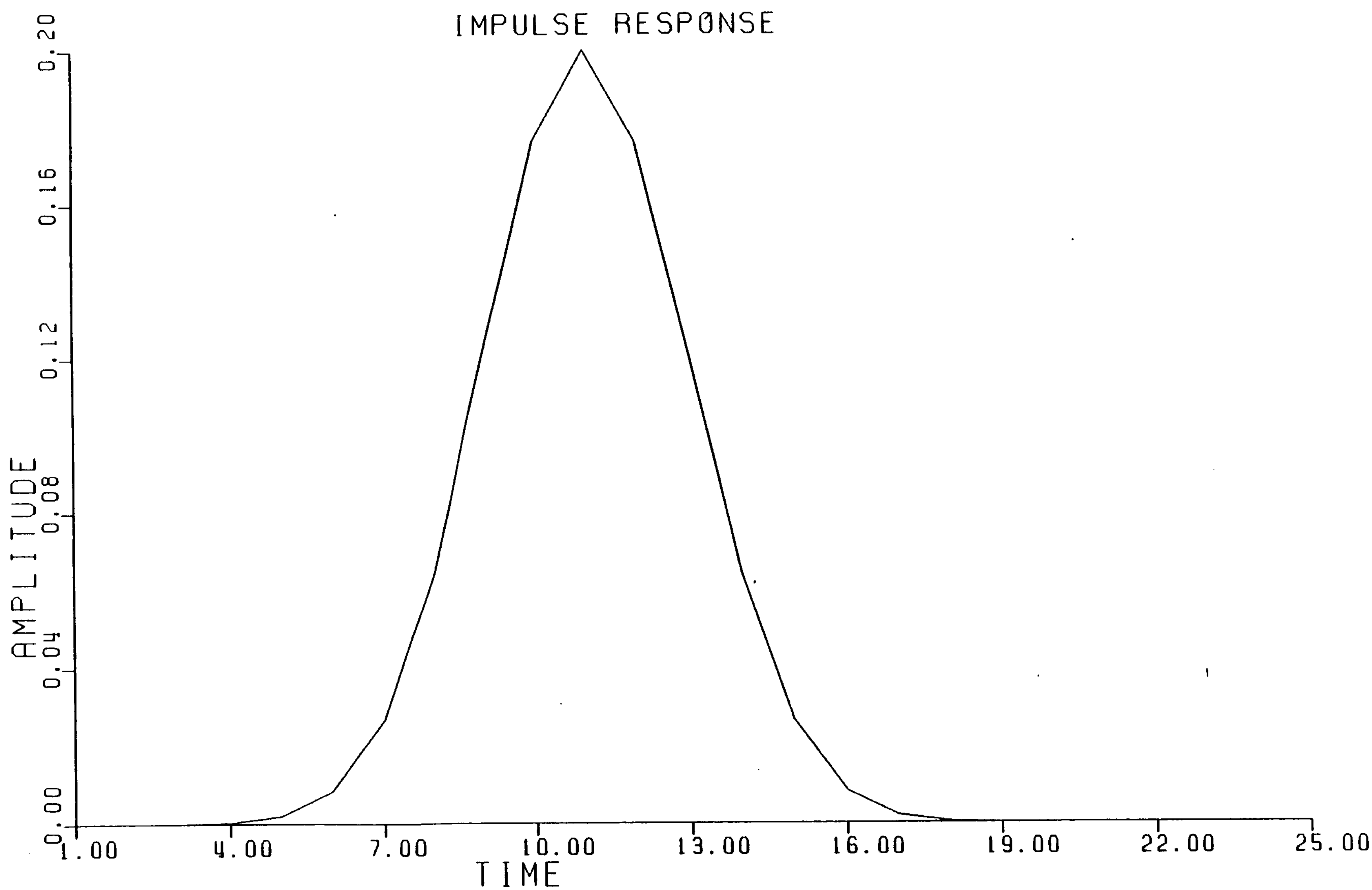


Fig. 4.28 WIDE GAUSSIAN

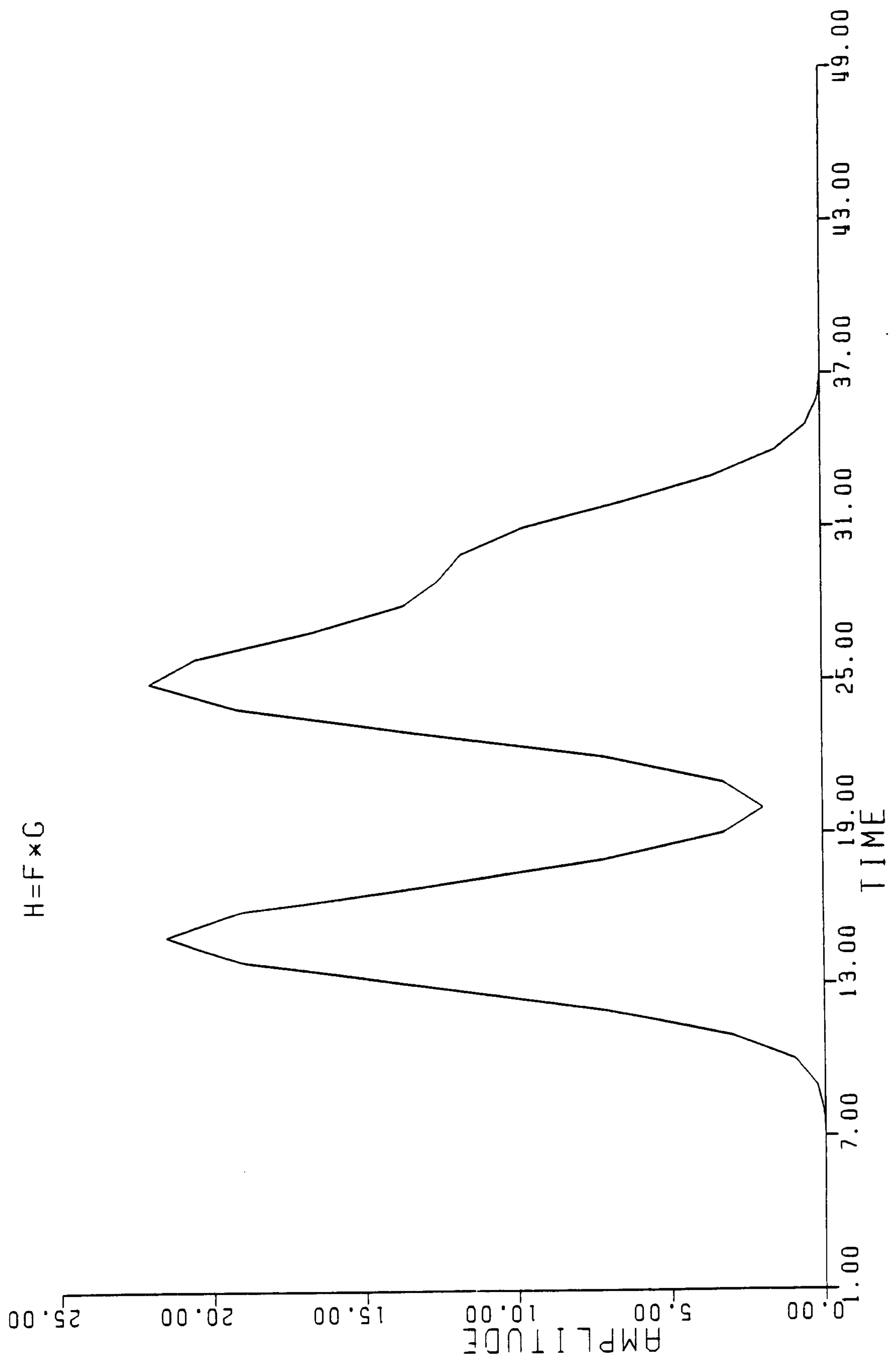


Fig. 4.29 MSE VS LN(SNR)

WIDE GAUSSIAN

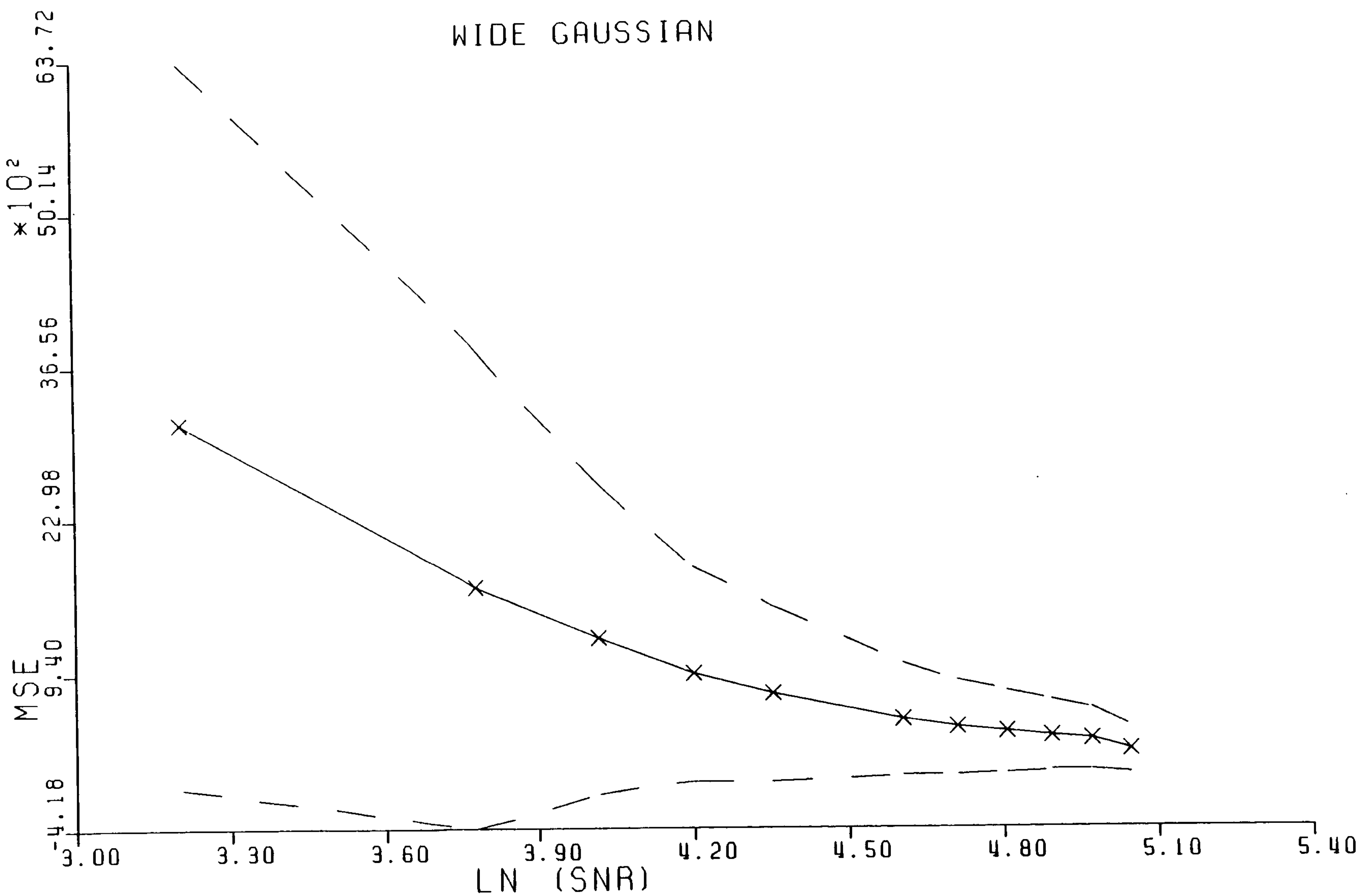


Fig. 4.30 SMOOTHING=0

WIDE GAUSSIAN

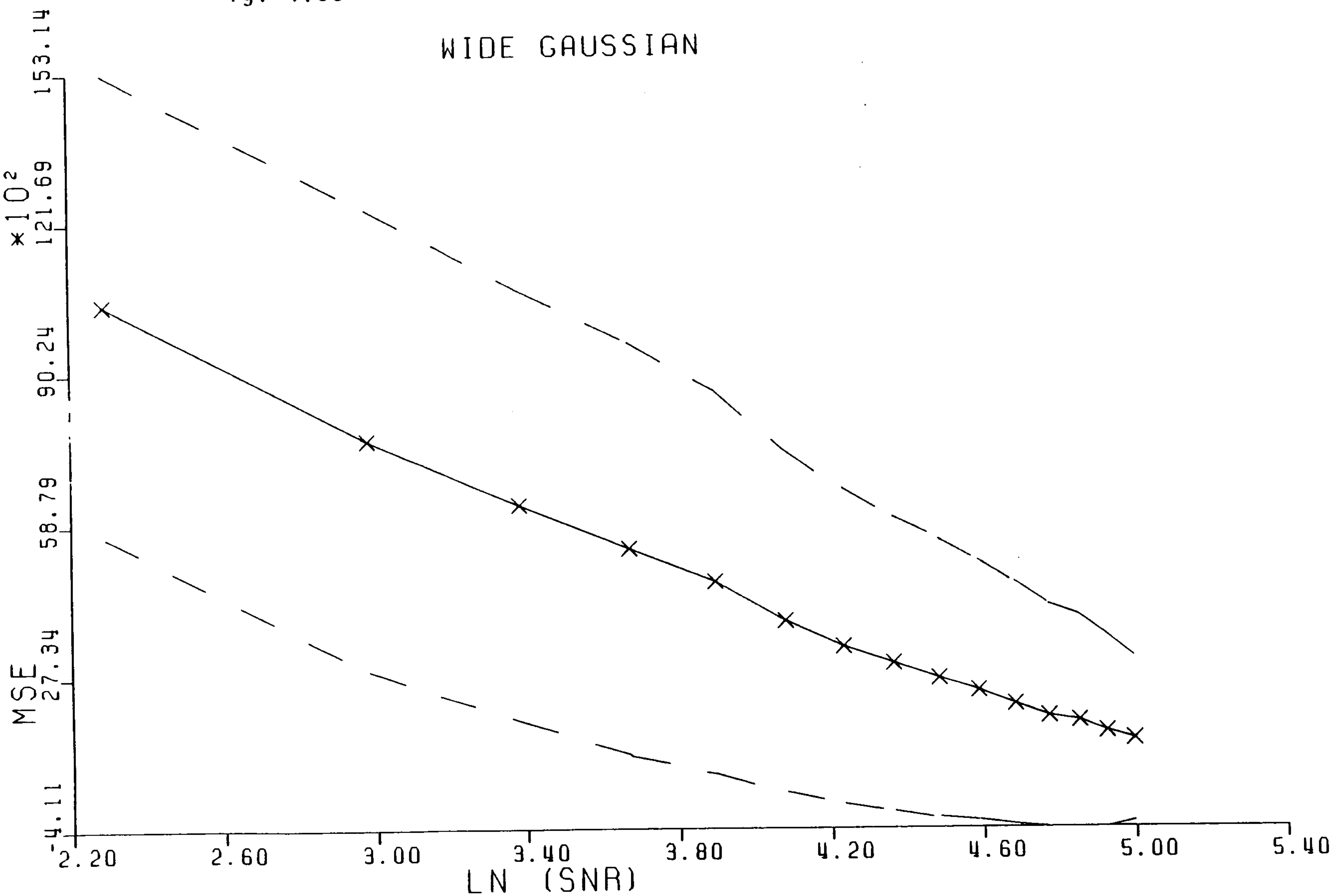
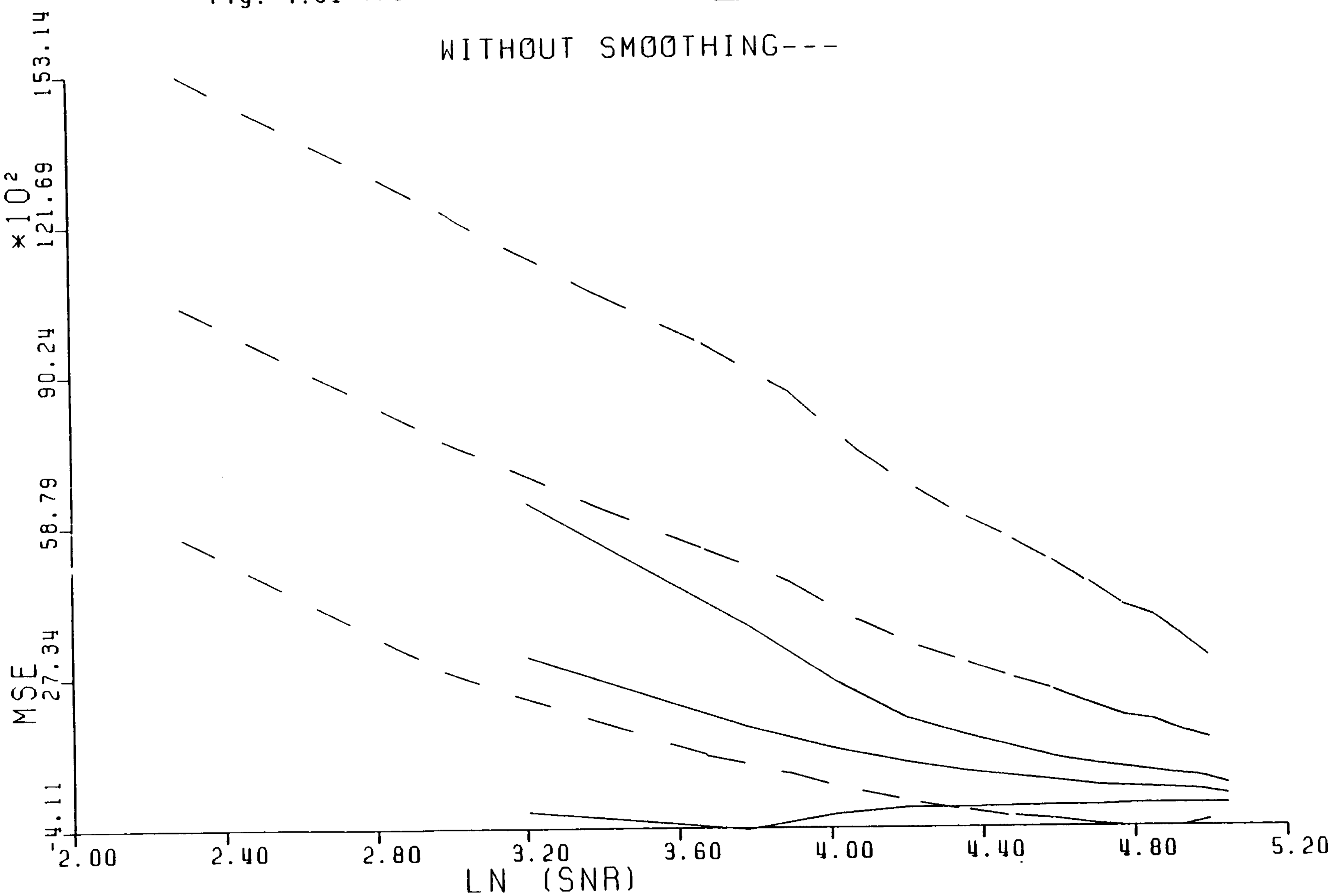


Fig. 4.31 WITH SMOOTHING______

WITHOUT SMOOTHING---



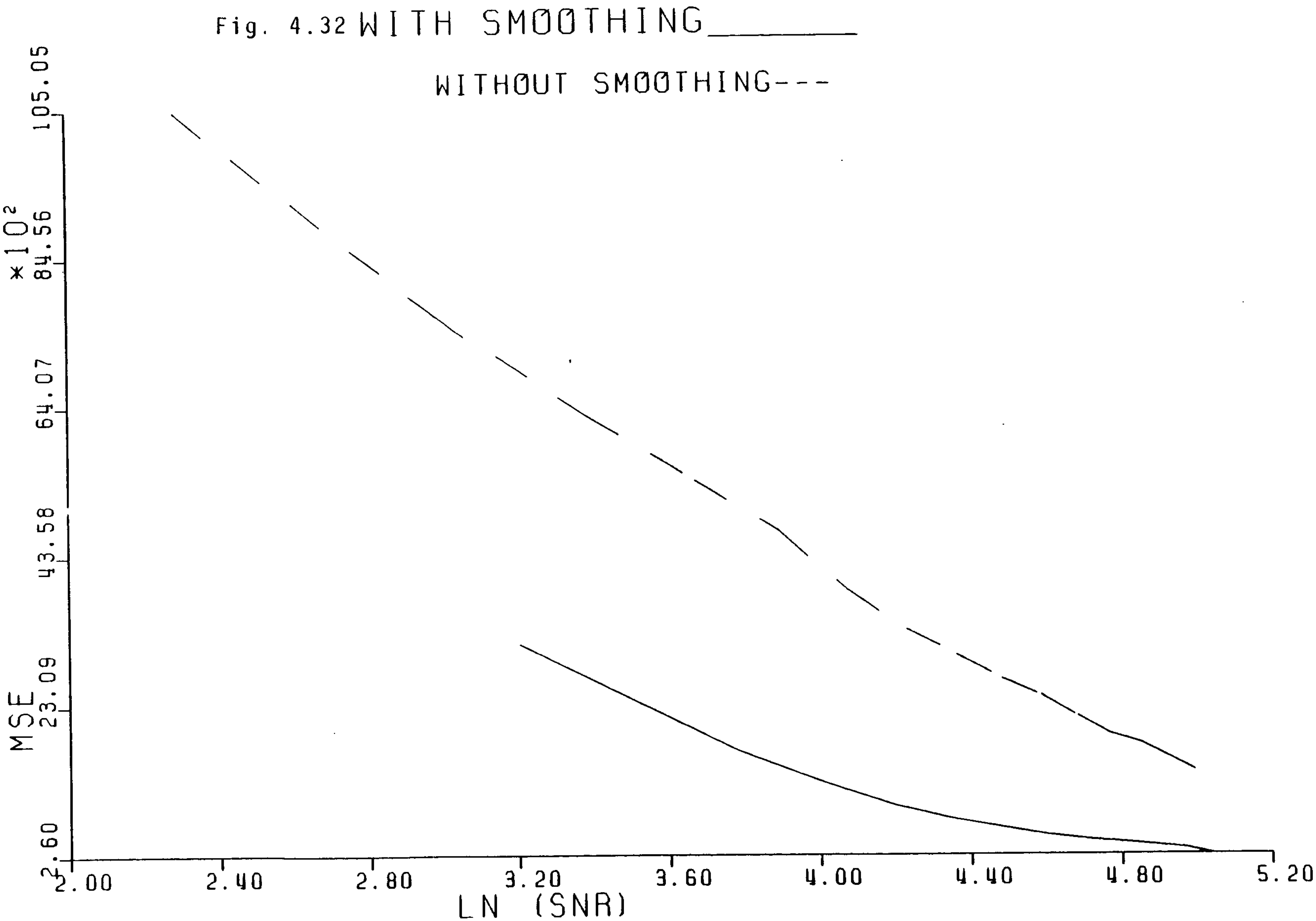

WITH SMOOTHING
WITHOUT SMOOTHING
105.05
84.56
64.07
43.58
23.09
2.60
$*10^2$
MSE
2.00
2.40
2.80
3.20
3.60
4.00
4.40
4.80
5.20
LN (SNR)

Fig. 4.32

Fig. 4.33 UNFOLDING ITR. VS SN

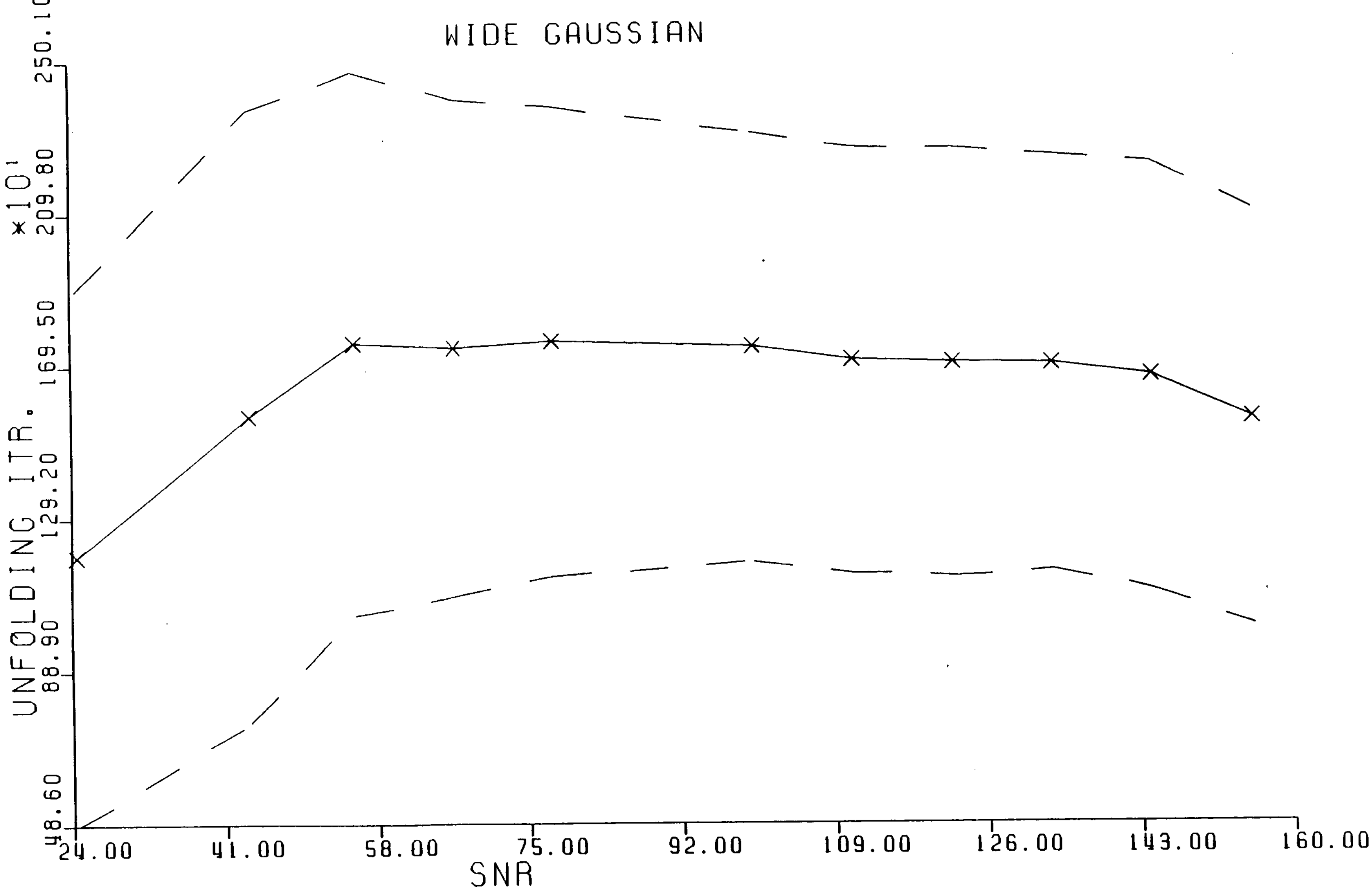


Fig. 4.34 SMOOTHING=0

WIDE GAUSSIAN UNF. I

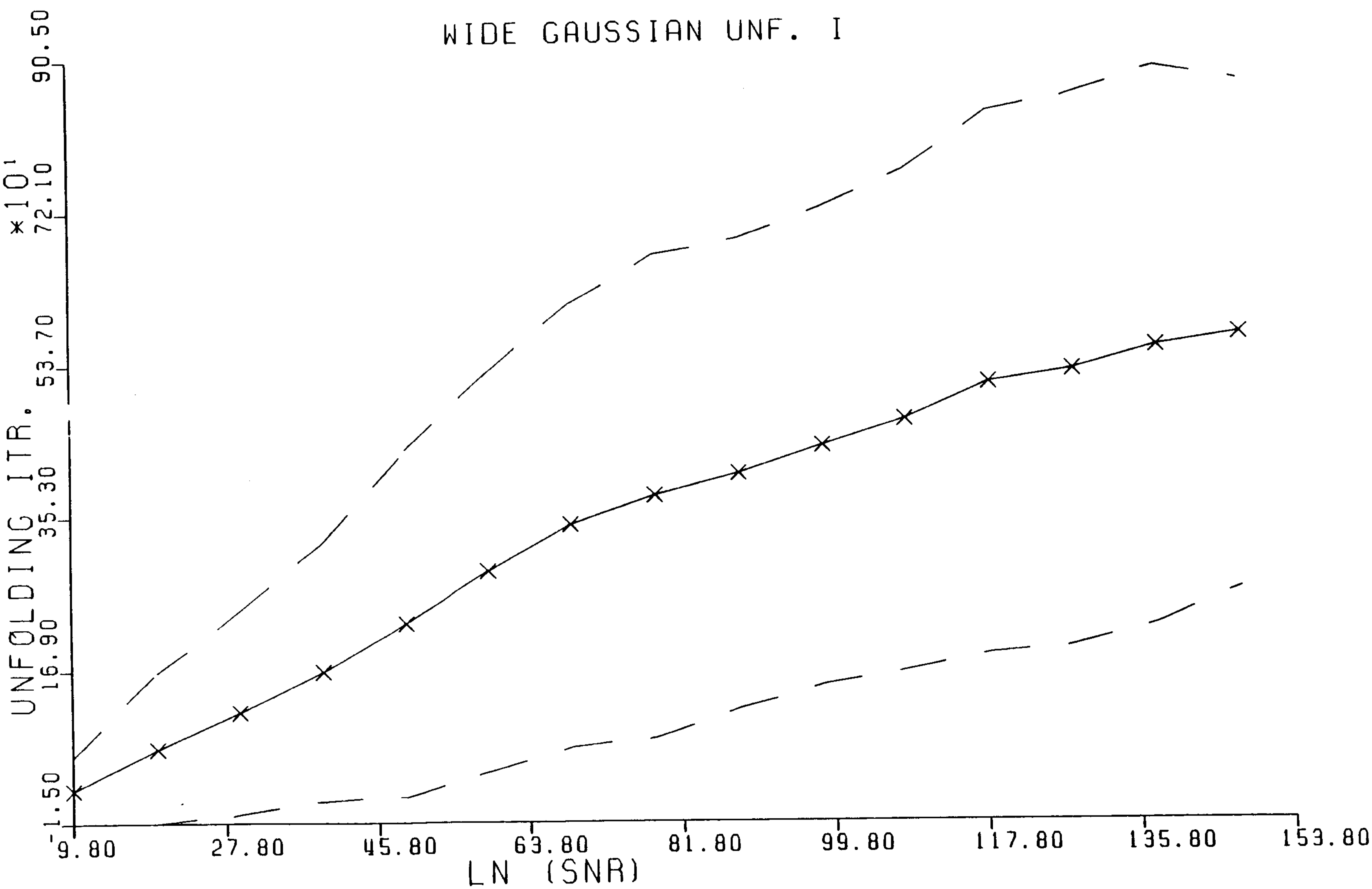


Fig. 4.35 WITH SMOOTHING______

WITHOUT SMOOTHING---

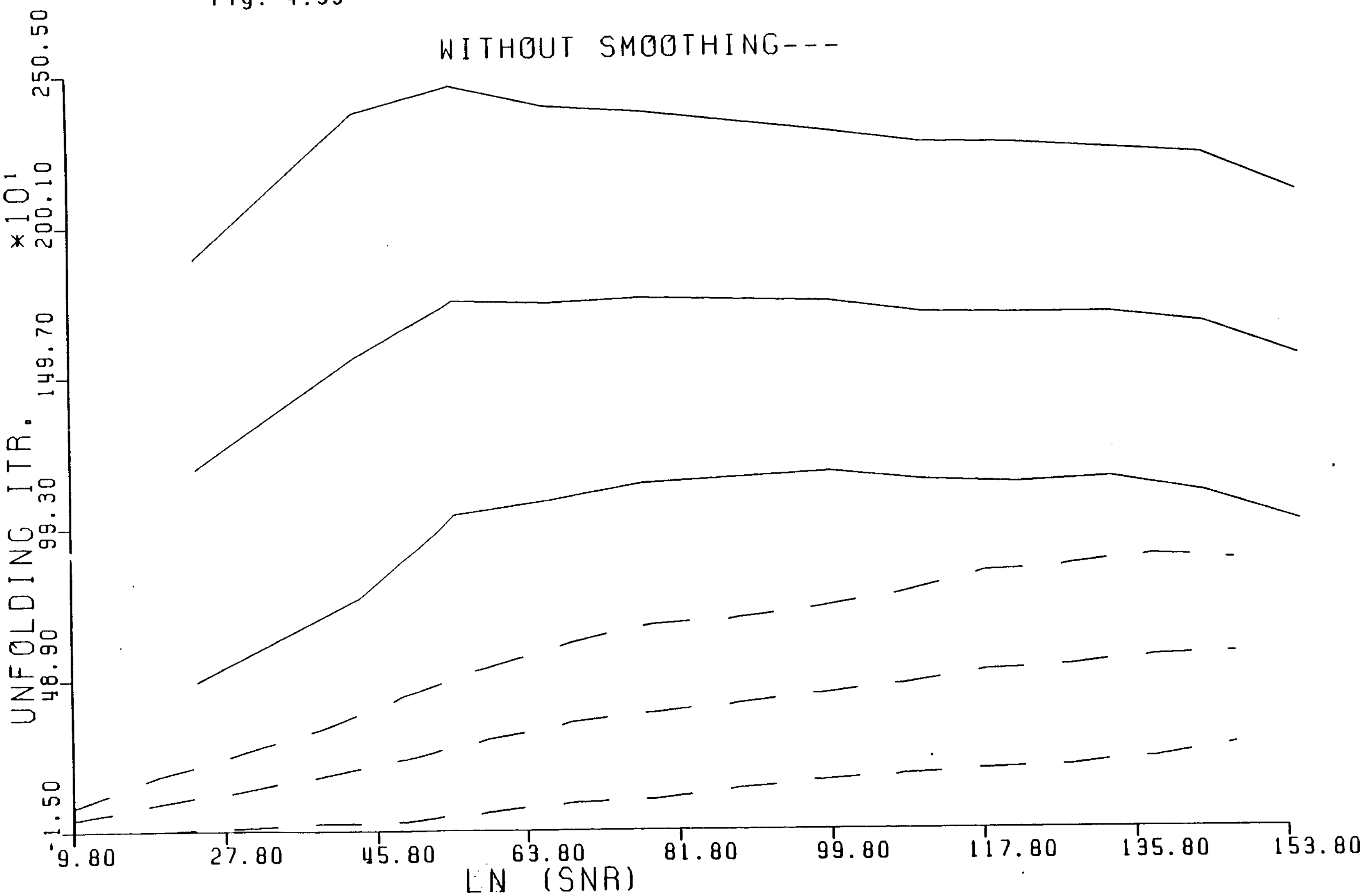


Fig. 4.36 WITH SMOOTHING_______

WITHOUT SMOOTHING---

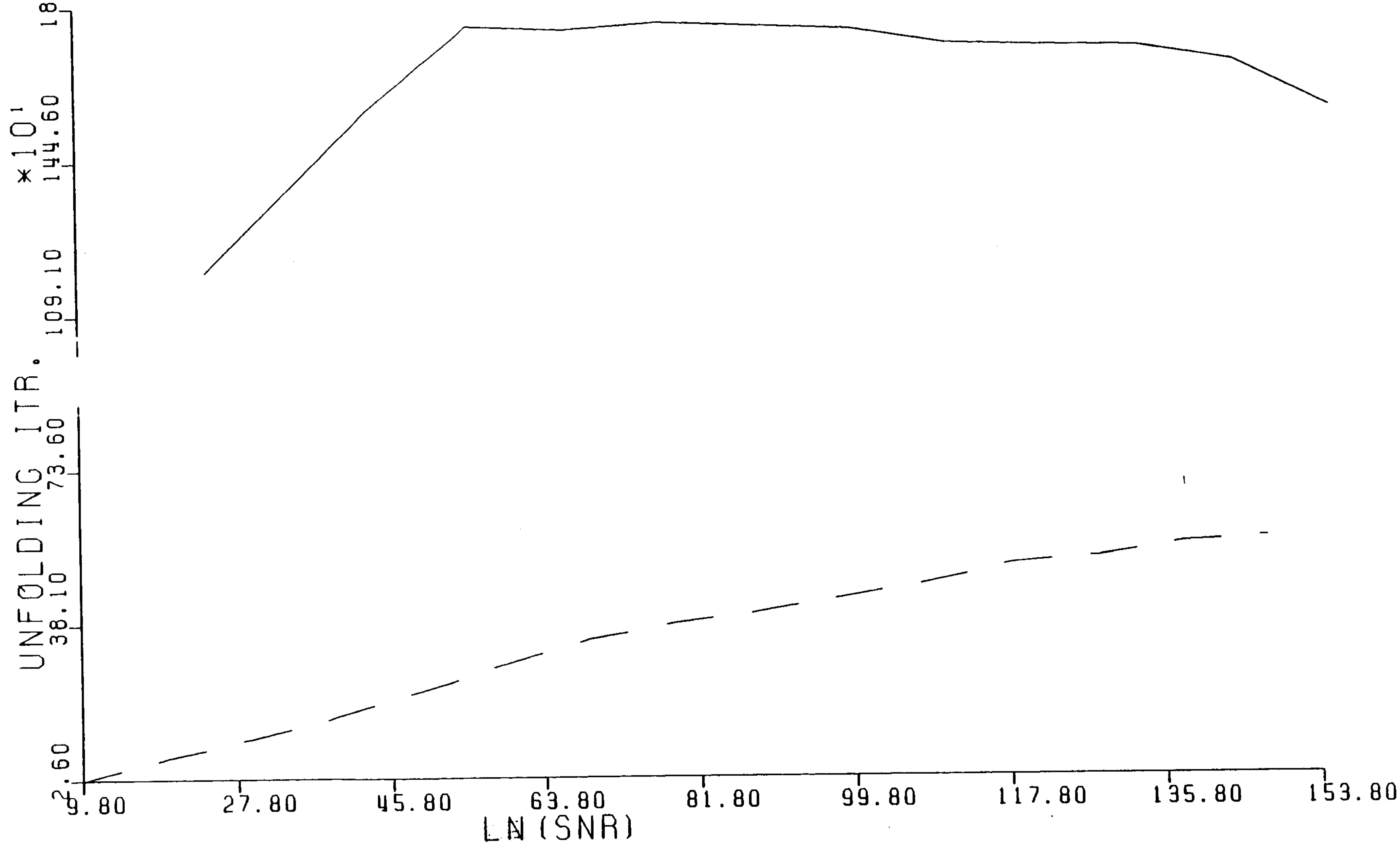


Fig. 4.37 SMOOTHING ITR. VS SN

WIDE GAUSSIAN

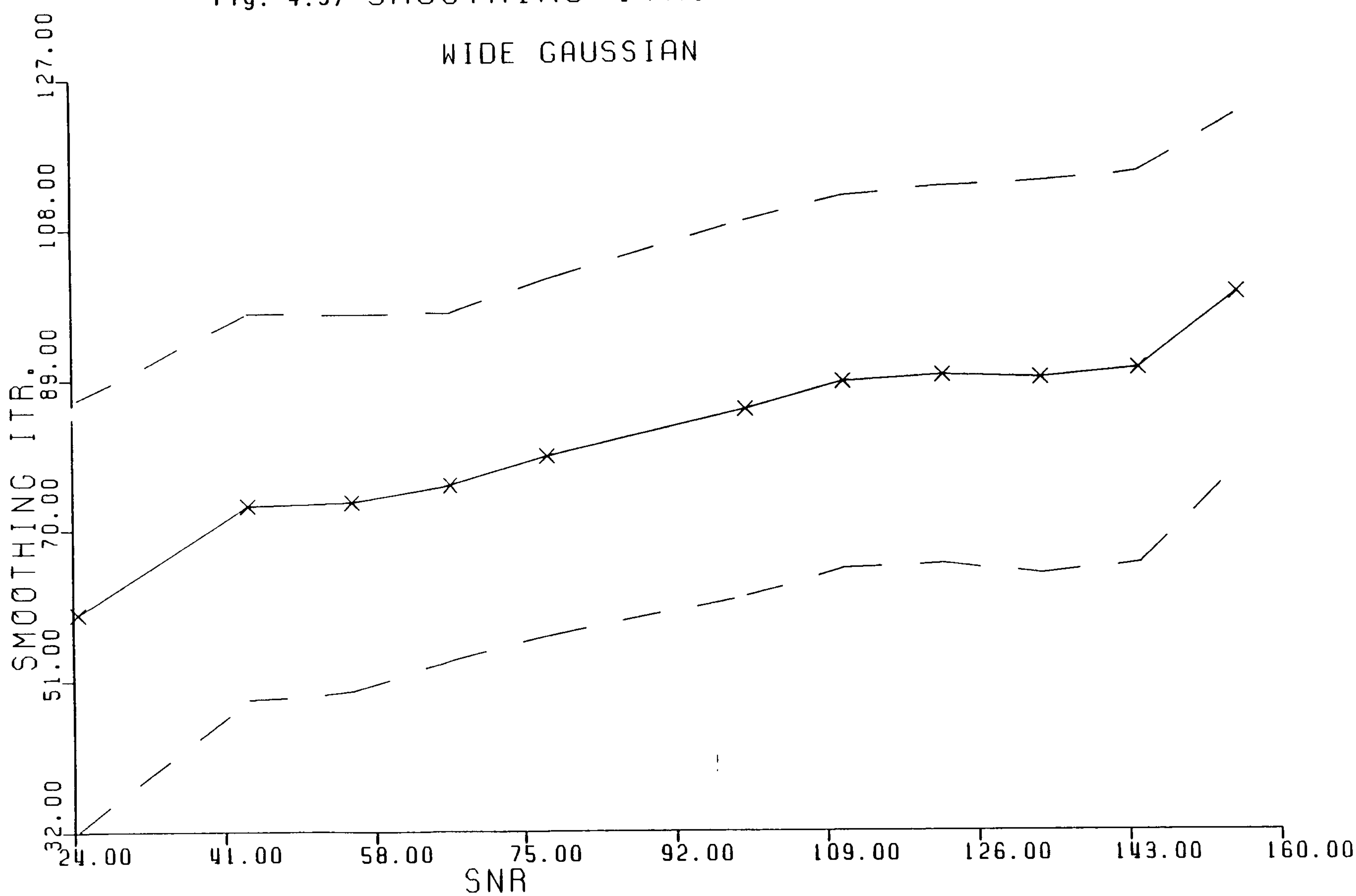


Fig. 4.33 DECONVOLVED RESULT

NOISE FREE , W.G

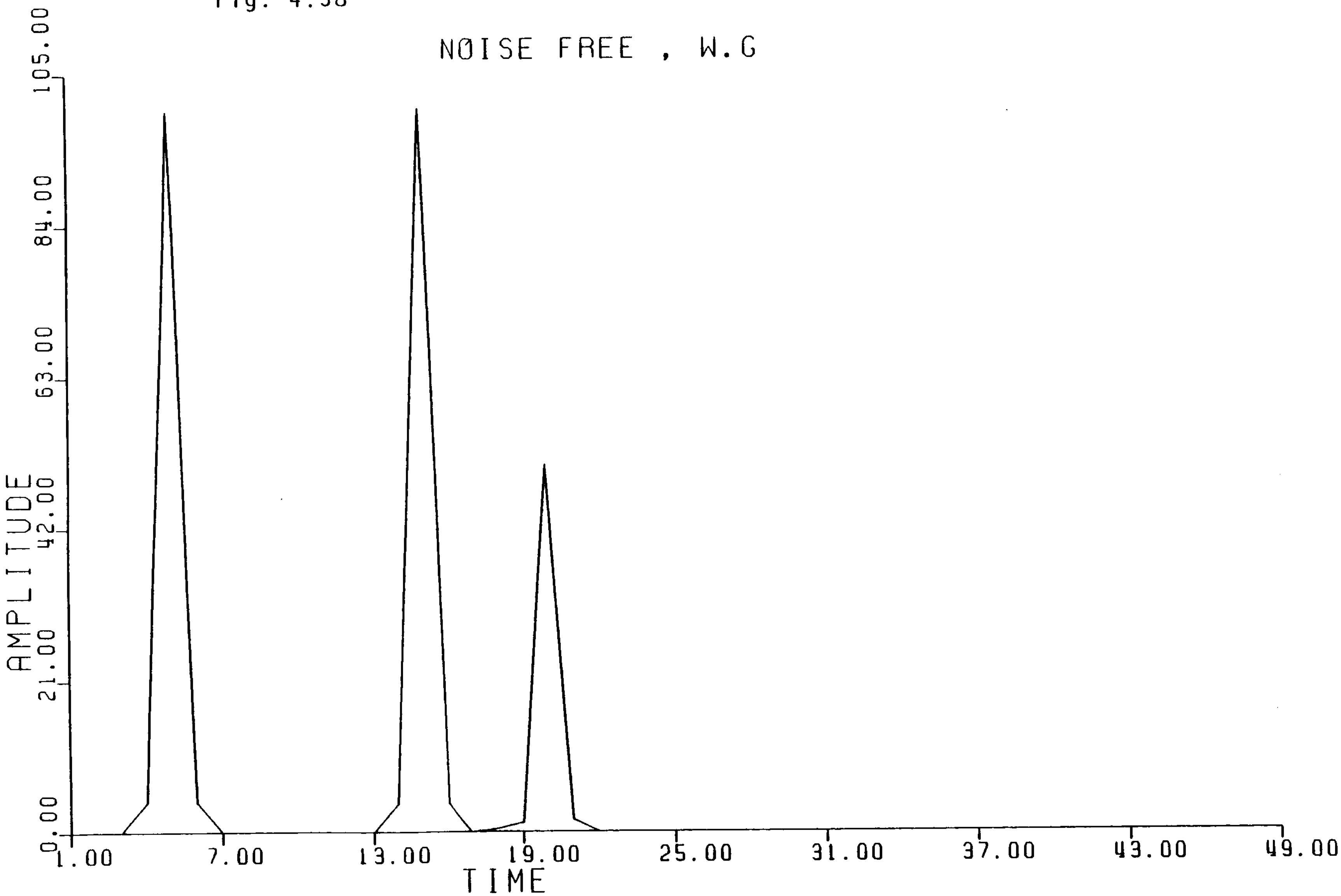


Fig. 4.39 NOISY H, SNR=10

WIDE GAUSSIAN

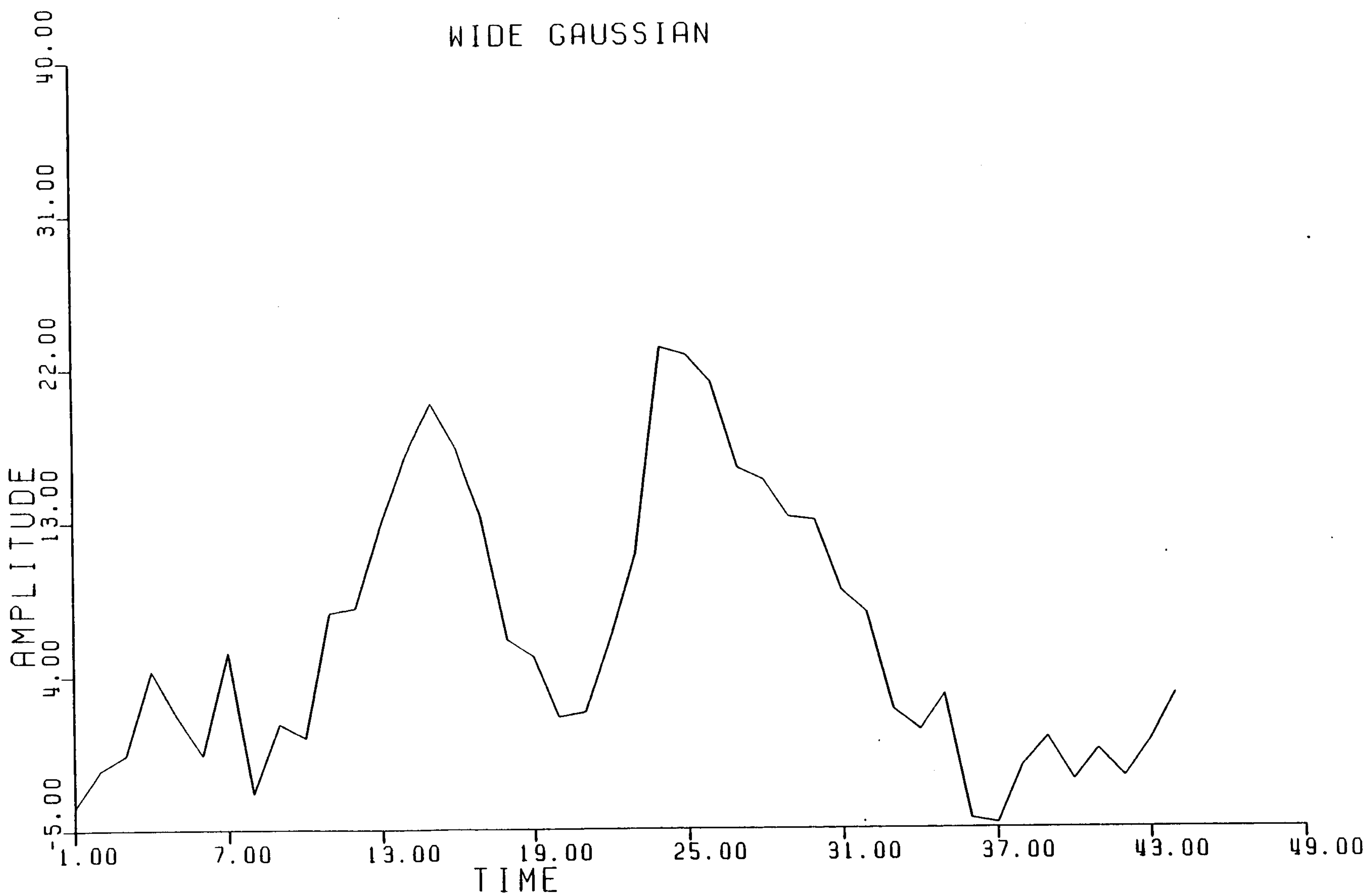
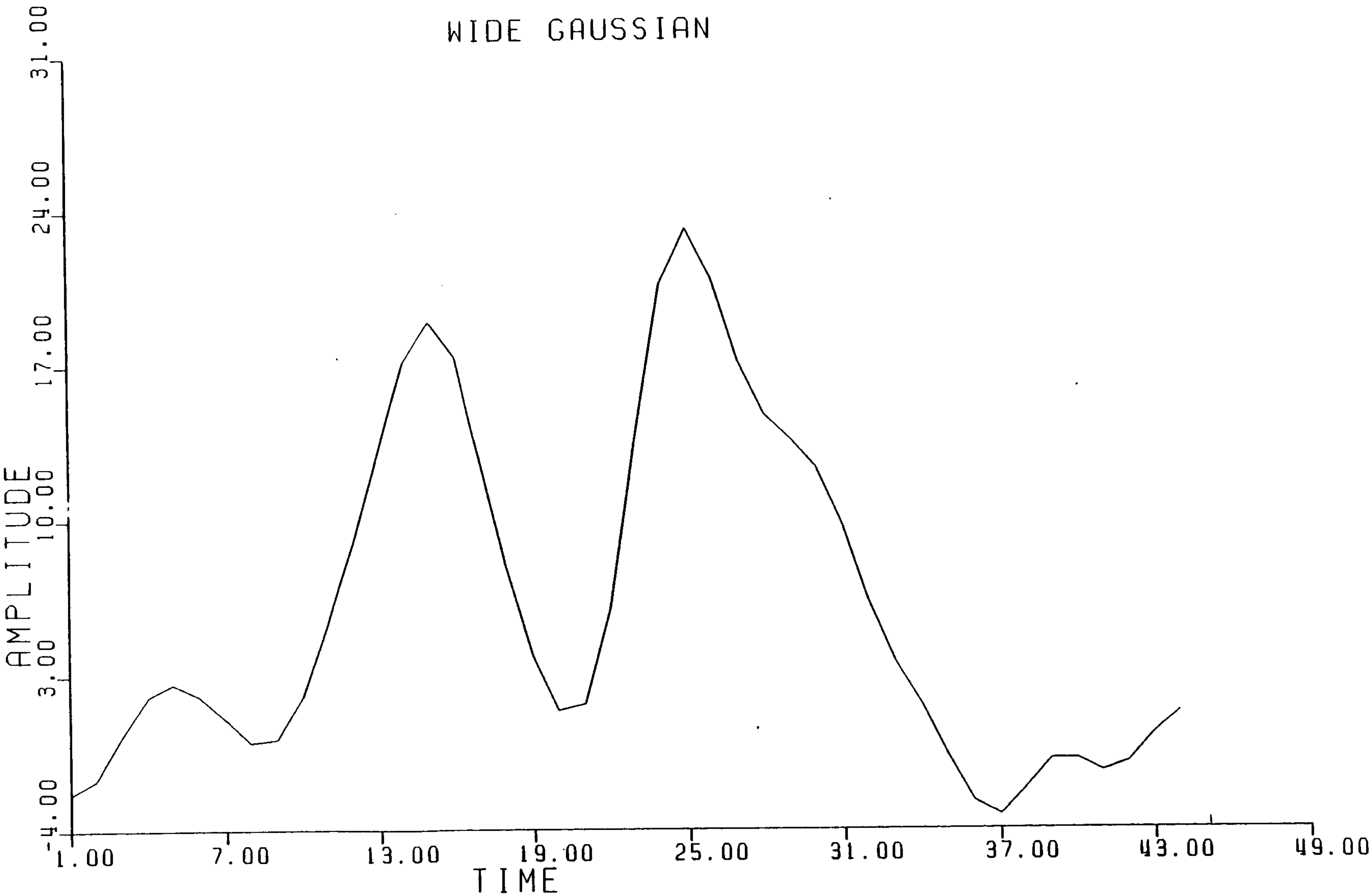


Fig. 4.40 SMOOTHED H, SNR=10

WIDE GAUSSIAN



C-9

Fig. 4.41 DCND. RSULT SMØTH.=0

SNR=10 WIDE GAUSN.

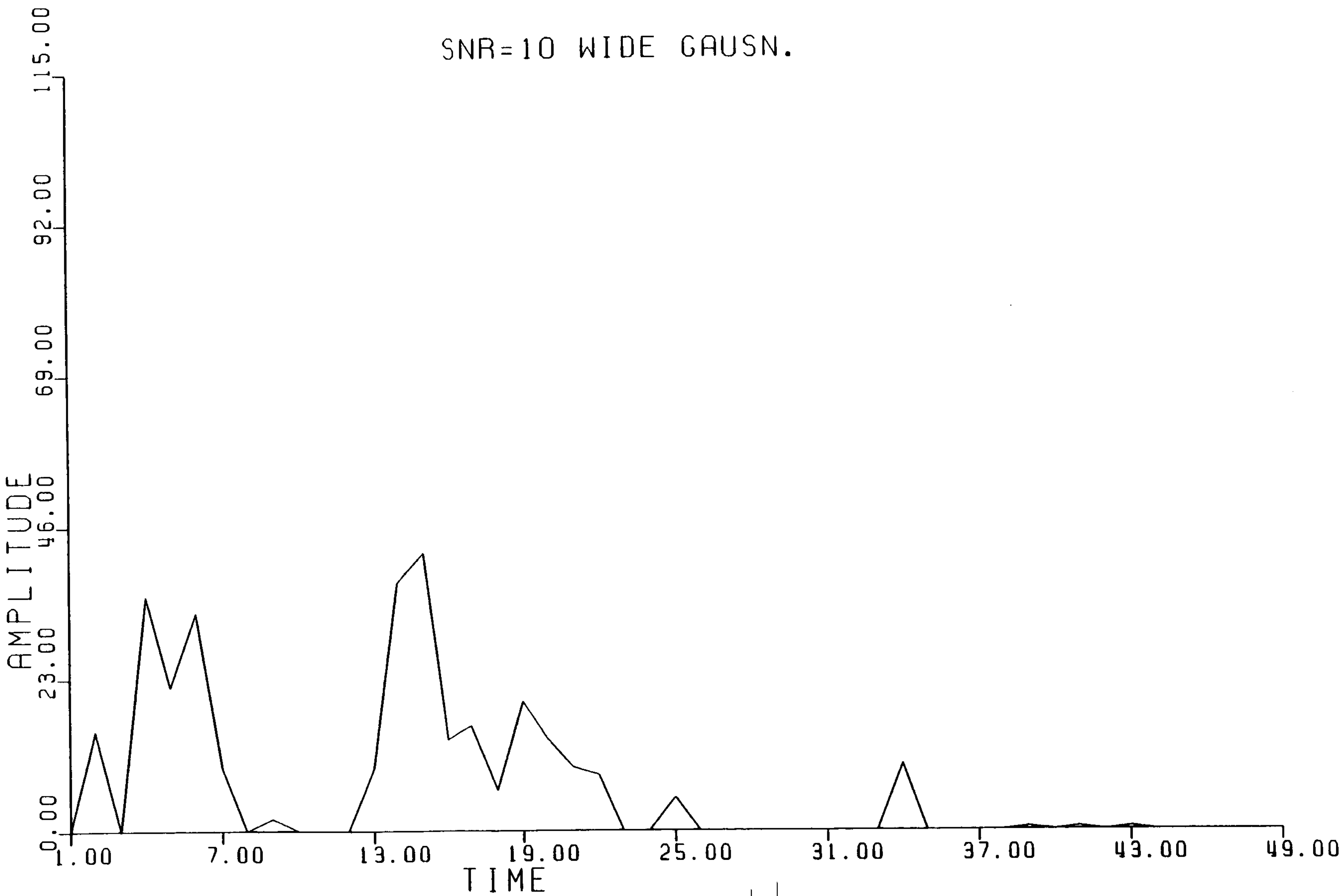


Fig. 4.42 DECONVOLVED RESULT

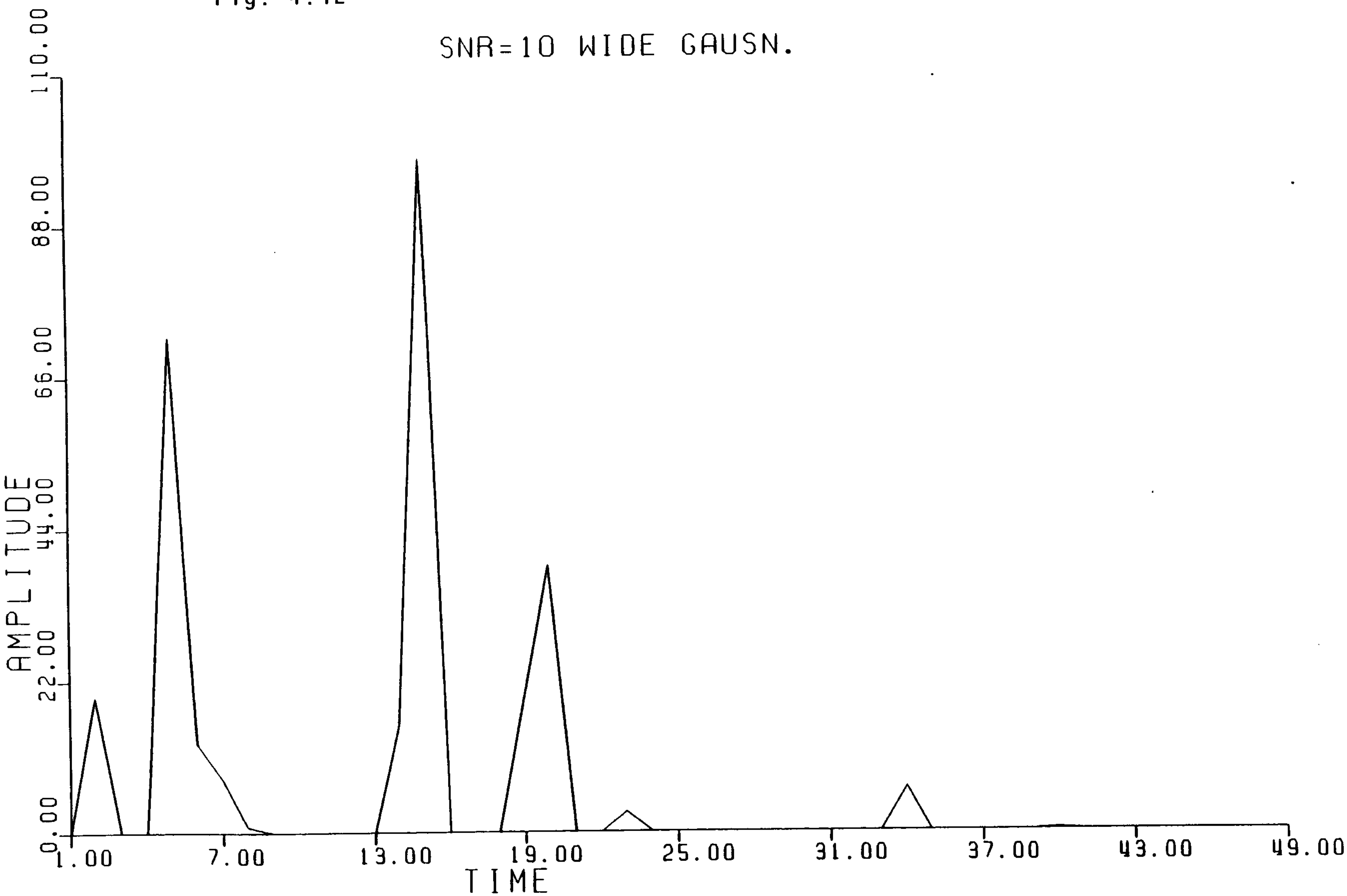


Fig. 4.43 NØISY H, SNR=43

WIDE GAUSSIAN

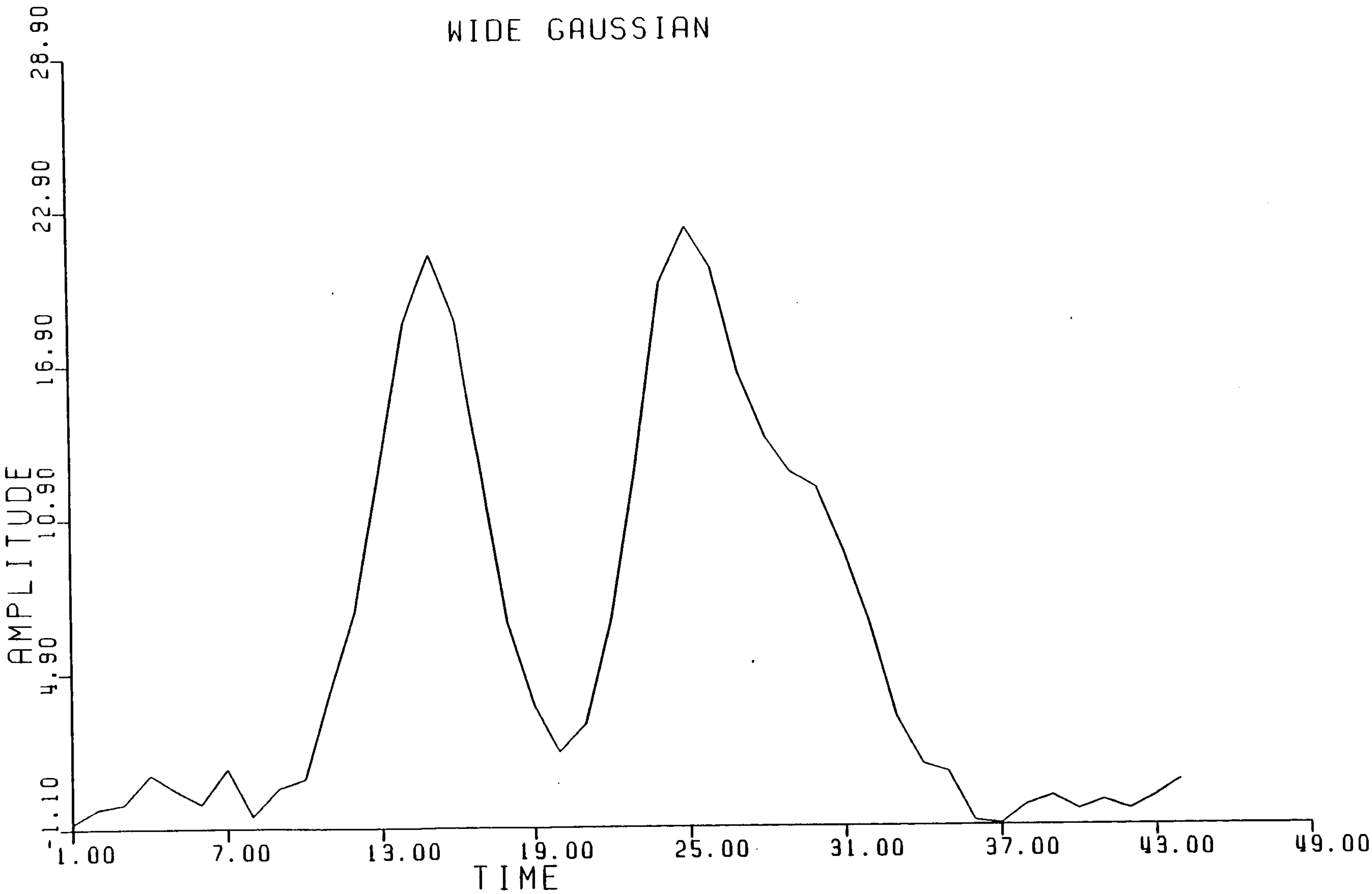


Fig. 4.44 SMOOTHED H, SNR=43

WIDE GAUSSIAN

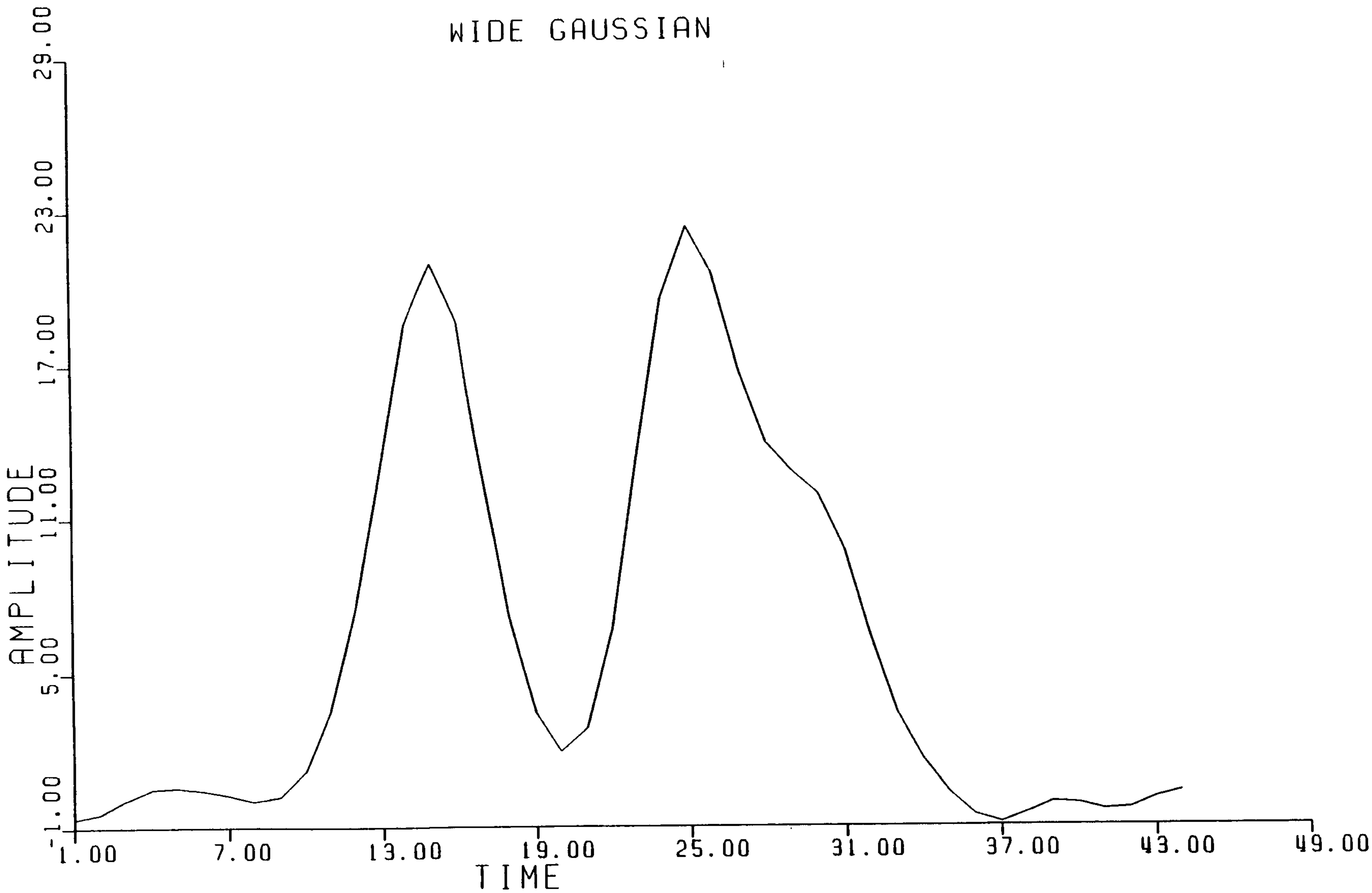


Fig. 4.45 DCND. RSULT SMOTH.=0

SNR=43 WIDE GAUSN.

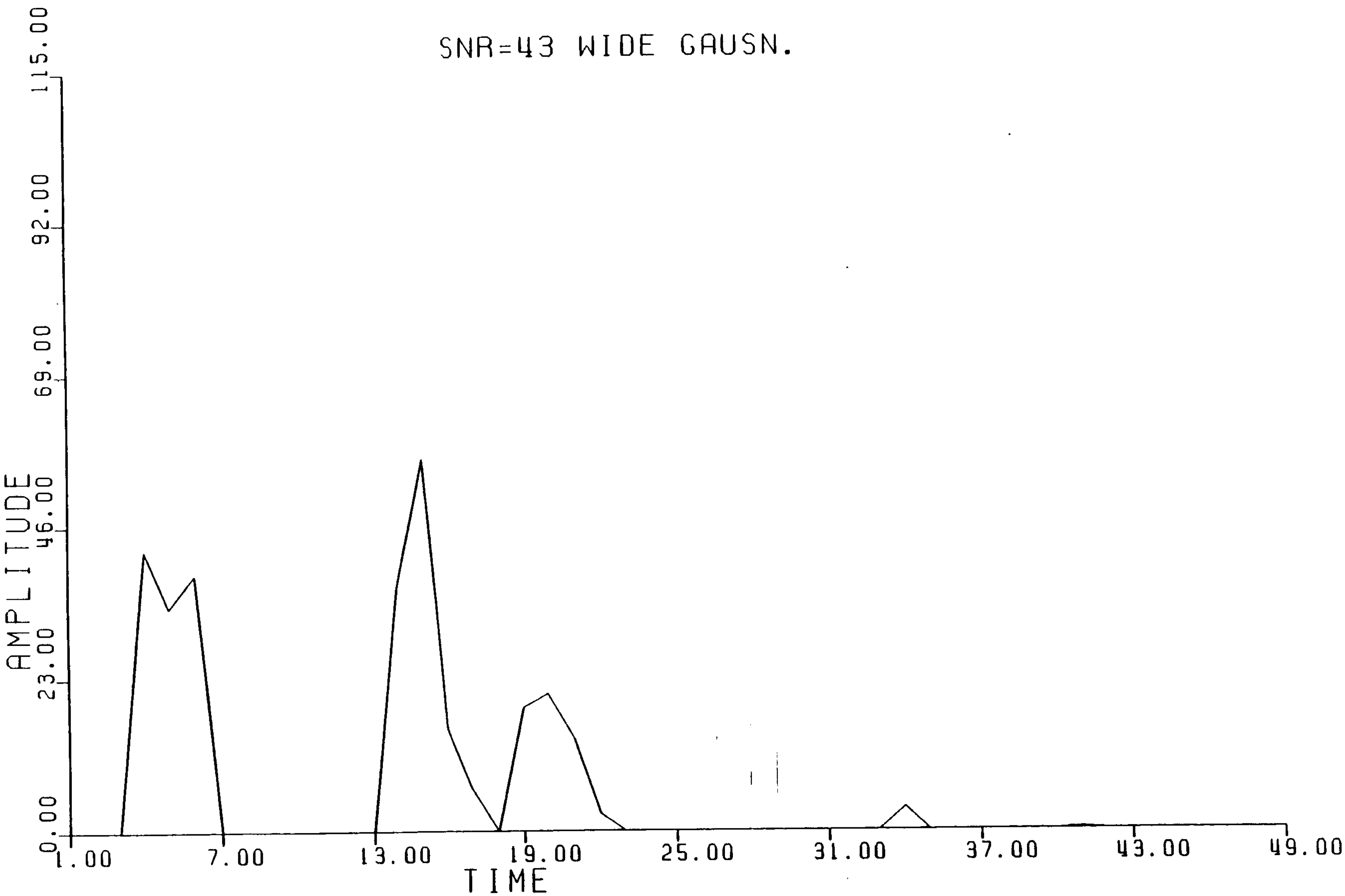


Fig. 4.46 DECONVOLVED RESULT

SNR=43 WIDE GAUSN.

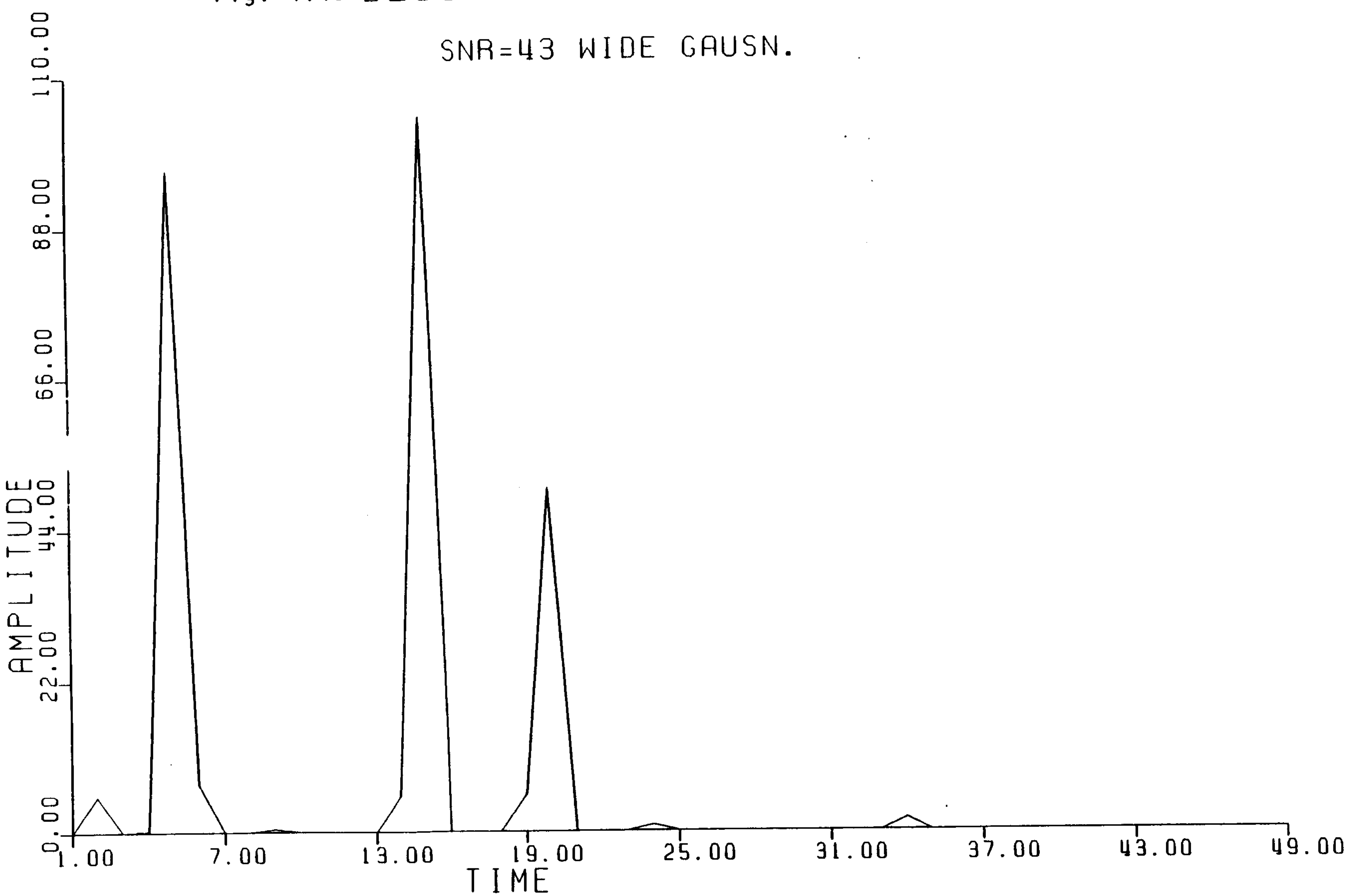


Fig. 4.47 NOISY H, SNR=155

WIDE GAUSSIAN

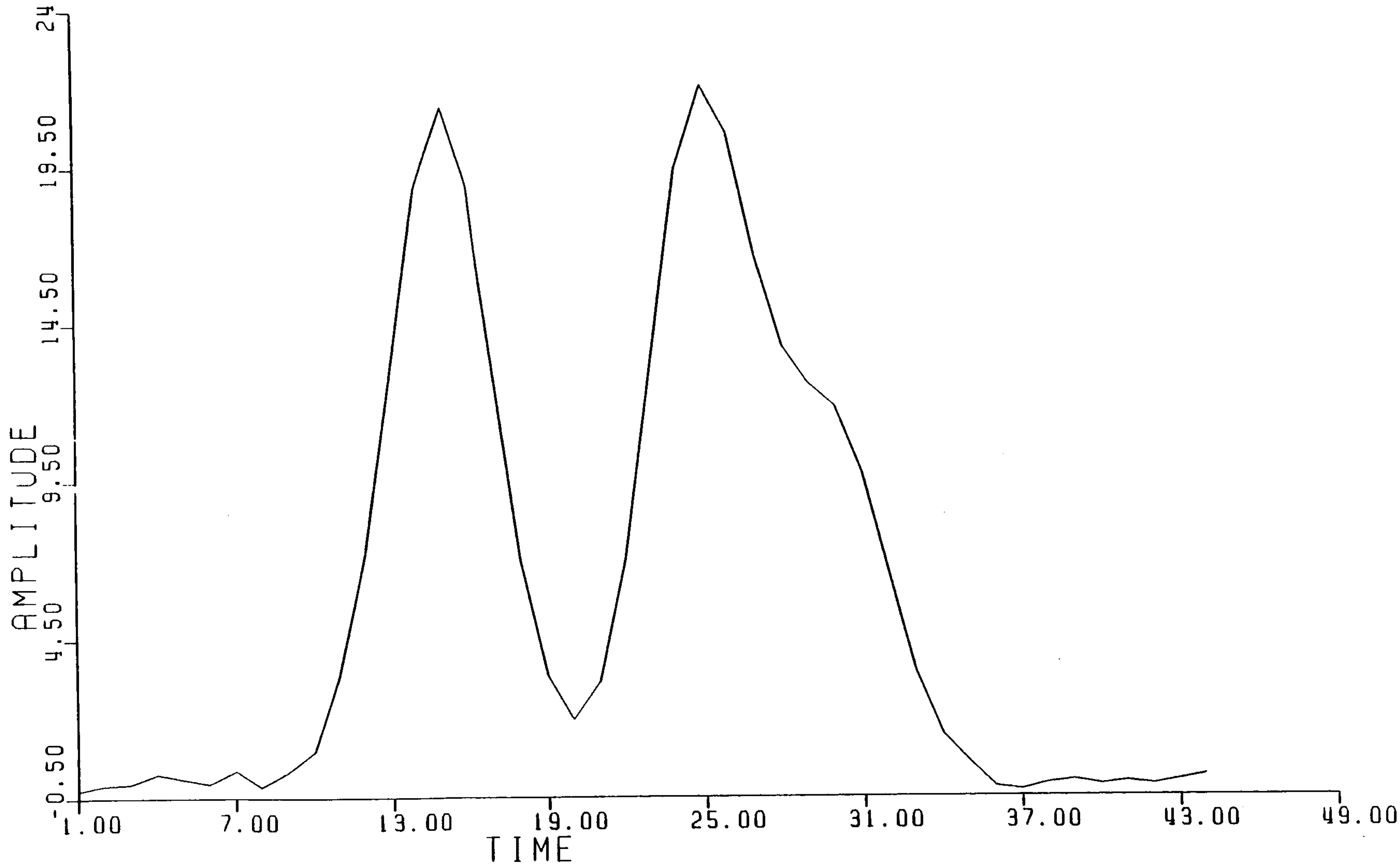


Fig. 4.48 SMOOTHED H, SNR=155

WIDE GAUSSIAN

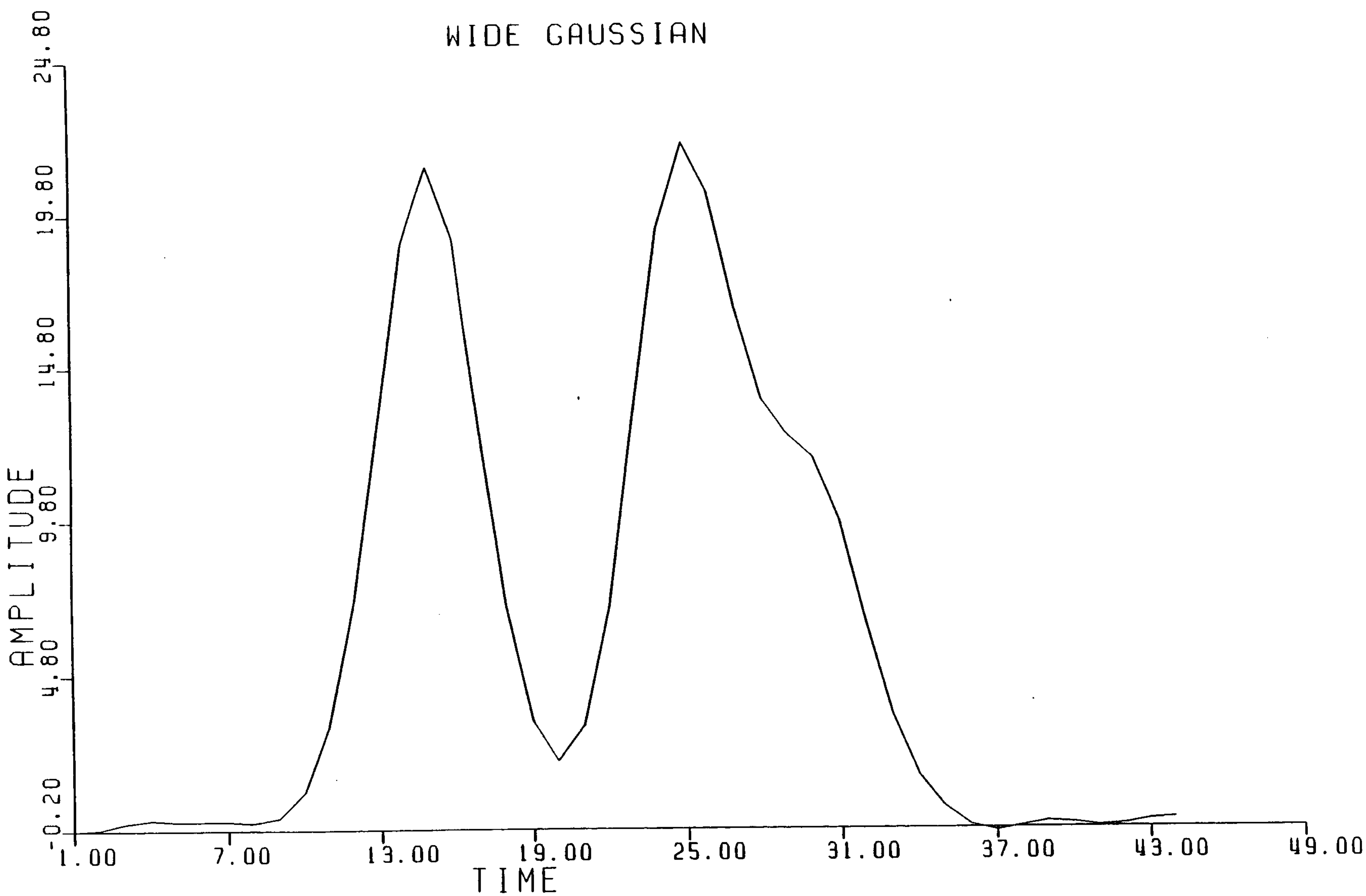
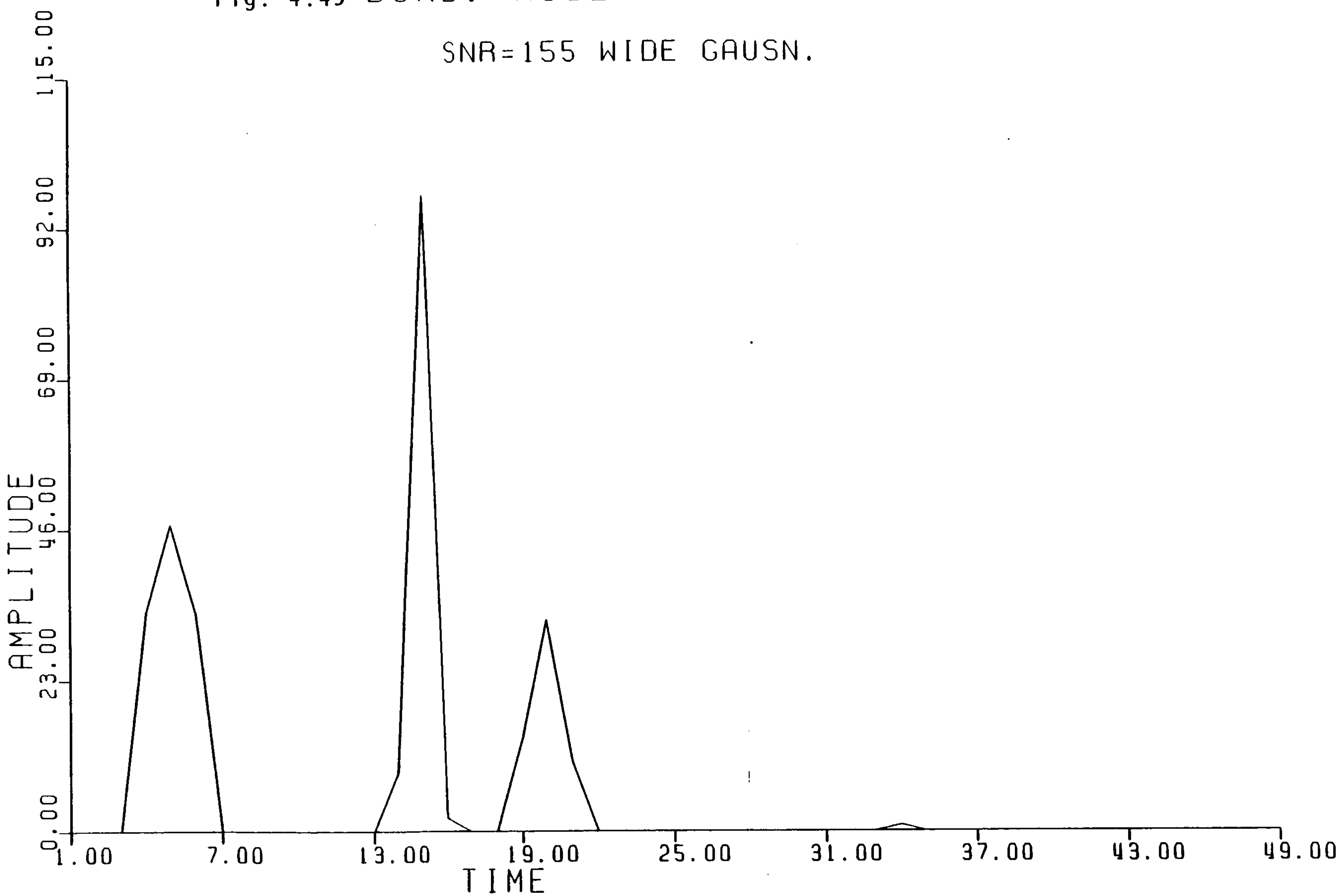


Fig. 4.49 DCND. RSULT SMØTH.=0

SNR=155 WIDE GAUSN.



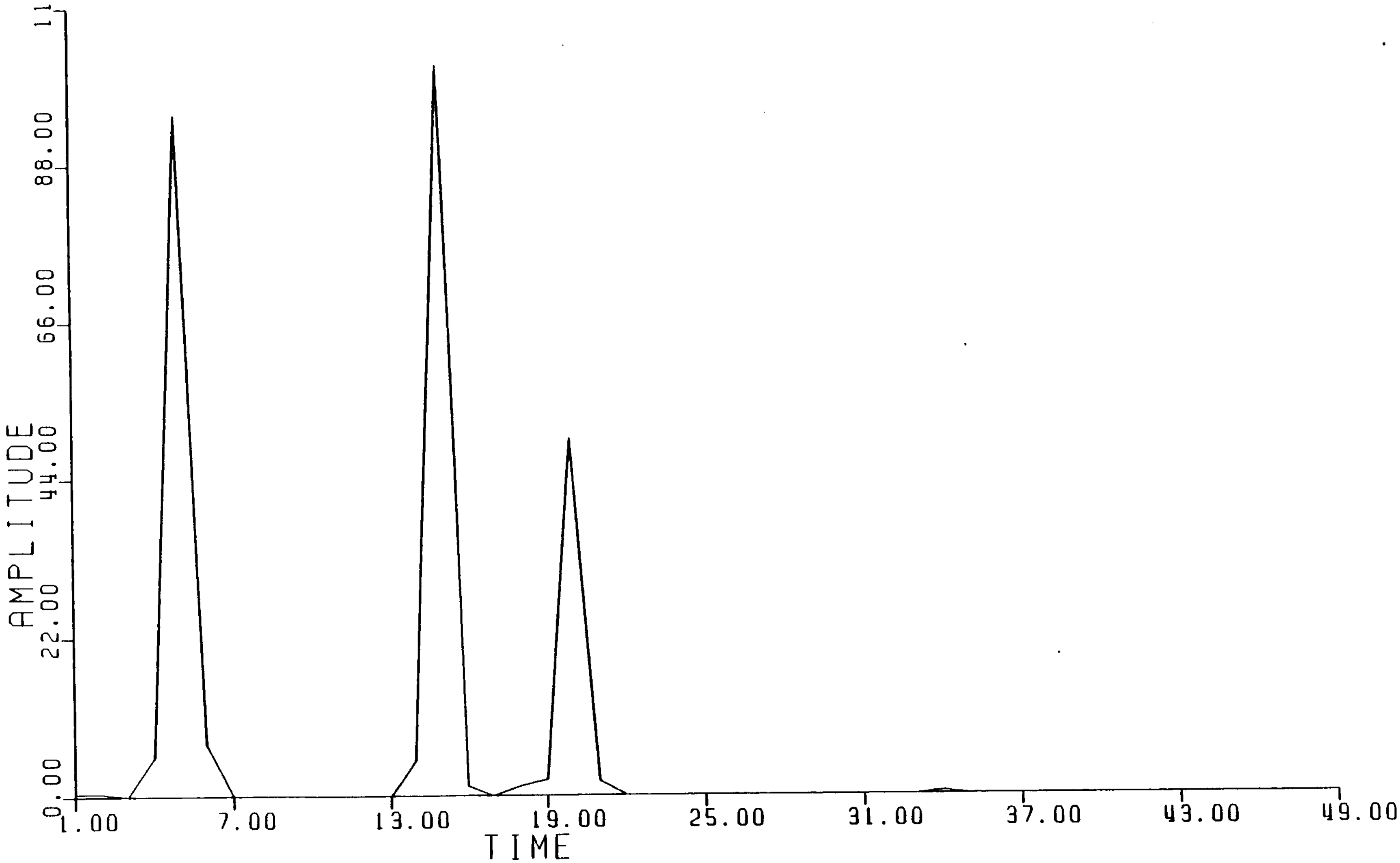


Fig. 4.50 DECONVOLVED RESULT

SNR=155 WIDE GAUSN.

Table 4.1 NARROW GAUSSIAN MSE RESULTS

SNR	MSE	S.D	MSE+SD	MSE−SD
11.91097	1569.940	968.0956	2538.036	601.8447
23.99113	435.1028	236.9715	672.0743	198.1314
36.42192	203.8768	101.1512	305.0280	102.7256
49.41155	119.3805	56.65189	176.0324	62.72861
63.21439	76.95680	35.97546	112.9323	40.98135
78.16010	53.37440	25.70371	79.07812	27.67069
94.70113	37.63945	18.10459	55.74404	19.53486
113.4964	26.83244	12.62090	39.45333	14.21154
135.5715	19.25389	8.915099	28.16899	10.33879
198.0053	9.329469	4.300094	13.62956	5.029375
248.7724	5.957883	2.743588	8.701470	3.214295
335.5135	3.347785	1.528916	4.876700	1.818869
566.9553	1.274442	0.5726864	1.847129	0.7017558
754.6075	0.7937800	0.3361854	1.129965	0.4575946

TABLE 4.2 NARROW GAUSSIAN UNFOLDING RESULTS

SNR	U.I	S.D	UI+SD	UI-SD
11.91097	34.74000	8.566936	43.30694	26.17307
23.99113	31.54000	8.144226	39.68423	23.39577
36.42192	29.04000	8.513425	37.55342	20.52658
49.41155	26.04000	8.416555	34.45656	17.62345
63.21439	24.94000	7.958417	32.89842	16.98158
78.16010	23.72000	7.391996	31.11200	16.32800
94.70113	22.74000	6.930541	29.67054	15.80946
113.4964	22.32000	6.537400	28.85740	15.78260
135.5715	22.08000	5.785638	27.86564	16.29436
198.0053	21.86000	4.783347	26.64335	17.07665
248.7724	22.08000	4.194472	26.27447	17.88553
335.5135	22.62000	3.393464	26.01347	19.22654
566.9553	23.26000	2.124241	25.38424	21.13576
754.6075	23.56000	1.601999	25.16200	21.95800

TABLE 4.3 NARROW GAUSSIAN NOISE REMOVAL RESULTS

MSE	S.I	S.D	SI+SD	SI-SD
11.91097	24.90000	31.86613	56.76613	-6.966129
23.99113	35.58000	32.69868	68.27869	2.881321
36.42192	38.72000	32.64417	71.36417	6.075836
49.41155	36.82000	29.37257	66.19257	7.447432
63.21439	36.54000	27.16410	63.70410	9.375902
78.16010	36.52000	26.50452	63.02452	10.01548
94.70113	37.54000	27.16558	64.70557	10.37443
113.4964	40.64000	27.70181	68.34181	12.93819
135.5715	40.90000	26.86876	67.76876	14.03124
198.0053	39.04000	24.40981	63.44981	14.63020
248.7724	40.18000	23.86436	64.04436	16.31564
335.5135	35.40000	15.84929	51.24929	19.55071
566.9553	34.02000	11.22941	45.24941	22.79059
754.6075	33.90000	9.814784	43.71479	24.08522

TABLE 4.4 NARROW GAUSSIAN MSE RESULTS WITHOUT SMOOTHING

SNR	MSE	S.D	MSE+SD	MSE-SD
11.91097	1703.399	968.3968	2671.796	735.0020
23.99113	454.9133	229.3589	684.2723	225.5544
36.42192	211.4959	98.13602	309.6319	113.3599
49.41155	122.0604	54.89975	176.9601	67.16062
63.21439	78.92259	35.51003	114.4326	43.41257
78.16010	54.44910	25.48473	79.93382	28.96437
94.70113	38.25743	17.85979	56.11723	20.39764
113.4964	27.27574	12.57349	39.84923	14.70225
135.5715	19.50090	8.884914	28.38581	10.61598
162.6571	13.74037	6.258127	19.99850	7.482242
198.0053	9.361519	4.285594	13.64711	5.075925
248.7724	5.965156	2.727615	8.692771	3.237540
335.5135	3.316905	1.513428	4.830333	1.803477
566.9553	1.207963	0.5458487	1.753811	0.6621140
754.6075	0.7189189	0.3160815	1.035000	0.4028375

TABLE 4.5 NARROW GAUSSIAN WITHOUT SMOOTHING

SNR	U.I	S.D	UI+SD	UI-SD
11.91097	27.64000	14.33982	41.97982	13.30018
23.99113	24.54000	13.42268	37.96268	11.11732
36.42192	22.42000	12.24596	34.66596	10.17404
49.41155	21.58000	11.01470	32.59470	10.56530
63.21439	20.56000	9.992316	30.55232	10.56768
78.16010	19.80000	8.991108	28.79111	10.80889
94.70113	19.44000	8.268397	27.70840	11.17160
113.4964	19.42000	7.563306	26.98331	11.85669
135.5715	19.36000	6.802235	26.16224	12.55777
162.6571	19.54000	6.287161	25.82716	13.25284
198.0053	19.72000	5.603713	25.32371	14.11629
248.7724	20.10000	5.004998	25.10500	15.09500
335.5135	20.46000	4.172338	24.63234	16.28766
566.9553	21.14000	2.835560	23.97556	18.30444
754.6075	21.32000	2.301651	23.62165	19.01835

TABLE 4.6 WIDE GAUSSIAN MSE RESULTS

SNR	MSE	S.D	MSE+SD	MSE -SD
24.65271	3156.546	3211.871	6368.417	-55.32495
43.81124	1700.655	2119.385	3820.039	-418.7297
55.57021	1251.332	1363.210	2614.542	-111.8776
66.68423	939.0714	938.2737	1877.345	0.7976685
77.79827	766.5312	767.7725	1534.304	-1.241333
100.0263	533.7740	491.5919	1025.366	42.18213
111.1404	464.5585	410.7849	875.3434	53.77365
122.2544	428.1473	359.5916	787.7390	68.55569
133.3685	390.8942	307.3308	698.2250	83.56332
144.4825	356.4906	270.7242	627.2148	85.76642
155.5966	263.8145	205.8321	469.6466	57.98245

TABLE 4.7 WIDE GAUSSIAN UNFOLDING ITERATIONS

SNR	U.I	SD	UI+SD	UI-SD
24.65271	1191.460	705.4540	1896.914	486.0059
43.81124	1565.500	809.9310	2375.431	755.5690
55.57021	1751.280	717.3513	2468.631	1033.929
66.68423	1740.380	657.7399	2398.120	1082.640
77.79827	1756.680	620.1076	2376.788	1136.573
100.0263	1738.940	566.6197	2305.560	1172.320
111.1404	1702.580	560.3640	2262.944	1142.216
122.2544	1695.520	563.3936	2258.914	1132.126
133.3685	1693.360	545.3138	2238.674	1148.046
144.4825	1658.380	560.5707	2218.951	1097.809
155.5966	1548.727	547.3613	2096.089	1001.366

TABLE 4.8 WIDE GAUSSIAN SMOOTHING ITERATIONS

SNR	SM	SD	MS+SD	MS-SD
24.65271	59.44000	27.10510	86.54510	32.33490
43.81124	73.10000	24.36001	97.46001	48.73999
55.57021	73.42000	23.77317	97.19317	49.64683
66.68423	75.52000	21.92007	97.44007	53.59992
77.79827	79.16000	22.50809	101.6681	56.65191
100.0263	85.16000	23.70769	108.8677	61.45232
111.1404	88.44000	23.49907	111.9391	64.94093
122.2544	89.26000	23.73757	112.9976	65.52243
133.3685	88.88000	24.65007	113.5301	64.22993
144.4825	90.04000	24.61216	114.6522	65.42784
155.5966	99.60606	22.24238	121.8484	77.36368

TABLE 4.9 WIDE GAUSSIAN MSE RESULTS WITHOUT SMOOTHING

SNR	MSE	SD	MSE+SD	MSE-SD
9.853436	10489.85	4821.409	15311.26	5668.438
19.70688	7664.270	4795.854	12460.12	2868.416
29.56031	6299.362	4464.521	10763.88	1834.840
39.41375	5392.745	4268.879	9661.624	1123.866
49.26719	4687.072	3965.199	8652.271	721.8733
59.12062	3875.684	3534.239	7409.923	341.4448
68.97407	3349.971	3248.931	6598.903	101.0398
78.82750	2986.006	3034.102	6020.108	-48.09595
88.68094	2675.142	2865.119	5540.261	-189.9771
98.53439	2429.807	2687.140	5116.947	-257.3323
108.3878	2152.302	2497.879	4650.181	-345.5771
118.2412	1910.079	2297.744	4207.823	-387.6647
128.0947	1787.783	2199.331	3987.114	-411.5476
137.9482	1595.527	1982.559	3578.086	-387.0325
147.8016	1415.916	1699.918	3115.834	-284.0026

TABLE 4.10 WIDE GAUSSIAN UNFOLDING ITR. RESULTS WITHOUT SMOOTHING

SNR	U. ITR.	SD	U. ITR.+SD	U. ITR.-SD
9.853436	26.94000	40.57507	67.51508	-13.63507
19.70688	76.24000	90.83051	167.0705	-14.59052
29.56031	119.1800	122.5290	241.7090	-3.348969
39.41375	167.7400	155.4104	323.1504	12.32961
49.26719	225.6200	208.6233	434.2433	16.99670
59.12062	286.8600	240.5387	527.3987	46.32124
68.97407	342.8600	266.3546	609.2147	76.50534
78.82750	377.3600	290.5133	667.8734	86.84665
88.68094	403.7200	282.1509	685.8709	121.5691
98.53439	436.4800	287.2698	723.7498	149.2102
108.3878	467.0800	300.2810	767.3610	166.7990
118.2412	511.1800	325.7479	836.9279	185.4321
128.0947	525.8800	331.2564	857.1364	194.6236
137.9482	554.9800	334.0431	889.0231	220.9369
147.8016	568.7000	304.6726	873.3726	264.0274

CHAPTER 5

EVALUATION OF PHASE-SHIFT METHOD OF MIGRATION WITH SYNTHETHIC DATA

5.1 INTRODUCTION

The phase shift method of migration was first introduced in 1978 by Jeno Gazdag (1978). Wave equation migration techniques have started with the pioneer work of Claerbout (1970 and 1976). By defining the problem in a downward moving coordinate system (to achieve the task of imaging), Claerbout (1970,1976) derived a simplified equation which is easier for numerical solution than the full wave equation. This partial differential equation, which is often referred to as the 15 degree equation, has been solved by the finite difference method.

Seismic data are obtained by placing a number of geophones at fixed intervals (Δx) along a straight line on the surface of the earth. Then at some depth a shot is set up and reflected sound waves are recorded by geophones. Each geophone recording is a graph in which the amplitude of the reflected sound wave is recorded vs time (x,t). This plot is called a trace. The task of migration is to find the geometrical shape (image) of the reflector from these traces. To find the image, one must use the x vs t data and convert it to x vs z data, where z is the depth. A filter can be designed to achieve the task of conversion (phase-shift). For constant velocity this filter is calculated once and can be used for each depth ΔZ. Passing the x vs t data through this filter gives the x vs t vs z data. By setting time t to zero the x vs z data is obtained. Since the filtering operation is a simple multiplication in the transform domain, this procedure is easily done there, but must be repeated for each depth Δz.

Therefore recorded seismic data (x,t,z=0) are first transformed to the frequency domain. This is done by taking a two-dimensional fast Fourier transform (2D-FFT). Then a dispersion relation as a filtering operator is computed. Depending on the velocity variation with depth, the action of this filter can greatly affect the speed of the program. The dispersion relation and action of the filter can be summarized as follows:

$$k_x^2 + k_z^2 = w^2 / v^2$$

Filter

$$\text{input} \longrightarrow \boxed{\exp\left(i\left(w^2/v^2 - k_x^2\right)^{1/2} z\right)} \longrightarrow \text{output}$$

The phase-shift method proceeds by extrapolating downward with $\exp(ik_z Z)$ and subsequent evaluation of the wavefield at $t=0$ (the reflectors explode at $t=0$), where $\exp(ik_z Z)$ is the desired filter transfer function.

It is assumed that reflectors explode at $t=0$ and the resulting wave field propagates perpendicular to the reflector. Some of the components of the wave field reach the surface and are recorded by geophones. Therefore passing the data through the filter and evaluating the result at $t=0$ corresponds to the image of the reflector just before explosion.

Of all the wide-angle methods of migration, this one most easily incorporates depth variation in velocity.The phase angle and obliquity function are correctly included, automatically.

The phase-shift method begins with a two-dimensional

Fourier transform (2D-FT) of the data set. Then the transformed data values, all in the (w,k_x)-plane, are downward continued to a depth by multiplying by

$$\exp(i\, K_z \Delta z) = \exp\{ -iw/v\, [\, 1-(v\, k_x / w)^2\,]^{1/2}\, \Delta z\, \}.$$

Assuming $\Delta z = V^* \Delta\tau$ the exponent becomes

$$C = \exp(-iw\, \Delta\tau\, [\, 1 -(v\, k_x / w)^2\,]^{1/2}\, \}$$

The data will be multiplied many times by C (by as many points in the grid size for each depthΔz), thereby downward continuing it by many steps of .

Next is the task of imaging. At each depth an inverse Fourier transform is followed by selection of its value at t=0. (Reflectors explode at t=0.) The computation is especially easy since the value at t=0 is merely a summation of each w frequency component. (This may be seen by substituting t=0 into the inverse Fourier integral.) Finally, the inverse Fourier transform from k_x to x is taken. The migration process, may be summarized as follow Claerbout (1985):

```
U(w,k_x) = FT[u(t,x)]
For τ=Δτ, 2Δτ, ......., end of time axis on seismogram {

    For all k_x {

        Image (k_x, τ)=0.

            For all w {

                C = exp{-iw Δτ [1-(vk_x / w)^2 ]^1/2 }

                U(w,k_x) = U(w,k_x) C

                Image(k_x, τ) = Image(k_x, τ) + U(w,k_x)

            }

        }

    image(x,τ) = FT[ Image(k_x, τ)]

  }.
```

Inverse migration (Modeling) proceeds in much the same way. Beginning from an upcoming wave that is zero at great depth, the wave is marched upward in steps by multiplications with $\exp(ik_z Z)$. As each level in the earth is passed, the exploding reflectors from that level are added into the upcoming wave.

A great deal of attention should be paid when writing the program for each of these steps. Some aspects of this are mentioned in the programming considerations later in this chapter.

A single spike in one of the traces corresponds to a half sphere reflector (imaged in two dimension) at some depth. According to the exploding reflector model at time zero, all the wavefronts reach the surface at the same time and same position (each wavefront can be thought of as a radius of the sphere). Therefore migrating a spike should give a half circle facing the space domain x-axis (or geophones).Forward migration or modeling should transform a point reflector in x and z space into a hyperbola in x and t space. A spike is assumed at location (32,32) in a grid of 256 (sampled t) by 64 (sampled x). The assumed values are $\Delta x=4$ m, $\Delta t=4$msec, and $V=1000$ m/sec to make $\Delta Z=4$ m. Various aspects of migration and modeling are discussed in this chapter and programs are given in Appendix D.

5.2 THEORETICAL BACKGROUND

In the following derivation, zero offset with the exploding reflector model is assumed. The zero offset seismic section $p(x,t,\tau)$ may be considered as a wave field measured at some specified depth from the surface of the earth. The variables x, t, and ta are the horizontal position, two-way travel time and the two-way vertical travel time. Computationally, the migration process can be regarded as a numerical approximation to the changes of the wave field as the sources and the recorders are moved downward into the earth. A recorded seismic section at the surface $p(x,t,\tau=0)$ serves as an initial condition for the solution of $p(x,t,\tau)$, the seismic section which would have been observed, had the sources and the recorders been positioned at depth $\Delta\tau$.

The phase shift method is derived from the equation,

$$P_{t\tau} = -(v^2 / 8)\, P_{xx} . \qquad (1)$$

This is a second order approximation to the two-dimensional scalar wave equation written in a downward-moving coordinate system (Claerbout, 1970,1976). It is also known as the 15 degree wave equation.

To keep the derivation simple no lateral variation of velocity is permitted, i.e., $v=v(\tau)$. Let the finite Fourier transform of P be defined as

$$P(k_x, w, \tau) = \Delta x \Delta t / 4 \pi^2 \sum \sum p(x,t,\tau) . \exp[\, -i(\, k_x x + wt\,)\,] \,,\qquad (2)$$

where Δx and Δt are the grid spacing.

In view of definition (2) the partial differential equation in (1) expressed in the frequency domain becomes

$$P_{\tau} = [\, -i(v\, k_x)^2 P\,] \,/\, 8\, w \,. \qquad (3)$$

The solution to (3) can be written in the following form

$$P(\tau + \Delta\tau) = P(\tau)\ \exp(\ -iQ\Delta\tau\ )\ , \tag{4}$$

in which

$$Q = (\ w\ k_x^2\ )\ /\ 2\ m^2\ ,\ \text{and}\ m = 2\ w\ /\ v_{rms}\ ; \tag{5}$$

where v_{rms} is the root mean square velocity averaged between the interval ta and .

The desired migrated section is given by the subset p(x, $t=\tau,\tau$) of the computed seismic section. Therefore, after each step we compute

$$p(x, t=\tau, \tau) = \sum \sum P(k_x, w, \tau)\exp[-i(k_x x + w\tau)]\ , \tag{6}$$

which is the migrated section in the (x-z) domain.

5.3 PROGRAMMING CONSIDERATIONS

5.3.1 Migration program

The most important part of the implementation of the phase shift method of migration is careful handling of the data in the Fourier domain. Calculation of k_x and w to be used in the dispersion relation must be done in the full domain, unlike the filtering problem in which calculation up to the Nyquist frequency usually suffices. For one-half of the data, k_x and w are

$$k_x=(2\pi/N_x\Delta x)\ (lk_x-1)\ ,\quad w=(2\pi/N_t\Delta t)\ (lw-1)\ ,$$

and for the second half or negative frequencies ,

$$k_x=k_x-2\pi/N_x\ ,\quad w=w-2\pi/N_t\ .$$

(Note that k in FORTRAN is assumed to be an integer so it must be named differently in the code, perhaps xk.) lk_x and lw are the assigned DO loops (from 1 to N_t and N_x, the number of sample points in the time and space domains respectively) and (lk_x-1) is for the DC or zero frequency level.

The sampling interval and corresponding velocity must be carefully chosen. Usually the velocity is chosen such that $\Delta z = \Delta x$. One other source of error is incrementing $\Delta\tau$ for each depth according to $\Delta z = v\,\Delta\tau$. should be kept constant. If it is incremented, then the original transformed data should be used for each depth or .

If the velocity is constant, the calculation of the exponent (filter coefficients or transfer function, the expression named C earlier) may be done in a two-dimensional array for the first depth and then may be used again for other values of $\Delta\tau$. This is because the only variable which can change with depth $\Delta\tau$ in expression C is velocity v.A simple IF statement will perform this modification (see the page concerning documentation of the program).

5.3.2 MODELING PROGRAM

The modeling program is very much the same as the migration program except that the three main DO loops, IZ, Ik, and Iw (concerning the three spasial frequency numbers for depth z, space domain x, and time axis t respectively) are interchanged. Unlike the migration program, there is no option of changing ΔZ; In the modeling ΔZ must be kept constant. Also, since z is running vertically upward (from some value to zero), one starts with the last array number (ximage(N_t -Iz+1, Ik_x)) and ends with the first number.

Approximately half of the Fourier coefficients can be set to zero, since those waves with ($w<v*k_x$) are evanescent and correspond to nonpropagating waves. One half of the Fourier coefficients are nonphysical if $\Delta x=v\,\Delta\tau/2$, and since normally Δx is greater than that, the number of the deleted Fourier coefficients is a smaller fraction than one-half of the total. To calculate the filter transfer function coefficient the expression C is used. If $w>v*k$, then $(1 - v * k / w)$ in the expression for C is a negative number and its square-root is not defined. Wave fields at these locations are called evanescent and filter coefficient are set to zero. If the geophone spacing (Δx) is such that $\Delta x=v\,\Delta\tau/2$, approximately half of these coefficient are zero.

5.4 RESULTS

the First part of this work concerns implementation of the method.A zero offset record section with an exploding reflector model is assumed. The sample interval in t is 4msec, and in x, 4meters for v=1000 meter/sec.When this v elocity is used Δz is equivalent to Δx. The migration examples represent results obtained from the 15 degree approximation. Fig. 5.1 shows a single spike at x=32, t=32, and z=0 (sampled location). Fig. 5.3 is the result of migration applied to Fig. 5.1. In Fig. 5.2, the spike is moved to a deeper location in time, t=64 and x=32, and then migrated. Fig. 5.4 is a good indication of sensitivity of migration to velocity. In Fig. 5.4 the spike at (32,32) is migrated with a v of half the correct value. The resolution (number of dots per unit area) is very poor when compared to the result of migrating the same spike with the true v, Fig. 3.

Fig. 5.5 represents modeling using the phase shift approach. In Fig 5 a spike at x=32, z=32, and t=0 is assumed. The data in(x,t,z=0)should look like a hyperbola, according to Huygens secondary point source model. The hyperbola in Fig. 5.5 is not too obvious because sampling points were chosen so that $\Delta z = \Delta x$. Fo this reason, the first arrival time is 128 msec (32*4/1000) and the last arrival time is 180msec. Examination of Fig.5.5 indicates first and last arrival times exactly the same as the above values. According to our model given by $(x^2 + z^2 = (v\ t)^2$, to get a more obvious hyperbola, one has to increase the x sampling (distance between geophones). When the sampling is increased from 4 to 8 meters, Fig. 5.6 is obtained . This result indicates that the above analysis is indeed correct. Fig. 5.7 is the output of the Stolt method of migration. The semicircular frown is because of the linear interpolation used here. However, if a sinc interpolation is used the semicircular frown will disappear (Claerbout, 1985) The periodicity problem of using the discrete Fourier transform (DFT, or fast Fourier transform, FFT) are obvious in all of the figures. This problem occurs due to the fact that sampling a function is equivalent to multiplying the function by a Shah function (train ofdelta functions)(BW,1978). According to the convolution theorem and repetitive property of the Shah function under convolution, transform of sampled functions are periodic. To overcome the problem either fine sampling in the transform domain or, zero padding in the function domain is required.

5.5 CONCLUSION

The phase shift method of migration is used for various synthethic data. Results are impressive but the computer time required is too large. One of the advantages of the phase shift is the fact that it allows for velocity variation with depth. Fig. 5.7 is the output of the Stolt method of migration. The resolution of the phase shift approach is clearly superior.

One of the disadvantages of the phase shift technique is the periodicity of the Fourier transform, which can be removed with zero padding. The elapsed time is about 40 minutes on an average day to get a run for a grid size of 256 by 64, so the slow speed is one of the drawbacks of this method.The phase shift method does not allow lateral variation of velocity; however, Gazdag in his paper about this problem in 1984, makes a suggestion which allows for lateral velocity variation by an interpolation method, the study of which is beyond the scope of this work.

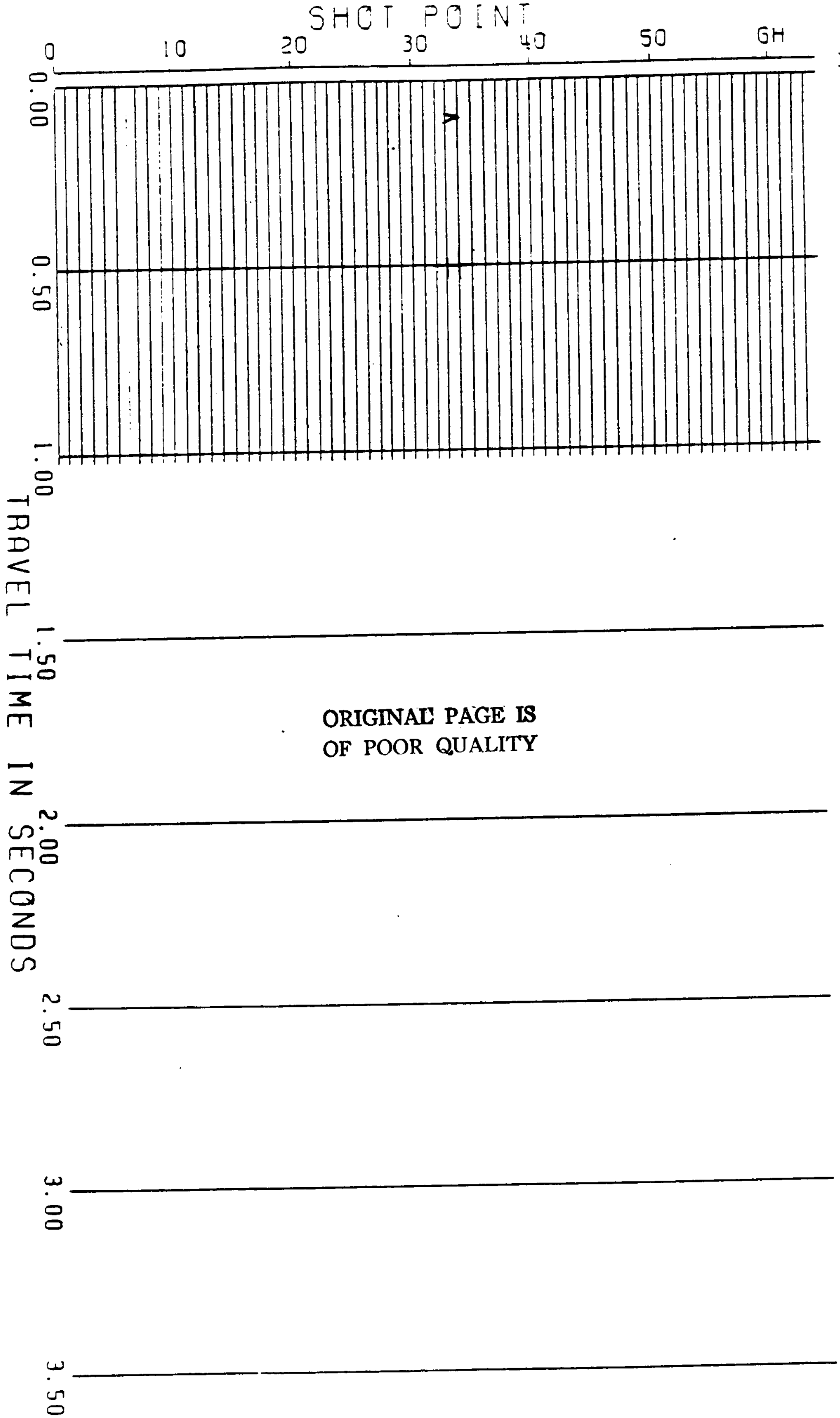

SHOT POINT
0
10
20
30
40
50
GH
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
TRAVEL TIME IN SECONDS

Fig. 5.1

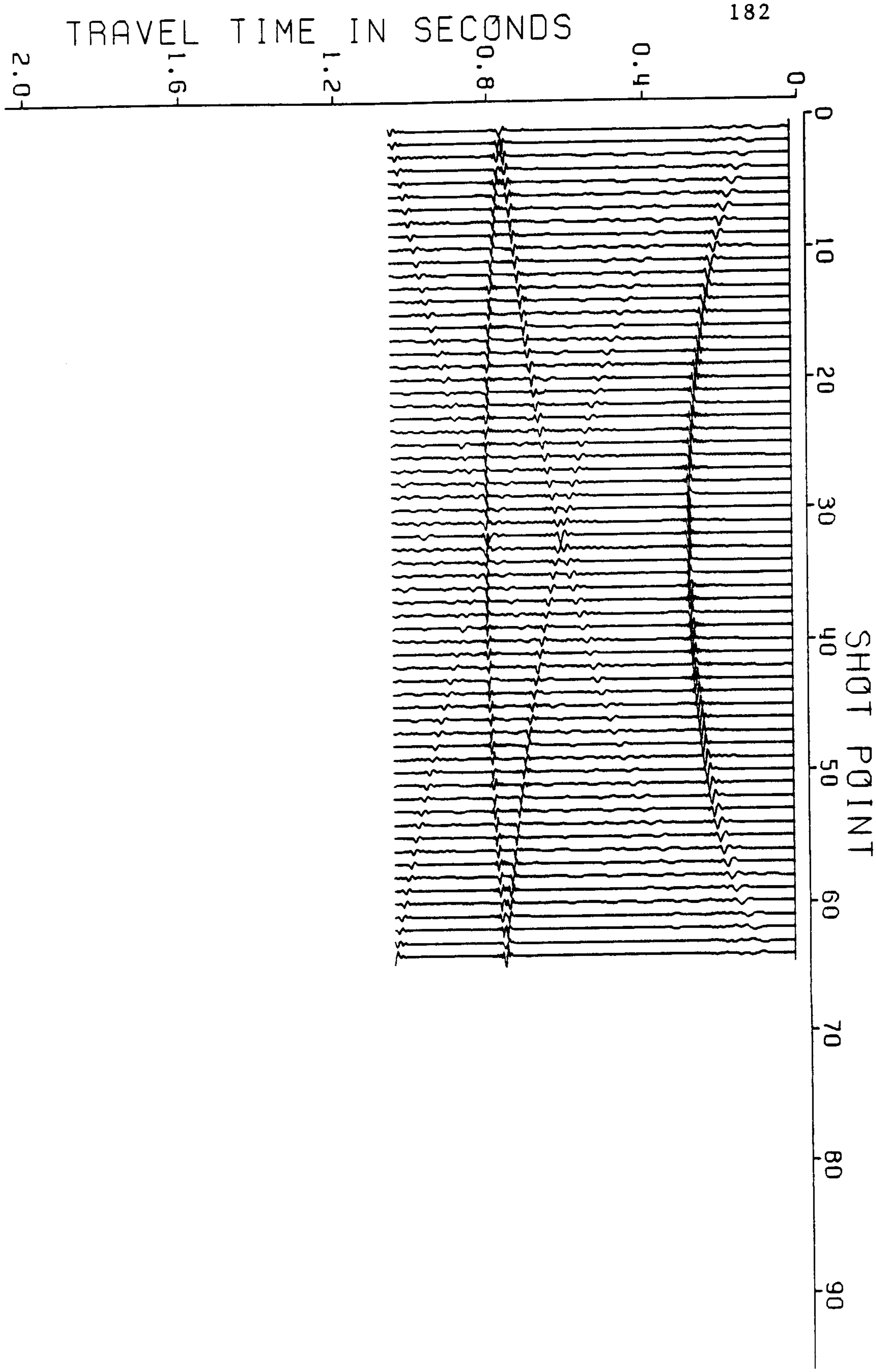

TRAVEL TIME IN SECONDS
0
0.4
0.8
1.2
1.6
2.0
SHOT POINT
0
10
20
30
40
50
60
70
80
90

Fig. 5.2

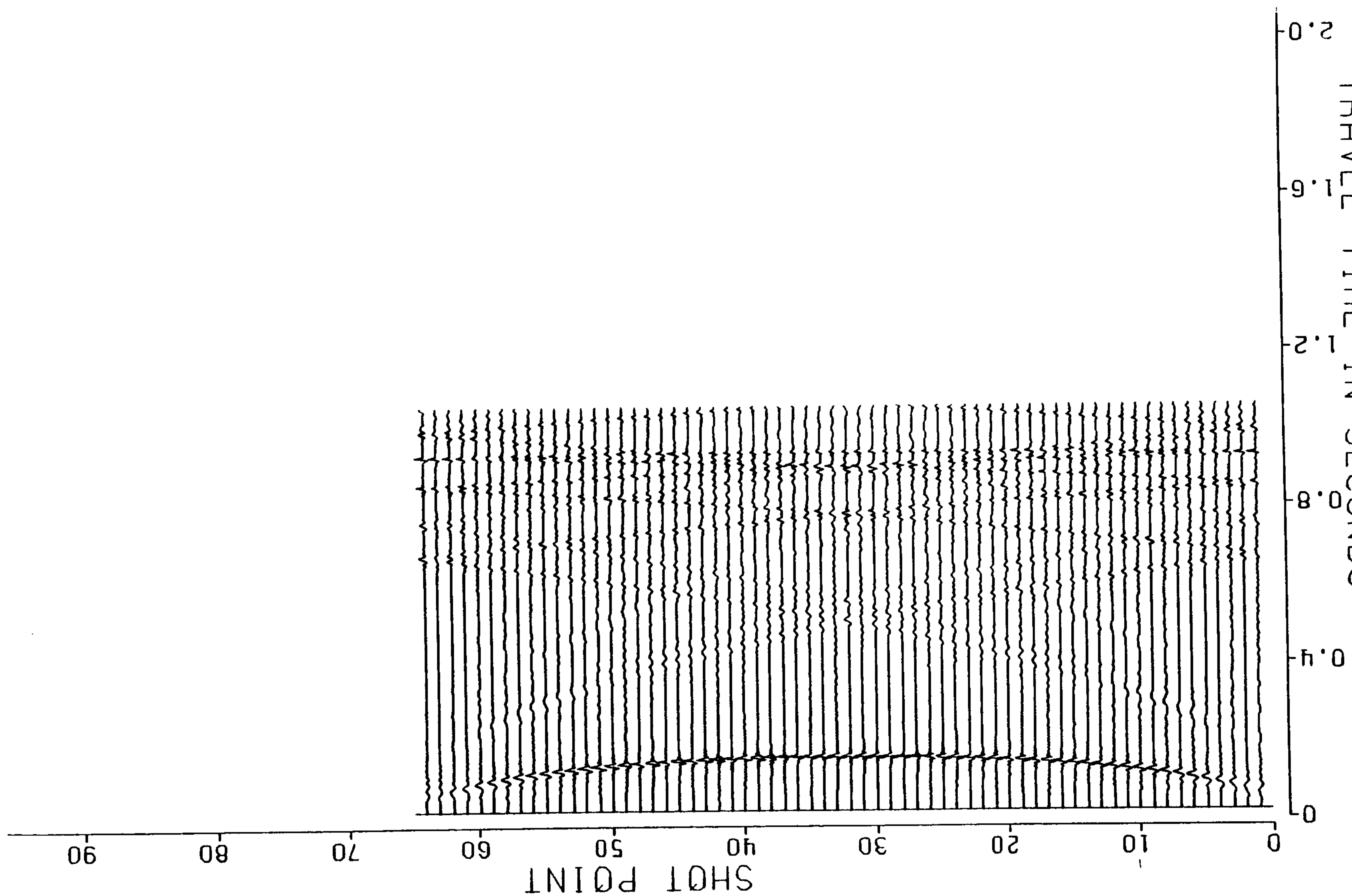

TRAVEL TIME IN SECONDS
2.0
1.6
1.2
0.8
0.4
0
SHOT POINT
0
10
20
30
40
50
60
70
80
90

Fig. 5.3

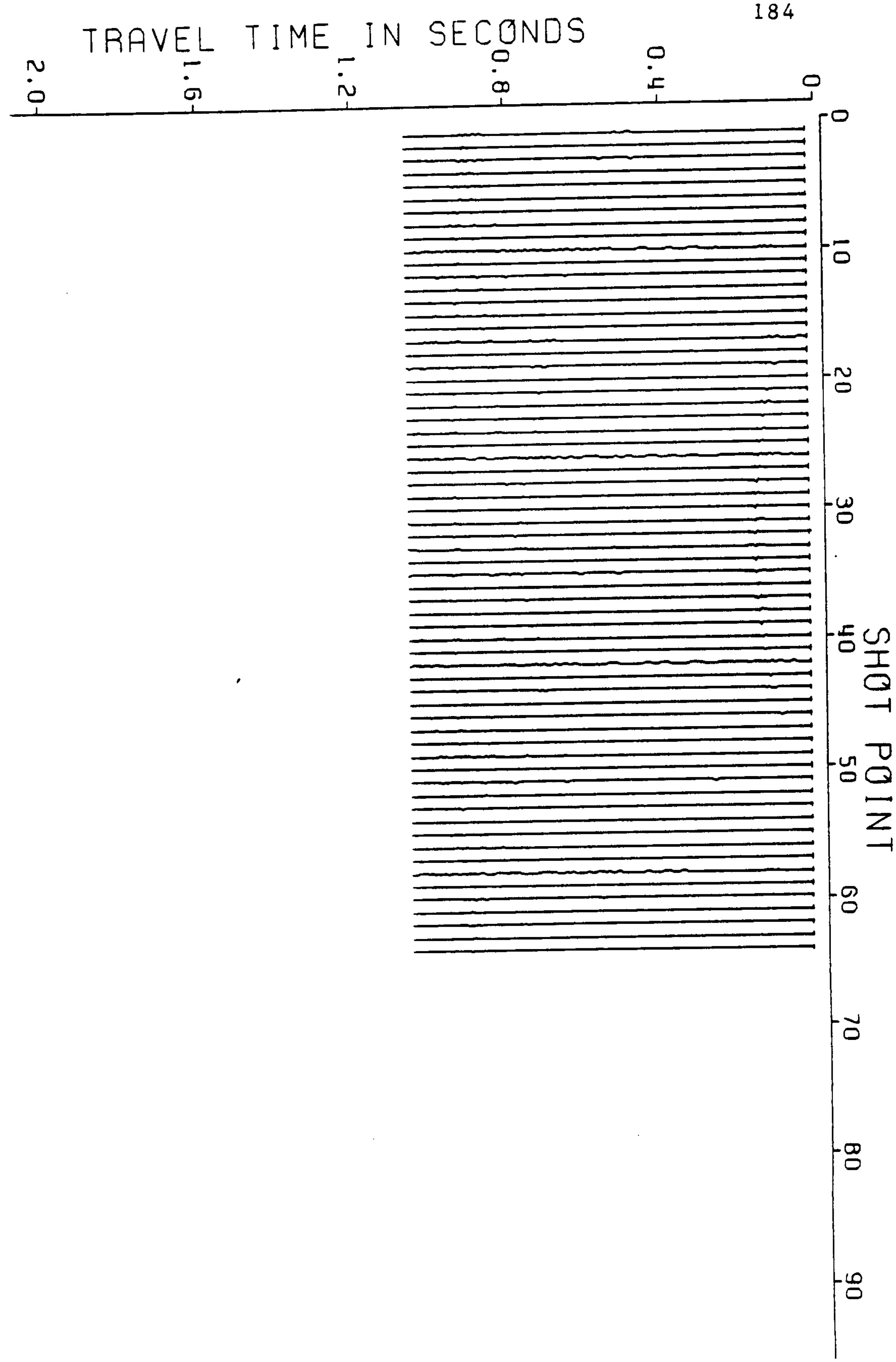
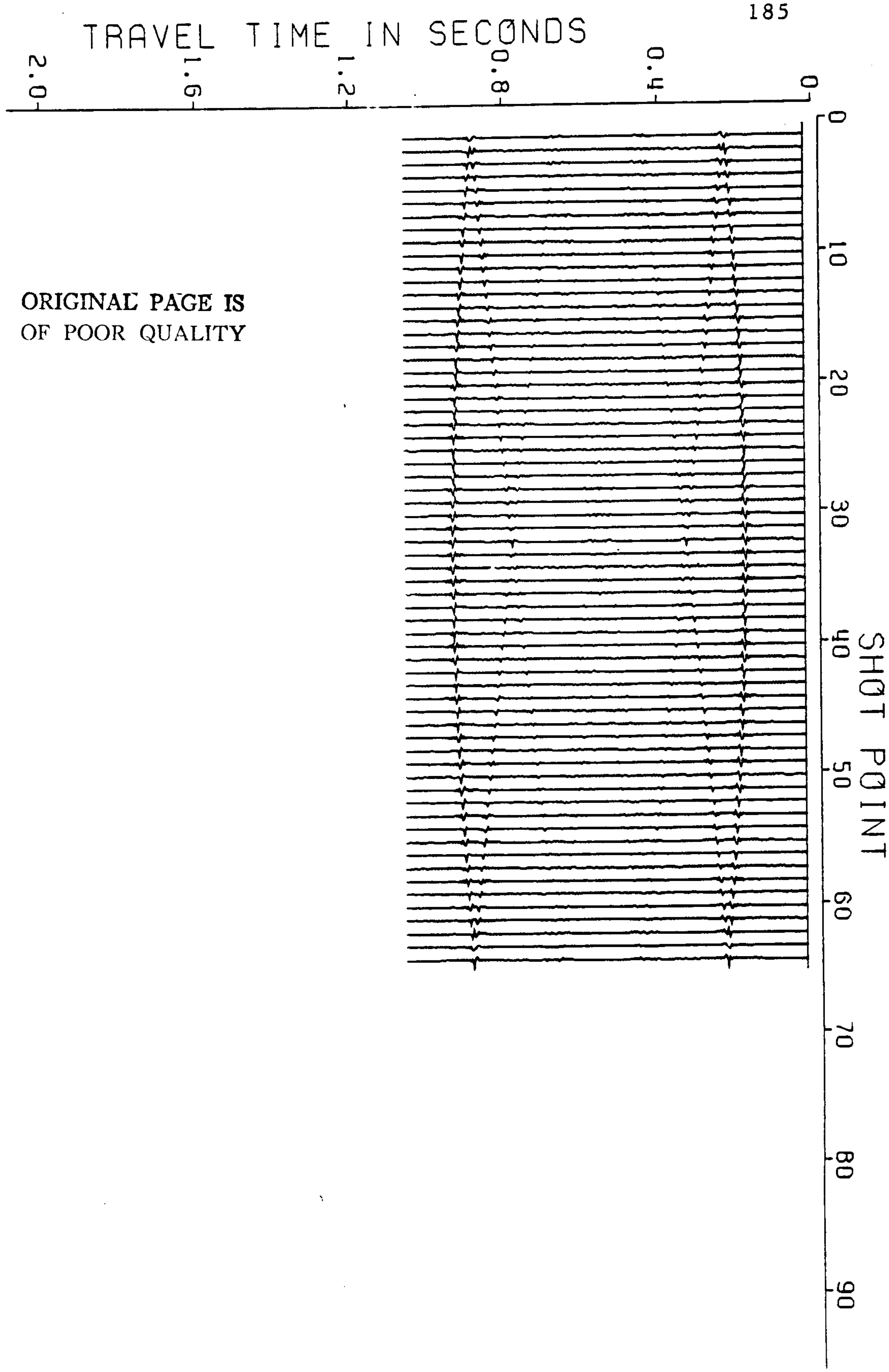

TRAVEL TIME IN SECONDS
2.0
1.6
1.2
0.8
0.4
0
SHOT POINT
0
10
20
30
40
50
60
70
80
90

Fig. 5.4



TRAVEL TIME IN SECONDS
2.0
1.6
1.2
0.8
0.4
0
SHOT POINT
0
10
20
30
40
50
60
70
80
90

Fig. 5.5

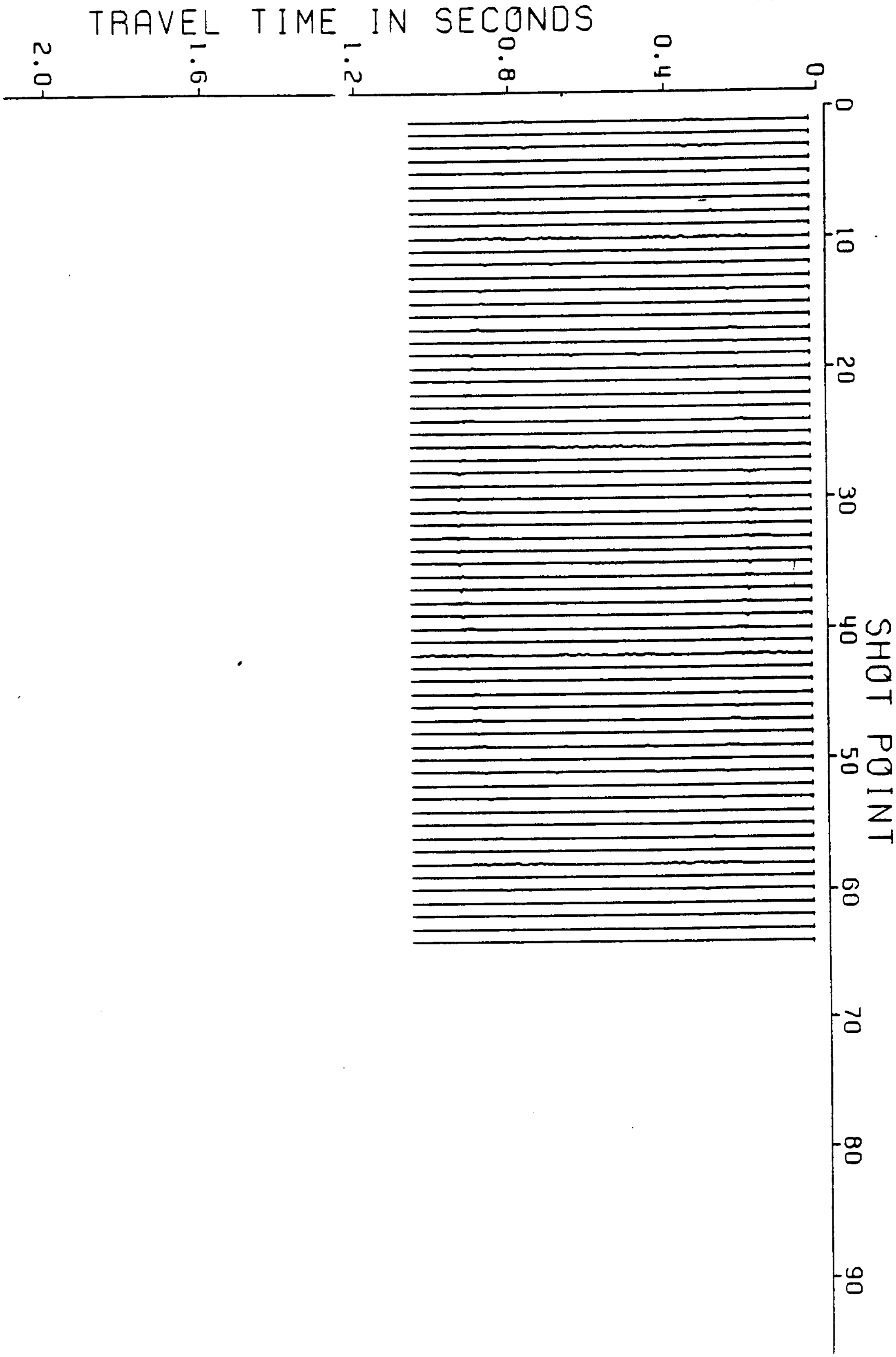

TRAVEL TIME IN SECONDS
2.0
1.6
1.2
0.8
0.4
0
SHOT POINT
0
10
20
30
40
50
60
70
80
90

Fig. 5.6

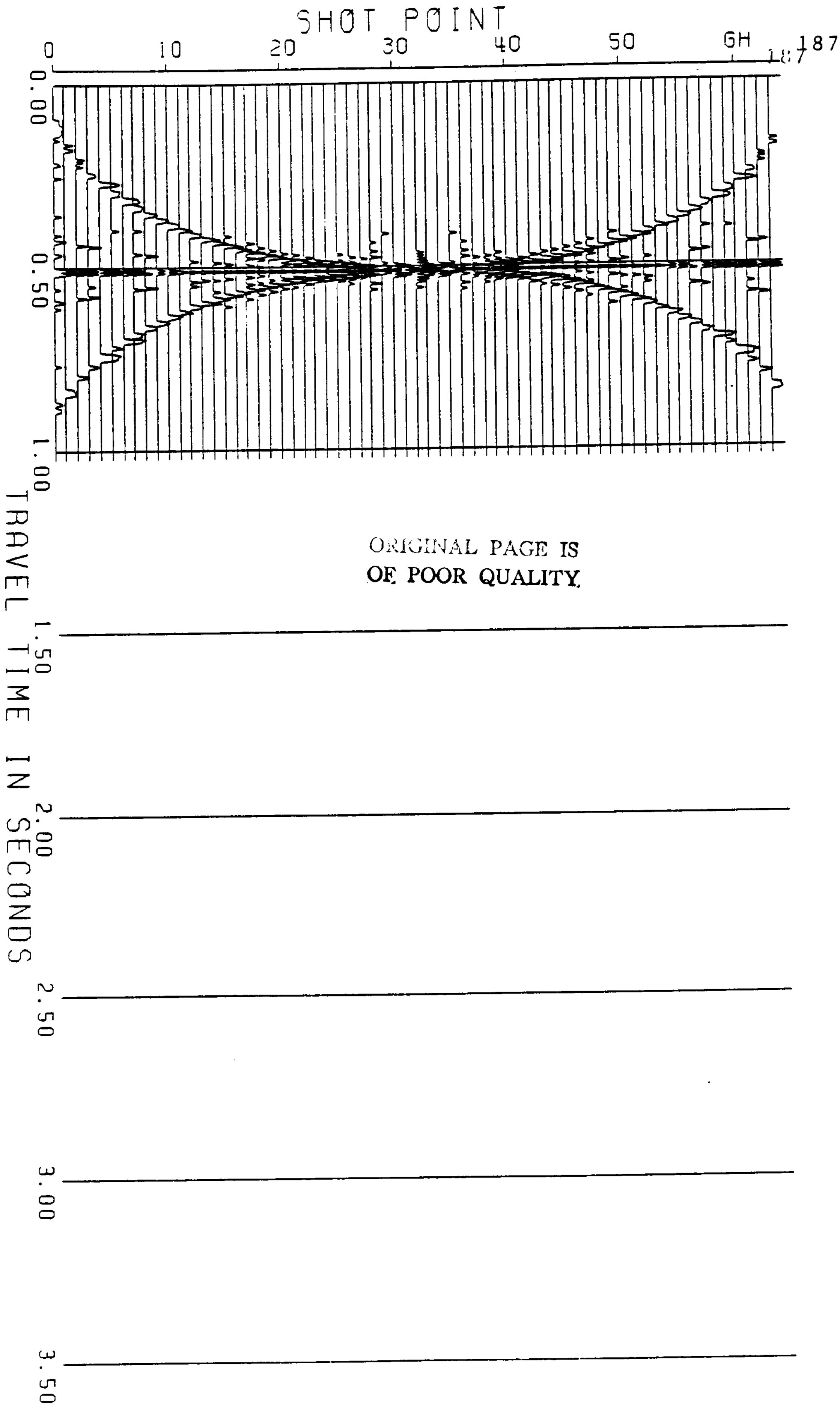

SHOT POINT
0
10
20
30
40
50
GH
187
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
TRAVEL TIME IN SECONDS

Fig. 5.7

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APPENDIX A

Always-Conergent Program

See E.J. Murphy, 1986 M.S. Thesis U.N.O. For Documentation.

```
C        FORTRAN PROGRAM FOR DECONVOLUTION - DCONL.FORW
C        DIFFERS FROM DCONJ: (1) GM TRANSFORM HAS LARGEST
C        ACTUAL MAGNITUDE OF 1.  (2)  FIRST ITERATION OF
C        MORRISON HAS GO WITH UNIT AREA.
C        USES ITERATIVE TECHNIQUE
C        HANDLES POSITIVE AND NEGATIVE GOING DATA
C        JULY 1983
C        READS DATA FILE FOR20.DAT,FOR19, AND FOR18.DAT
C        G(I) = RESPONSE (APPARATUS) FUNCTION
C        H(I)=BROADENED FUNCTION
         DIMENSION XX(2048),H(1152,3),GS(256),P(256),
       1 LF(150),QAZ(16000)
         DIMENSION G(2048),GNEW(257),I1OUT(23),HO(2000)
         COMPLEX X(2048),GM(257),CAPG(2048),Z(2048)
         COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY,SUM3
         EXTERNAL FFT
C        RESPONSE AND BROADENED FUNCTIONS ARE READ FROM
C        DATA FILE

         I=1
 6       FORMAT (G)
105      READ(20,6,END=110) G(I)
7        FORMAT (2G)
         I = I + 1
         GOTO 105
110      NG = I-1

         I =1
120      READ(18,*,END=125) HO(I)
         I = I+1
         GOTO 120
```

```
125     NHORIG= I-1
        NH=NHORIG

        NHSV = NH
        DO 45 I = 1,NH
45      XX(I) = I-1
C       FIRST MOMENT CALCULATION
        SUM = 0.
        SUM1=0
        SUM3=0
        DO 20 I = 1,NG
        GS(I)=G(I)
        SUM1=SUM1+ABS(G(I))
        SUM3=SUM3+G(I)*G(I)
20      SUM = SUM+G(I)
C       FIND FIRST MOMENT - FIND ORIGIN
        SUM2 = 0.
        MM=3
        DO 30 I = 1,NG
        GO TO (27,28,41),MM
27      SUM2=SUM2+ABS(I*G(I))
        GO TO 30
28      SUM2 = SUM2 + I*G(I)*G(I)
        GOTO 30
41      SUM2=SUM2 + I*G(I)
30      CONTINUE
201     FORMAT (' SUM2 = ',G)
        GO TO (38,39,42), MM
38      SUM2=SUM2/SUM1
        GO TO 40
39      SUM2=SUM2/SUM3
        GOTO 40
42      SUM2=SUM2/SUM
40      ISUM2 = SUM2 +0.5
        JSUI=2
        SUM2=1
        NU=20
C       NFT=NUM OF POINTS IN FOURIER DOMAIN FOR INVERSE
C       FILTER, MAX = 2048
C       NIT=NO. OF PTS. IN FOUR. DOM. FOR CALC. OF GM,
C       MAX = 256
        ITTY=0
        NFT=2048
        NIT=128
71      FORMAT(I)
        DO 80 I=NH+1,NFT
80      XX(I)=I-1
        ISU=1
        IF (ISU .EQ. 0) GOTO 68
        IF (NU .EQ. 0) GO TO 68
        IST=1
```

```
      NNS=0
      IF(NNS.EQ.0) GO TO 68
68    CONTINUE
C     TAKE FFT OF G
      DO 22 I=1,NG
22    X(I)=CMPLX(G(I),0.)
      ND=NG+1
      DO 54 I=ND,NFT
54    X(I)=CMPLX(0.,0.)
      CALL FFT(NFT,X,CAPG,-1.)
C     PHASE MULT TO GET CAPG CORRESPONDING TO SMALL
C     G IN RIGHT ORDER
C     USE SHIFT THEOREM TO PUT ORIGIN AT FIRST MOMENT
      Y=2*3.1415926*(SUM2-1)/NFT
      N21=(NFT/2)+1
      DO 140 I=1,NFT
      IF (I.LT.N21) Z(I)=CMPLX(COS((I-1)*Y),SIN((I-1)*Y))
      IF (I.EQ.N21) Z(I)=CMPLX(COS((NFT/2)*Y),0.)
      IF (I.GT.N21) Z(I)=CMPLX(COS((I-NFT-1)*Y),
     1 SIN((I-NFT-1)*Y))
140   CAPG(I)=CAPG(I)*Z(I)
      DO 37 I=1,NG
37    X(I)=(CMPLX(GS(I),0.))
      DO 655 I=ND,NIT
655   X(I)=CMPLX(0.,0.)
      CALL FFT(NIT,X,GM,-1.)
      TEMP = CABS(GM(1))
      DO 23 I = 2,(NIT/2) + 1
   23 IF (CABS(GM(I)).GT.TEMP) TEMP = CABS(GM(I))
      MGM=1
      DO 24 I=1,NIT
      XMAG=CABS(GM(I))/TEMP
      GOTO (81,24),MGM
81    IF (I.GT.((NIT/2)+1)) GOTO 24
24    GM(I)=CMPLX(XMAG,0.)*(-1)**(I-1)
C     TAKE INVERSE FFT OF GM
      CALL FFT(NIT,GM,X,+1.)
      SCL =TEMP/SUM
      DO 25 I = 1,NIT
      GNEW(I) = REAL(X(I))
25    G(I) = GNEW(I)*SCL
      NG = NIT + 1
      M = (NIT/2) + 1
      GNEW(1) = GNEW(1)/2.
      GNEW(NG)=GNEW(1)
      G(1) = G(1)/2.
      G(NG) = G(1)
C     DECONVOLUTION CALCULATION PERFORMED IN SUBROUTINE
      IJN=1
      GOTO(29,31),IJN
31    CALL DCON(NG,NH,M,H,GNEW,CAPG,G,SCL,NHORIG,HO)
829   call exit
```

```
29        DO 32 I = 1,NG
32        G(I) = GNEW(I)
          GOTO 31
          END
C
          SUBROUTINE DCON(NG,NH,M,H,G,CAPG,GO,SCL,NHORIG,HO)
C         SMOOTHING AND UNFOLDING SUBROUTINE
C         GEORGE E. IOUP DECONVOLUTION = MORRISON SMOTHNG +
C         VAN CITTERT UNF
C         NS = NUMBER OF SMOOTHINGS, >=0
C         NU = NUMBER OF UNFOLDINGS, >=0
C         M = I OF THE PEAK OF G(I)
C         NH = NUMBER OF POINTS OF H
C         NG = NUMBER OF POINTS OF G
          DIMENSION H(1152,3),G(257),F(1152),HI(1152),
        1 M2(1152),XX(2048)
          DIMENSION FS(2048),M3(1152),K(1152),AN(200),
        1 SH(1200,1),GO(2048)
          DIMENSION SPK(500),SQU(500),ITERAVE(1000),
        1 XSME(1000),QAZ(16000)
          DIMENSION HP(1000),VAR(1000),Q(200),
        1 XMSEAVE(1000),LOP(1000)
          COMPLEX CAPG(2048),CAPHF(2048),X(2048)
          COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY,SUM3

          I=1
776       READ(19,281,END=775)SPK(I)
          I=I+1
          GO TO 776
775       LSPK=I-1

          SUMH=0.
          SUMH1 = 0.
          SUMH2 = 0.
          DO 6 I=1,NH
          SUMH1 = H(I,1) + SUMH1
          SUMH2 = H(I,1)*H(I,1) + SUMH2
6         SUMH=ABS(H(I,1))+SUMH
C         ADD END ZEROES
8         NHN=NH
9         XNH = FLOAT(NH)
13        NHEAD = NG - M
14        NTAIL = M - 1
15        NHH1 = NHEAD + NH + 1

          TYPE*,'TYPE IN THE FOLLOWING INFORMATION IN ONE LINE'
          TYPE*,'    1)  HOW MANY SNR CASES DO YOU WISH ?TYPE
        1 BEGIN,END,STEP'
          TYPE*,'    2)  HOW MANY CASES FOR EACH SNR ?'
          TYPE*,'    3)  NUMBER OF SMOOTHING ITERATIOANS ? BEGIN,
        1 END'
          TYPE*,'    4)  RESULT OF EACH SNR CASE TO BE STARTED
```

```
     1 AT ? I4OUT'
      TYPE*,'    5)  MAX UNFOLDING ITERATION ? NU'
      TYPE*,'    6)  WHICH CASE DO YOU WHISH? BEGIN,END,STEP'
      type*,'    7)  output result files decon=id, smoth=is'
      ACCEPT*,ITRB,ITREN,ITRST,N,ILB,ILE,I4OUT,NU,NB,NE,NSTEP

      DO 660 ITRUESNR=ITRB,ITREN,ITRST
      NH=NHORIG
      JRAN=777
      CALL AMINI(HO,NH,1.,0,1,JRAN,SNR,QAZ)
      OLDSNR=SNR
      SF=(OLDSNR/ITRUESNR)**2
      JRAN=777
      DO 661 JN=1,N
      CALL AMINI(HO,NH,SF,IOUT,JN,JRAN,SNR,QAZ)
661   AN(JN)=SNR
      P=0.
      DO 333 IA=1,N
333   P=AN(IA)+P
      AVRSNR=P/N
      TYPE*,AVRSNR
      JIJI=1
      DO 665 INC=1,1,1
      NH=NHORIG
      IQA=(INC*NH)-(NH-1)
      IWS=INC*NH


      L=1
      DO 664 IED=IQA,IWS
      H(L,1)=QAZ(IED)
664   L=L+1
C     write(2,1000)(i,h(i,1),i=1,nhn)

16    DO 19 IH = 1,NH
17    IH1 = NHH1 - IH
18    IH2 = NH + 1 - IH
19    H(IH1,1) = H(IH2,1)
20    NH = NH + NHEAD + NTAIL
21    DO 22 IH3 = 1,NHEAD
22    H(IH3,1) = 0.0
23    DO 24 IH4 = NHH1,NH
24    H(IH4,1) = 0.
55    XNHI = 1./XNH
60    ERRH = 0.
C     HI = RECIPROCAL ARRAY OF H
65    DO 69 I3 = 1,NH
      IF (H(I3,1)) 68,67,68
```

```
67      HI(I3) = 0.
        GOTO 69
68      HI(I3) = 1./H(I3,1)
69      CONTINUE

        DO 632 IDT=1,NH
632     SH(IDT,1)=H(IDT,1)

        DO 666 IL=ILB,ILE
        NS=IL

        DO 633 IDY=1,NH
633     H(IDY,1)=SH(IDY,1)



C       PERFORM THE SMOOTHINGS
70      DO 130 I3=1,NH
        H(I3,2) = 0.
75      M1 = I3 - M + 1
80      M2(I3) = MAX0(M1,1)
85      M3(I3) = MIN0((I3 + NG - M),NH)
90      K(I3) = MAX0(1,(2-M1))
95      M4 = M2(I3)
100     M5 = M3(I3)
105     K1 = K(I3)

110     DO 120 I4 = M4,M5
115     H(I3,2) = H(I4,1) * GO(K1) + H(I3,2)
120     K1 = K1 + 1
130     CONTINUE
C130    ERRH = ABS((H(I3,2) - H(I3,1))*HI(I3)) + ERRH
C135    ERRH = ERRH * XNHI
C       SKIP SMOOTINGS AND PUT H BACK IF REQUESTED
        IF (NS.NE.0) GOTO 500
        DO 310 I = 1,NH
        H(I,3) = H(I,1)
310     H(I,2) = H(I,1)
        GOTO 320
500     I=1
        IF(NS.NE.1) GO TO 140
        DO 330 I=1,NH
330     H(I,3)=H(I,2)
        GO TO 320

140     DO 200 I5 = 2,NS
150     DO 195 I6 = 1,NH
155     H(I6,3) = H(I6,2)
160     M4 = M2(I6)
165     M5 = M3(I6)
170     K1 = K(I6)
175     DO 185 I7 = M4,M5
180     H(I6,3) = (H(I7,1) - H(I7,2))*G(K1) + H(I6,3)
185     K1 = K1 + 1
        H(I6,2) = H(I6,3)
```

```
195     CONTINUE
        I=I5
200     CONTINUE
405     FORMAT(I5,6X,G)
320     CONTINUE
        IF(ISU.EQ.0) GO TO 290
C       CALCULATE INVERSE FILTERED F
        DO 201 K2=1,NH
201     X(K2)=CMPLX(H(K2,3),0.)
        K3=NH+1
        DO 202 K4=K3,NFT
202     X(K4)=CMPLX(0.,0.)
        CALL FFT(NFT,X,CAPHF,-1.)
        DO 204 K5 = 1,NFT
        IF (CAPG(K5).EQ.CMPLX(0.0,0.0)) GOTO 203
        CAPHF(K5) = CAPHF(K5)/CAPG(K5)
        GOTO 204
203     CAPHF(K5) = CMPLX(0.0,0.0)
204     CONTINUE
        CALL FFT(NFT,CAPHF,X,+1.)
        NFT2=NFT/2
        NIT2=NIT/2
        SUMF=0
C       FIND WHAT PERCENTAGES OF F ARE IN VARIOUS WINDOWS
        DO 340 I=1,NFT
        FS(I)=REAL(X(I))
        IF(I.EQ.NIT2) SUMF1=SUMF
        IF(I.EQ.(NHN+NIT2))SUMF3=SUMF
        IF(I.EQ.NH)SUMF5=SUMF
340     CONTINUE
        IJ=1
        II=1
 455    FORMAT (G)
C       write(IS,1000)(I,h(i+nhead,3),i=1,nhn)
        XNORM=2.3772E+04
445     DO 420 I = 1,NH
        H(I,2) = H(I,2)/XNORM
        H(I,1) = H(I,1)/XNORM
 420    H(I,3) = H(I,3)/XNORM

        XTEMP=10.01**25
        XSME(ILB)=10.01**25
        xss=10000.
215     DO 285 I9 = 1,NU
220     ERRF = 0.
225     DO 280 I10 = 1,NH
240     F(I10)=H(I10,2)
245     M4 = M2(I10)
250     M5 = M3(I10)
255     K1 = K(I10)
260     DO 270 I11 = M4,M5
265     F(I10) = (FS(I11)-H(I11,2))*G(K1) + F(I10)
```

```
270     K1 = K1 + 1
C       POINT SUCCESSIVE
        H(I10,2)=F(I10)
280     CONTINUE
        ERRF = ERRF * XNHI
        I=I9
        DO 999 J=LSPK+1,NHN
999     SPK(J)=0.
        XMSE=0.
        suf=0.
        DO 998 J=1,NHN
C       TYPE*,F(J+NIT2),SPK(J)
        suf=suf+f(j+nit2)
998     XMSE=XMSE+(F(J+NIT2)-SPK(J))**2
        xdf=xss-suf
c       TYPE*,'   ',xmse,I9,NS,suf,xdf
        DIF=XTEMP-XMSE
        IF(DIF.LE.0.001)GO TO 990
        IF(XTEMP.LT.XMSE)GO TO 990
555     XTEMP=XMSE
        xss=suf
        type 937, xmse,dif,suf,abs(xdf),i9
937     format(g,2x,f10.7,2x,g,2x,f10.7,2x,i3)
281     FORMAT(2G)
285     CONTINUE
990     CONTINUE
c       TYPE*,XTEMP,I9-1,NS
        XSME(IL+1)=XTEMP
        LOP(IL+1)=I9-1
        IF(XSME(IL+1).GT.XSME(IL)) GO TO 291
 1000   format(2x,i3,10x,g)
        WRITE(id,1000)(I,F(I+NIT2),I=1,NHN)
290     GO TO 666
666     CONTINUE
291     TYPE*,XSME(IL),LOP(IL),IL-1,INC,AVRSNR,DIF
        WRITE(I4OUT,*)XSME(IL),LOP(IL),IL-1,INC,AVRSNR,DIF
        ITERAVE(JIJI)=LOP(IL)
        XMSEAVE(JIJI)=XSME(IL)
665     JIJI=JIJI+1
        CLOSE(UNIT=I4OUT)
        I4OUT=I4OUT+1
        SNRAVRG=ALOG(AVRSNR)
        PLO=0
        OLP=0
        DO 659 IAVER=1,N
        PLO=PLO+ITERAVE(IAVER)
659     OLP=OLP+XMSEAVE(IAVER)
        AVRGITER=PLO/N
        AVRGMSE=OLP/N
658     FORMAT(2G)
660     CONTINUE
```

```
300     RETURN
        END
C
        SUBROUTINE FFT(N,X,Y,SIGN)
C       COMPUTES FORWARD OR INVERSE FOURIER TRANSFORM FOR ANY
C       SET
C       OF DISCRETE DATA POINTS.
C       N = NUMBER OF DATA POINTS = POWER OF TWO
C       SIGN: -1 FOR A FORWARD TRANSFORM AND +1 FOR AN
C       INVERSE TRANSFORM
C       X = ORIGINAL DATA
C       Y = FOURIER TRANSFORM OF DATA
C       BOTH X AND Y ARE COMPLEX NUMBERS
        COMPLEX W,X(256),Y(256)
        INTEGER R
C       CALCULATIONS
        N2 = N/2
        FLTN = N
        NSTAGE = IFIX(ALOG(FLTN)/ALOG(2.))
        PHI2N = 6.283185307179586/FLTN
        DO 3 J = 1,NSTAGE
        N2J = N/(2**J)
        NR = N2J
        NI = (2**J)/2
        DO 2 I = 1,NI
        IN2J = (I-1)*N2J
        FLIN2J = IN2J
        TEMP = FLIN2J*PHI2N*SIGN
        W = CMPLX(COS(TEMP),SIN(TEMP))
        DO 2 R = 1,NR
        ISUB = R + IN2J
        ISUB1 = R + IN2J*2
        ISUB2 = ISUB1 + N2J
        ISUB3 = ISUB + N2
        Y(ISUB) = X(ISUB1) + W*X(ISUB2)
        Y(ISUB3) = X(ISUB1) - W*X(ISUB2)
2       CONTINUE
        DO 3 R = 1,N
3       X(R) = Y(R)
C       FACTOR OF (1/N) IN INVERSE TRANSFORM
        IF (SIGN.LT.0.) GOTO 5
        DO 4 R = 1,N
4       Y(R) = Y(R)/FLTN
5       RETURN
        END

        SUBROUTINE AMINI(H,NH,SF,IOUT,JN,JRAN,SNR,QAZ)
        DIMENSION H(1000),HP(1000),VAR(1000),Q(1000),QAZ(10000)
15      FORMAT (G)
        RMS = 0.
```

```
          AMAX = ABS(H(1))
          SD = SQRT(SF)
          DO 230   I = 1, NH

          IF (ABS(H(I)).GT.AMAX) AMAX = ABS(H(I))
          CALL GAUSS(SD,H(I),HP(I),JRAN)
          RMS = (HP(I) - H(I))**2 + RMS
230       CONTINUE
          RMS = SQRT(RMS/(NH+1))
          SNR = AMAX/RMS

C         WRITE (IOUT,15) (HP(I),I=1,NH)
          IBG=(NH*JN)-(NH-1)
          IED=NH*JN
          L=1
          DO 888 ICA=IBG,IED
          QAZ(ICA)=HP(L)
888       L=L+1
          RETURN
          END

          SUBROUTINE GAUSS(S,AM,V,JRAN)
          A=0.0
          DO 1 I=1,12
1         A=A+RAN(JRAN)
          V=(A-6.0)*S+AM
          RETURN
          END
```

Reeblurring Program

See R. Powe, 1985 M.S. Thesis U.N.O. For Documentation.

```
C         FORTRAN PROGRAM REBLUR - FOR DECONVOLUTION OF DATA USES
C         ITERATIVE TECHNIQUE - READS DATA FILES FOR20 & FOR21
          DIMENSION H(2048,3),G(2048),GN(2048),I1OUT(40),
     1    ILIST(100000),M2(2048),K(2048),V(2048),AU(2048),HN(2048)
          DIMENSION HI(2048),M3(2048),DATA(4096),IOT(100)
          DIMENSION F(2048,3),SPK(1000),SQU(100000),IT(100),QAZ(1600
          TYPE 400
 400      FORMAT(' NUMBER OF ITERATION '$)
          ACCEPT *,NUNF
```

```
          NHS=0
C          TYPE 401
C 401       FORMAT(' # OF PTS. IN FOURIER DOMAIN FOR FILTER '$)
C          ACCEPT *,NFT
          NFT=2048
C          TYPE 402
C 402       FORMAT(' ADD ON ZEROS ? :YES=1 ; NO=0 '$)
C          ACCEPT *,NEXZ
          NEXZ=1
C          TYPE 403
C 403       FORMAT(' # OF NON-STANDARD ITERATIONS '$)
C          ACCEPT *,NNS
          NNS=0
C          TYPE 404
C 404       FORMAT(' TYPE IN NON-STANDARD ITERATIONS '$)
C         ACCEPT *,(I1OUT(I),I=1,NNS)


C          TYPE*,'INPUT FILE IF=?'
C         ACCEPT*,IF

          I=1
555       READ(11,554,END=553)IT(I)
          I=I+1
          GOTO555
554       FORMAT(I3)
553       LIT=I-1
          DO 552 J=1,LIT
552       IF=IT(J)
          I=1
560       READ(12,554,END=561)IOT(I)
          I=I+1
          GOTO560
561       LIOT=I-1
          DO 562,J=1,LIOT
562       I3OUT=IOT(J)

          I=1
121       READ(9,281,END=125)  QAZ(I)
          I=I+1
          GO TO 121
125       NH=I-1

          IBG=IF*379-378
          IND=IF*379
          L=1
          DO 863 J=IBG,IND
          H(L,1)=QAZ(J)
863       L=L+1
          NH=IND+1-IBG

          ND=NH
```

```
        I=1
129     READ(15,281,END=128) G(I)
        I=I+1
        GO TO 129
128     NG=I-1
C       TYPE *,NG

        I=1
115     READ(14,114,END=116) SPK(I)
114     FORMAT(G)
        I=I+1
        GO TO 115
116     LE=I-1
C        TYPE *,LE

C       DATA (ILIST(L),L=1,3)/100,20,50/
        DO 666 J=1,NUNF
666     ILIST(J)=J
        DO 10 J=1,NG
10      V(J)=G(NG-J+1)
        NG1=NG
        LAU=NG+NG-1
        CALL FOLD(NG,V,NG,G,LAU,AU)
        IF(LAU.EQ.NFT) GO TO 15
        DO 18 I=LAU+1,NFT
18      AU(I)=0.
15      DO 5 J=1,NFT
        DATA(2*J-1)=AU(J)
5       DATA(2*J)=0.0
        CALL FFT(NFT,-1,DATA,ZXMAX)
C       TYPE *,ZXMAX
        ABAS=0.
        DO 1 I=1,LAU
        GN(I)=AU(I)/ZXMAX
1       ABAS=ABS(GN(I))+ABAS
C       TYPE *,'ABAS=',ABAS
        NHN1=NH+NG-1
        CALL FOLD(NH,H,NG,V,NHN1,HN)
        DO 2 J=1,NHN1
2       H(J,1)=HN(J)/ZXMAX
        M=NG
        NG=LAU
        NH=NHN1
        NHN=NH
        XNH=NH
        NHEAD=0
        NTAIL=0
        IF(NEXZ.EQ.0)GO TO 30
        NHEAD=NG-M
        NTAIL=M-1
        NHH1=NHEAD+NH+1
```

```
        DO 19 IH=1,NH
        IH1=NHH1-IH
        IH2=NH+1-IH
19      H(IH1,1)=H(IH2,1)
        NH=NH+NHEAD+NTAIL
        DO 22 IH3=1,NHEAD
        22      H(IH3,1)=0.
        DO 24 IH4=NHH1,NH
24      H(IH4,1)=0.
30      XNHI=1./XNH
C       TYPE *,XNHI,NHEAD,NTAIL
        ERRH=0.
        DO 130 I3=1,NH
        M1=I3-M+1
        M2(I3)=MAX0(M1,1)
        M3(I3)=MINO((I3+NG-M),NH)
        K(I3)=MAX0(1,(2-M1))
130     CONTINUE
        IF(NHS.EQ.0.) GO TO 210
        DO 131 I31=1,NH
        M4=M2(I31)
        M5=M3(I31)
        K1=K(I31)
        DO 120 I4=M4,M5
        H(I31,2)=H(I4,1)*GN(K1)+H(I31,2)
120     K1=K1+1
131     ERRH=ABS(H(I31,2)-H(I31,1))+ERRH
        ERRH=ERRH*XNHI
        I=1
C       WRITE(63,48) I,ERRH
        DO 200 I5=3,NHS
        ERRH=0.0
        DO 195 I6=1,NH
        H(I6,3)=H(I6,2)
        M4=M2(I6)
        M5=M3(I6)
        K1=K(I6)
        DO 185 I7=M4,M5
        H(I6,3)=(H(I7,1)-H(I7,2))*GN(K1)+H(I6,3)
185     K1=K1+1
195     ERRH=ABS(H(I6,3)-H(I6,2))+ERRH
        ERRH=ERRH*XNHI
C200    WRITE(63,48) I5,ERRH
200     CONTINUE
48      FORMAT(I5,6X,G)
        CLOSE(UNIT=63)
        GO TO 211
210     DO175 J=1,NH
175     H(J,3)=H(J,1)
211     DO 212 I12=1,NH
        F(I12,2)=H(I12,3)
212     F(I12,1)=H(I12,3)
```

```
C          IOUT=22
           I2OUT=50
           IJ=1
           II=1
           DO 285 I9=1,NUNF
           ERRF=0.
           DO 280 I10=1,NH
           F(I10,3)=F(I10,1)+F(I10,2)
           M4=M2(I10)
           M5=M3(I10)
           K1=K(I10)
           DO 270 I11=M4,M5
           F(I10,3)=-F(I11,2)*GN(K1)+F(I10,3)
 270       K1=K1+1
           ERRF=ABS(F(I10,3)-F(I10,2))+ERRF
 280       CONTINUE
           DO 286 I=1,NH
 286       F(I,2)=F(I,3)
           I=I9
           IF(I.NE.ILIST(II)) GO TO 282
C          WRITE(IOUT,281) (F(IZ+NHEAD,3),IZ=1,NHN)
           SQU(1)=1000
           DO 999 I=LE+1,ND
 999       SPK(I)=0.
           XMSE=0.
           DO 998 I=NG,NHN+NHEAD
 998       XMSE=XMSE+(F(I,3)-SPK(I-NG+1))**2
C          WRITE(110,997)XMSE
           SQU(I9+1)=XMSE
           DIF=SQU(I9+1)-SQU(I9)
           IF(SQU(I9).LT.SQU(I9+1))GOTO 990
C          TYPE 997,XMSE,I9
 997       FORMAT('XMSE=',G,'ITERATION',I5)

           SUM=0.
           DO 299 IJK=1,NHN
 299       SUM=SUM+F(IJK+NHEAD-1,3)
C          I=I9

C          IF(I.NE.ILIST(II)) GO TO 282
C          WRITE(IOUT,281) (F(IZ+NHEAD,3),IZ=1,NHN)
C          TYPE 997,XMSE,ERRF

C          TYPE *,I9,SUM
C          CLOSE(UNIT=IOUT)
C          IOUT=IOUT+1
           II=II+1
 282       IF(NNS.EQ.0) GO TO 285
           IF(I.NE.I1OUT(IJ)) GO TO 285
 281       FORMAT(E50.4)
C          WRITE(I2OUT,281) (F(IZ+NHEAD,3),IZ=1,NHN)
C          TYPE 997,XMSE,ERRF
```

```
          SUM=0.
          DO 298 IJK =1,NHN
298       SUM=SUM+F(IJK+NHEAD-1,3)
C          TYPE *,I9,SUM
C         CLOSE(UNIT=I2OUT)
C         I2OUT=I2OUT+1
          IJ=IJ+1
285       CONTINUE
          GOTO 991
990       TYPE*,XMSE,' ',I9,' ',IF,' ',DIF,' ',1
          JD1=1
          WRITE(I3OUT,*)XMSE,I9,IF,DIF,JD1
          GOTO993
991       TYPE*,XMSE,' ',I9,' ',IF,' ',DIF,' ',0
          ID=0
          WRITE(I3OUT,*)XMSE,I9,IF,DIF,ID
C         WRITE(60,281) (H(IZ+NHEAD,3),IZ=1,NHN)
C993      WRITE(22,114)(F(IZ+NHEAD,3),IZ=1,NHN)
993       ERRF=ERRF*XNHI

C          TYPE *,ERRF
          IF=IF+1
C         IF(IF.GT.90)GOTO 994
          WRITE(11,554)IF
          I3OUT=I3OUT+1
          WRITE(12,554)I3OUT
          GOTO992
C994      IF=IT(1)
C         I3OUT=IOT(1)
C         WRITE(91,554)I3OUT
C         WRITE(92,554)IF
992       END

          SUBROUTINE FOLD(LA,A,LB,B,LC,C)
          DIMENSION A(LA),B(LB),C(LC)
          CALL ZERO(LC,C)
          DO 1 I=1,LA
          DO 1 J=1,LB
          K=I+J-1
1         C(K)=C(K)+A(I)*B(J)
          RETURN
          END

          SUBROUTINE ZERO(LX,X)
          DIMENSION X(LX)
          IF(LX.LE.0) RETURN
          DO 1 I=1,LX
1         X(I)=0.0
          RETURN
          END

          SUBROUTINE FFT(NN,ISIGN,DATA,ZXMAX)
```

```
      DIMENSION DATA(4096),XMAG(2048)
      COMPLEX G1(2048)
      N=2*NN
      J=1
      DO 5 I=1,N,2
      IF(I-J)1,2,2
1     TEMPR=DATA(J)
      TEMPI=DATA(J+1)
      DATA(J)=DATA(I)
      DATA(J+1)=DATA(I+1)
      DATA(I)=TEMPR
      DATA(I+1)=TEMPI
2     M=N/2
3     IF(J-M)5,5,4
4     J=J-M
      M=M/2
      IF(M-2)5,3,3
5     J=J+M
      MMAX=2
6     IF(MMAX-N)7,10,10
7     ISTEP=2*MMAX
      THETA=6.2831853/FLOAT(ISIGN*MMAX)
      SINTH=SIN(THETA/2)
      WSTPR=-2*SINTH*SINTH
      WSTPI=SIN(THETA)
      WR=1.
      WI=0.
      DO 9 M=1,MMAX,2
      DO 8 I=M,N,ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
      DATA(I)=DATA(I)+TEMPR
8     DATA(I+1)=DATA(I+1)+TEMPI
      TEMPR=WR
      WR=WR*WSTPR-WI*WSTPI+WR
9     WI=WI*WSTPR+TEMPR*WSTPI+WI
      MMAX=ISTEP
      GO TO 6
10    DO 30 I=1,NN
30    XMAG(I)=SQRT((DATA(2*I-1))**2+(DATA(2*I))**2)
      ZXMAX=0.
      DO 20 I=1,NN
      IF(XMAG(i).GE.ZXMAX) ZXMAX=XMAG(i)
20     CONTINUE
      DO 40 K=1,NN
40    G1(K)=CMPLX(DATA(2*K-1),DATA(2*K))
      RETURN
      END
```

LS Program

See R._Powe, 1985 M.S. Thesis U.N.O. For Documentation.

```
C       PROGRAM INFILP.FOR - 21 MAR 85
        DIMENSION H(1100),F1(250),AB(1100),ABR(1100)
        DIMENSION B(100),C(250),F(1000),C2(2300),HN(1100)
        DIMENSION F2(1000),F3(2000),SS(1000),SPK(1000)
        REAL A(100),W(1000),V(1000),P(1000)
        REAL LAP
        I=1
888     READ(19,62,END=887)SPK(I)
        I=I+1
        GOTO888
887     LS=I-1
        TYPE*,'INPUT FILE=?'
        ACCEPT*,IF
        I=1
55      READ(IF,62,END=120) H(I)
        I=I+1
        GO TO 55
120     LH=I-1
        I=1
56      READ(20,62,END=121) A(I)
        I=I+1
        GO TO 56
121     LA=I-1
C       TYPE 100
C100    FORMAT( '    TYPE IN N=FILTER LENGTH ' )
C       ACCEPT *,N
        N=999
        TYPE 900
900     FORMAT( '  NOISE IN DATA : YES=1;NO=0 ')
        ACCEPT *,NID
C       NID=1
        IF(NID.NE.1) GO TO 190
        I=1
35      READ(21,62,END=36) HN(I)
        I=I+1
        GO TO 35
36      Z1=HN(1)
        DO 90 J=1,LH
```

```
90      AB(J)=H(J)-HN(J)
        Z1=AB(1)
        DO92 L=1,LH
92      ABR(L)=AB(LH-L+1)
        LC2=2*LH-1
        CALL FOLD(LH,AB,LH,ABR,LC2,C2)
        Q1=C2(LH)
        DO 93 K=1,N
93      F2(K)=C2(LH+K-1)
        T1=F2(1)
        TYPE 200
 200    FORMAT (' TYPE IN XNORM')
        ACCEPT *,XNORM
C       XNORM=16
        DO 94 K=1,N
94      F2(K)=F2(K)/XNORM
190     LB=LA
        Z=A(1)
        DO 10 I=1,LA
        B(I)=A(LA-(I-1))
10      CONTINUE
        LC=LA+LB-1
        CALL FOLD(LA,A,LB,B,LC,C)
        Q=C(LA)
C       TYPE *,Q1,Q
        DO 20 I=1,LA
        F1(I)=C(LA+(I-1))
20      CONTINUE
        T=F1(1)
C       IF(NID.NE.1) GO TO 31
C       DO 30 I=1,LA
C       F1(I)=F1(I)/LA
C30     CONTINUE
31      T3=T+T1
        IF(NID.NE.1) GO TO 37
        DO 95 J=1,LA
95      F(J)=(F1(J)+F2(J))
        DO 96 J=LA+1,N
96      F(J)=F2(J)
        T4=F(1)
        Q=T4
        DO 66 K=1,N
66      F(K)=F(K)/T4
        GO TO 32
37      DO 99 I=1,LA
99      F(I)=F1(I)/T
32      CALL LEVREC(F,W,V,N)
        EN=0.
        DO 59 I=1,LA
59      EN=A(I)**2.+EN
        LAP=9.0068E+03
        DO 40 I=1,N
```

```
        P(I)=W(I)*(1./V(N))*(1./Q)*LAP
40      CONTINUE
        LF3=LH+N-1
C       CALL FOLD(LA,A,N,P,LC21,C21)
        CALL FOLD(LH,H,N,P,LF3,F3)
        ZT=F3(1)
C       TYPE *,ZT,Q,Z1,T,T1,T3
C       WRITE(45,63) (F3(J),J=1,LF3)
63      FORMAT(8(1PE15.6))
        CLOSE(UNIT=45)
C       TYPE *,EN,LAP,A(1),V(N)

        DO 13 K=1,LF3
13      WRITE(22,*) F3(K)
62      FORMAT(G)
C       WRITE(52,62)(C21(I),I=1,LC2)
        DO 150 I=LS+1,LH
150     SPK(I)=0.
        XMSE=0.
        DO 130 I=1,LH
130     XMSE=(F3(I)-SPK(I))**2+XMSE
        TYPE140,XMSE
        TYPE*,'OUTPUT FILE FOR XMSE ?'
        ACCEPT*,IOT
        WRITE(IOT,*)XMSE
140     FORMAT(' XMSE= ',G)
12      END

        SUBROUTINE LEVREC(F,W,V,N)
        REAL F(1000),W(1000),R(1000),V(1000),D(1000),E(1000)
        W(1)=1
        V(1)=1
        D(1)=F(1)
        DO 2 K=2,N
2       D(K)=0.0
        DO 5 J=2,N
        EE=0.0
        DO 3 I=2,J
3       EE=EE+F(I)*W(J-I+1)
        E(J)=EE
        R(J)=E(J)/V(J-1)
        V(J)=V(J-1)-(E(J)*R(J))
        DO 4 I=1,J
4       W(I)=D(I)-(R(J)*D(J+1-I))
        DO 5 I=1,J
5       D(I)=W(I)
C       WRITE(47,345) (W(J),J=1,N)
        CLOSE(UNIT=47)
345     FORMAT(8(1PE15.6))
        RETURN
        END
```

```
      SUBROUTINE FOLD(LA,A,LB,B,LC,C)
      DIMENSION A(LA),B(LB),C(LC)
      LC=LA+LB-1
      CALL ZERO(LC,C)
      DO 1 I=1,LA
      DO 1 J=1,LB
      K=I+J-1
1     C(K)=C(K)+A(I)*B(J)
      RETURN
      END
      SUBROUTINE ZERO(LX,X)
      DIMENSION X(LX)
      IF(LX.LE.0) RETURN
      DO 1 I=1,LX
1     X(I)=0.0
      RETURN
      END

      SUBROUTINE FFT(NN,ISIGN,DATA)
      DIMENSION DATA(4100)
      N=2*NN
      J=1
      DO 5 I=1,N,2
      IF(I-J)1, 2,2
1     TEMPR=DATA(J)
      TEMPI=DATA(J+1)
      DATA(J)=DATA(I)
      DATA(J+1)=DATA(I+1)
      DATA(I)=TEMPR
      DATA(I+1)=TEMPI
2     M=N/2
3     IF(J-M)5,5,4
4     J=J-M
      M=M/2
      IF(M-2)5,3,3
5     J=J+M
      MMAX=2
6      IF(MMAX-N)7,10,10
7     ISTEP=2*MMAX
      THETA=6.2831853/FLOAT(ISIGN*MMAX)
      SINTH=SIN(THETA/2.)
      WSTPR=-2.*SINTH*SINTH
      WSTPI=SIN(THETA)
      WR=1
      WI=0
      DO 9 M=1, MMAX, 2
      DO 8 I=M , N, ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
```

```
          DATA(I)=DATA(I)+TEMPR
8         DATA(I+1)=DATA(I+1)+TEMPI
          TEMPR=WR
          WR=WR*WSTPR-WI*WSTPI+WR
9         WI=WI*WSTPR+TEMPR*WSTPI+WI
          MMAX=ISTEP
          GO TO 6
10        RETURN
          END
```

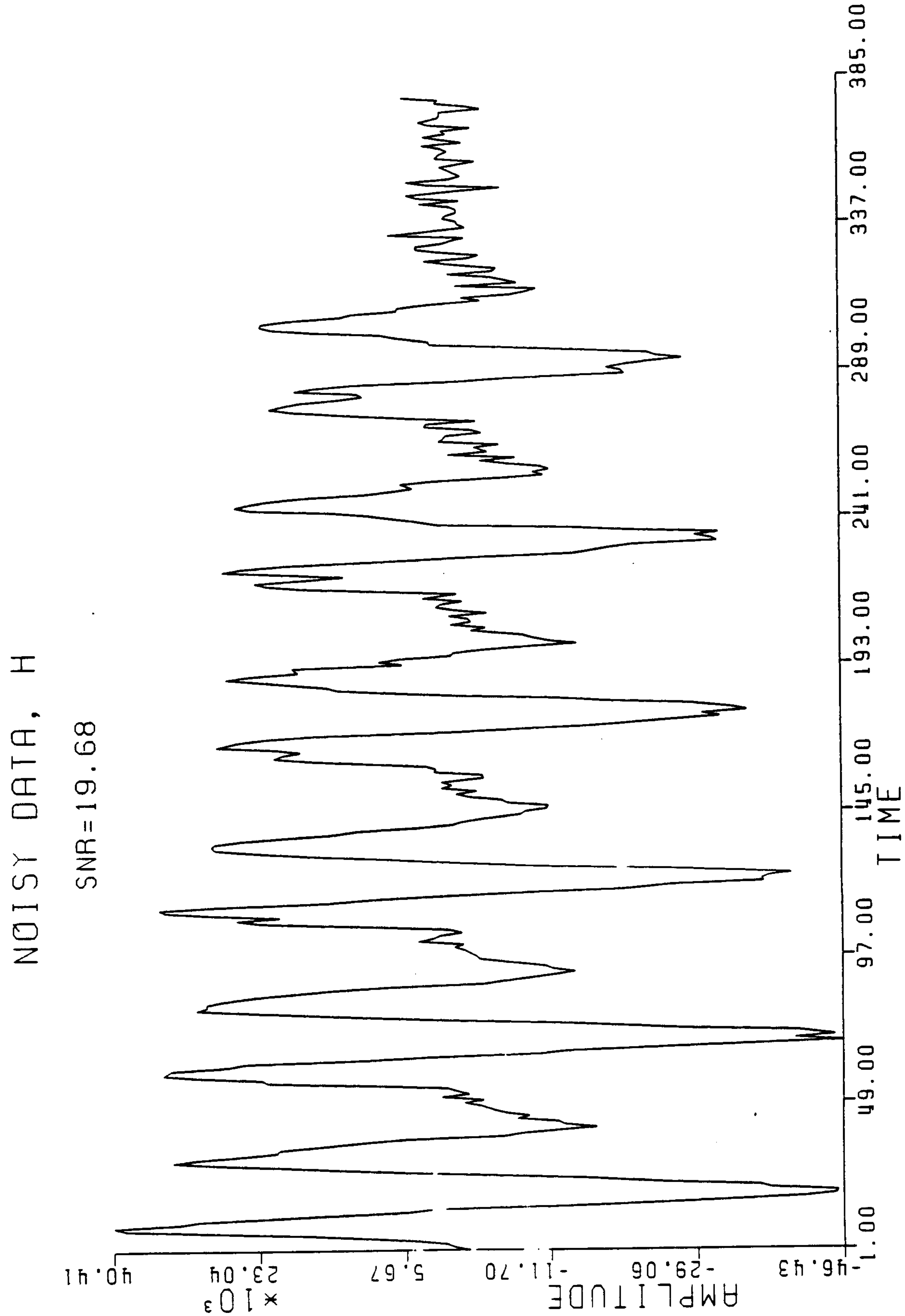
Gaussian Distributed Noise Generator Program

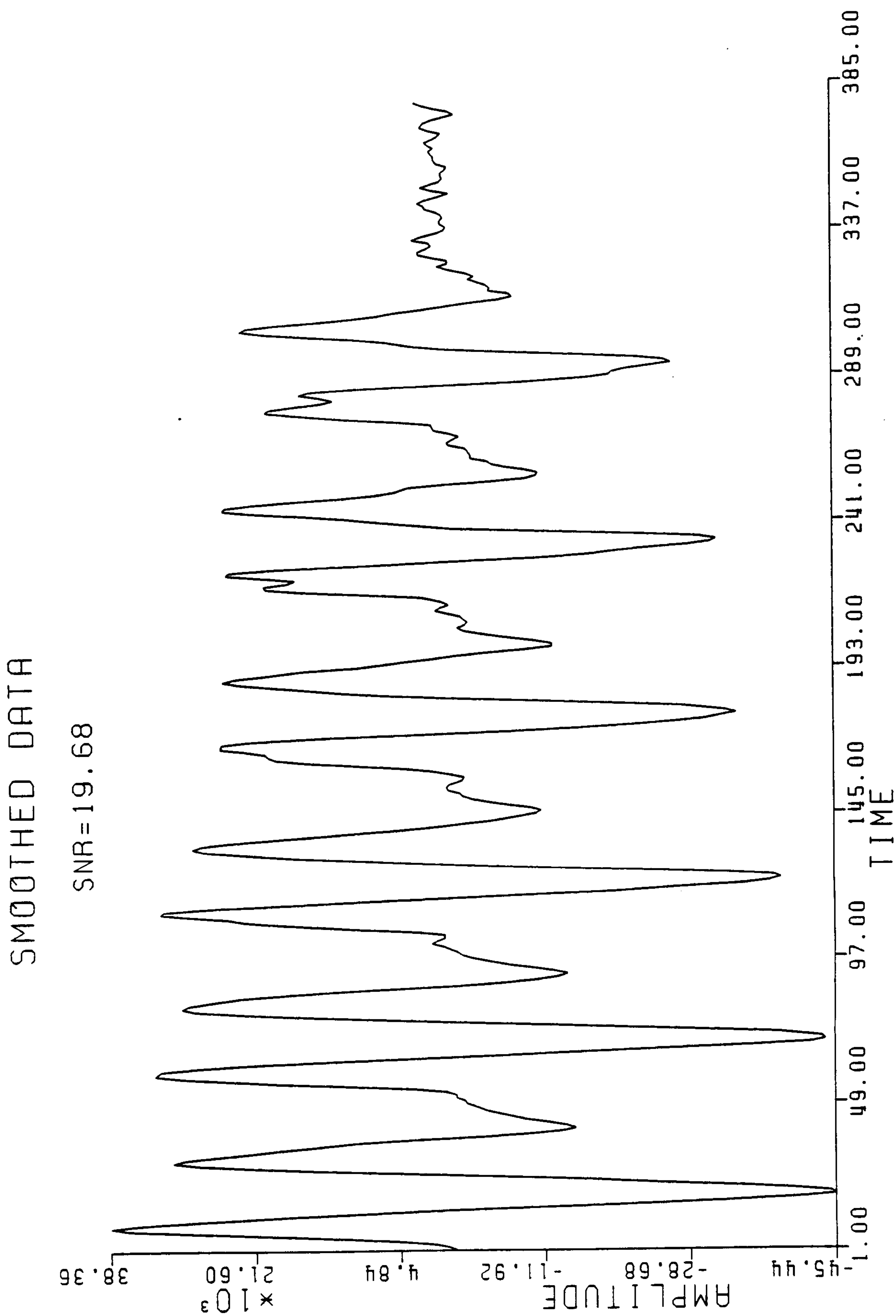
See J. Leclere, 1984 M.S. Thesis U.N.O. For Documentation

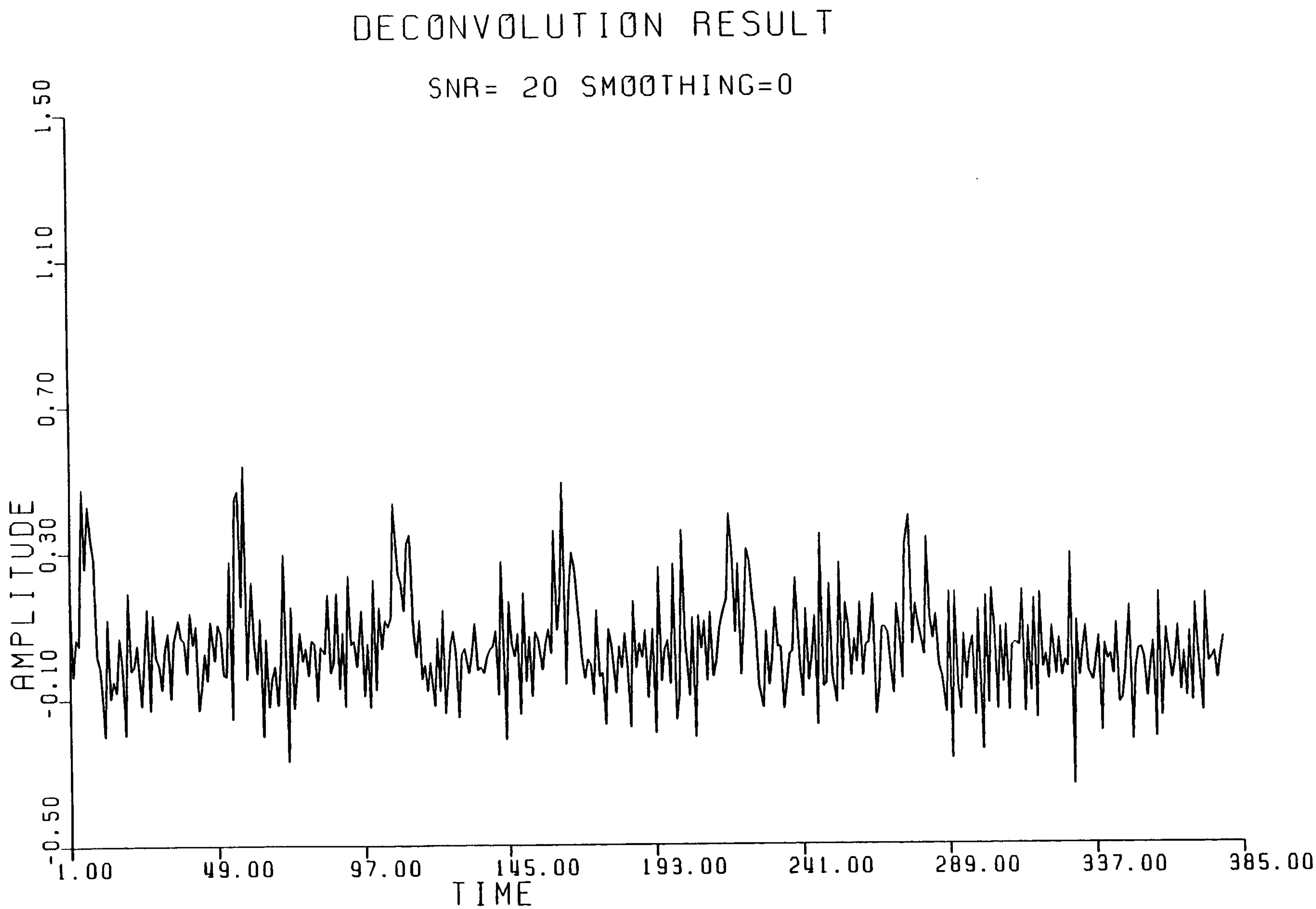
```
C         PROGRAM CNSGEN.FOR - PROGRAM TO GENERATE CONSTANT NOISE
C   PRODUCES GAUSSIAN DISTRIBUTED NOISE ON POSITIVE/NEGATIVE DATA
          DIMENSION H(10000),HP(10000),VAR(10000),Q(100)
C         READ IN H FILE
          I=1
5         READ (18,15,END=7) H(I)
          I = I + 1
          GOTO 5
          7         NH = I - 1

          TYPE 10
10        FORMAT (' SCALE FACTOR? IULMT? '$)
          ACCEPT*,SF,IULMT
15        FORMAT (G)
          IOUT=9
          JRAN=777

          IBEGIN=1
          DO 16 L=IBEGIN,IULMT
          RMS = 0.
          AMAX = ABS(H(1))
          SD = SQRT(SF)
          DO 230  I = 1, NH
          IF (ABS(H(I)).GT.AMAX) AMAX = ABS(H(I))
          CALL GAUSS(SD,H(I),HP(I),JRAN)
          RMS = (HP(I) - H(I))**2 + RMS
230       CONTINUE
C         TYPE*,AMAX
          RMS = SQRT(RMS/(NH+1))
```

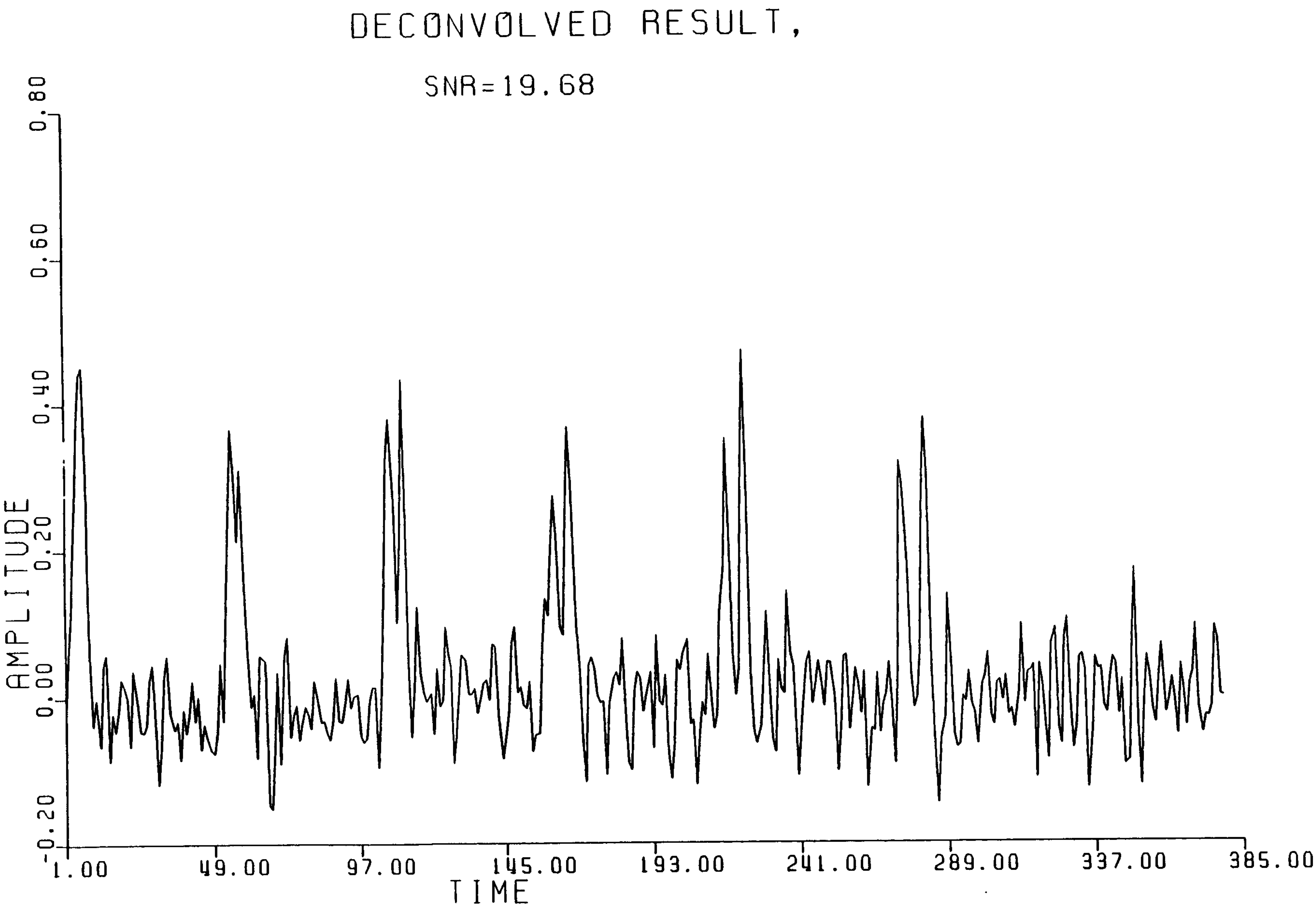
```
C       IF (RMS.EQ.0.) GOTO 235

        SNR = AMAX/RMS
        Q(L)=SNR
C235    TYPE 20,  SF, RMS, SD, SNR
20      FORMAT (' SF = ',G,' RMS = ',G,' SD = ',G,/' SNR = ',G)
        TYPE*,SNR,L
        WRITE (IOUT,15) (HP(I),I=1,NH)

 16     CONTINUE
        P=0.
        DO 333 J=1,IULMT
333     P=Q(J)+P
        R=P/IULMT
        TYPE*,R
        END
C       Subroutine GAUSS
C
C       PURPOSE
C
C       Computes a normally distributed random number with
C               a given mean and standard deviation
C
C       USAGE
C
C               CALL GAUSS(S,AM,V)
C
C
C       DESCRIPTION OF PARAMETERS
C
C       S - the desired standard deviation of the normal
C       distribution
C       AM - the desired mean of the normal distribution
C       V - the value of the computed normal random variable
C
C       REMARKS
C
C               This subroutine uses a machine specific uniform
C               random number generator
C
C       METHOD
C
C    Uses 12 uniform random numbers to compute normal
C    random numbers by central limit theorem.  The result
C    is then adjusted to match the given mean and standard
C    eviation.  The uniform random numbers computed within
C    he subroutine are computed by the FORTRAN "RAN" function.
C
C
C
        SUBROUTINE GAUSS(S,AM,V,JRAN)
```

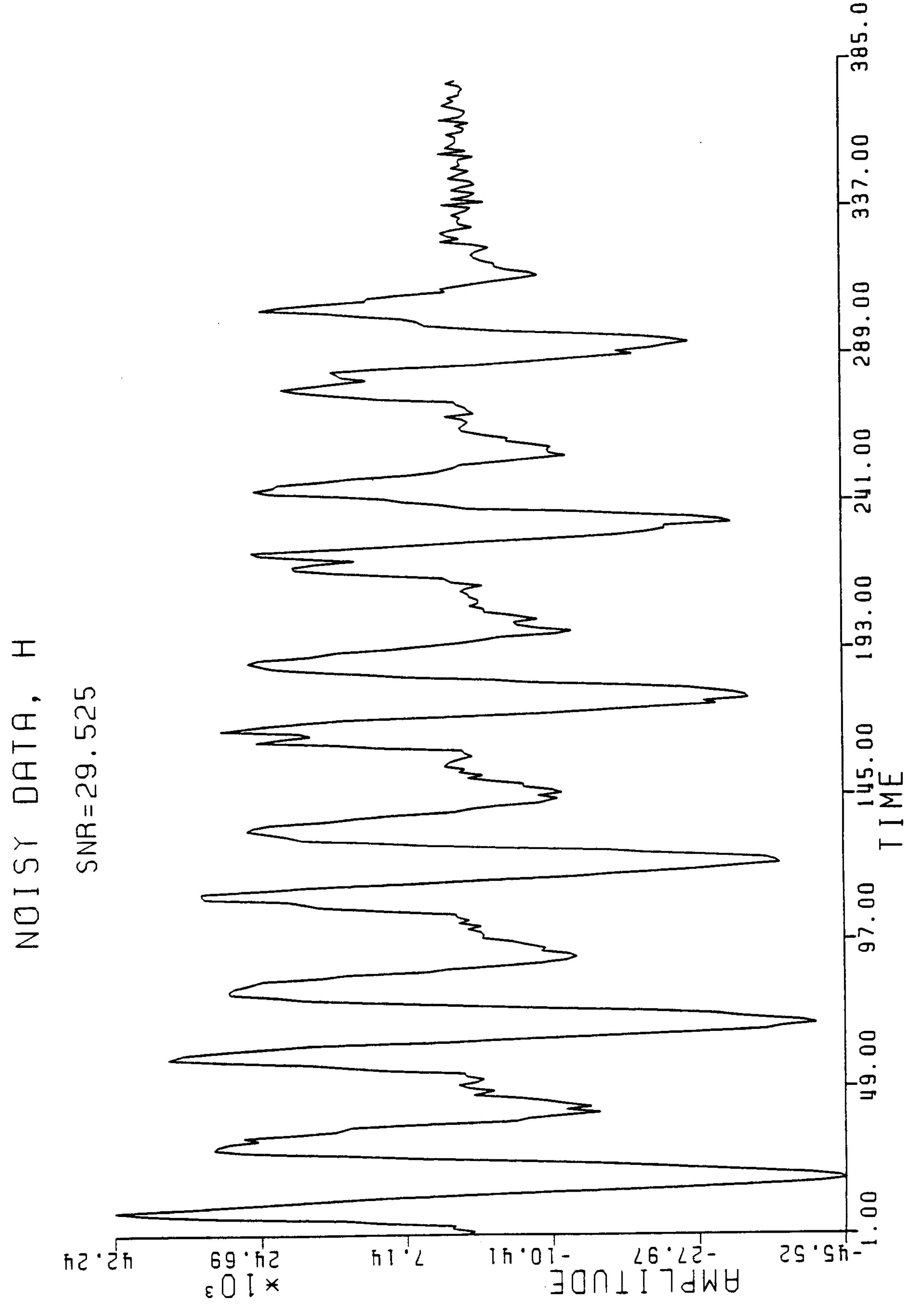
```
      A=0.0
      DO 1 I=1,12
1     A=A+RAN(JRAN)
      V=(A-6.0)*S+AM
      RETURN
      END
```

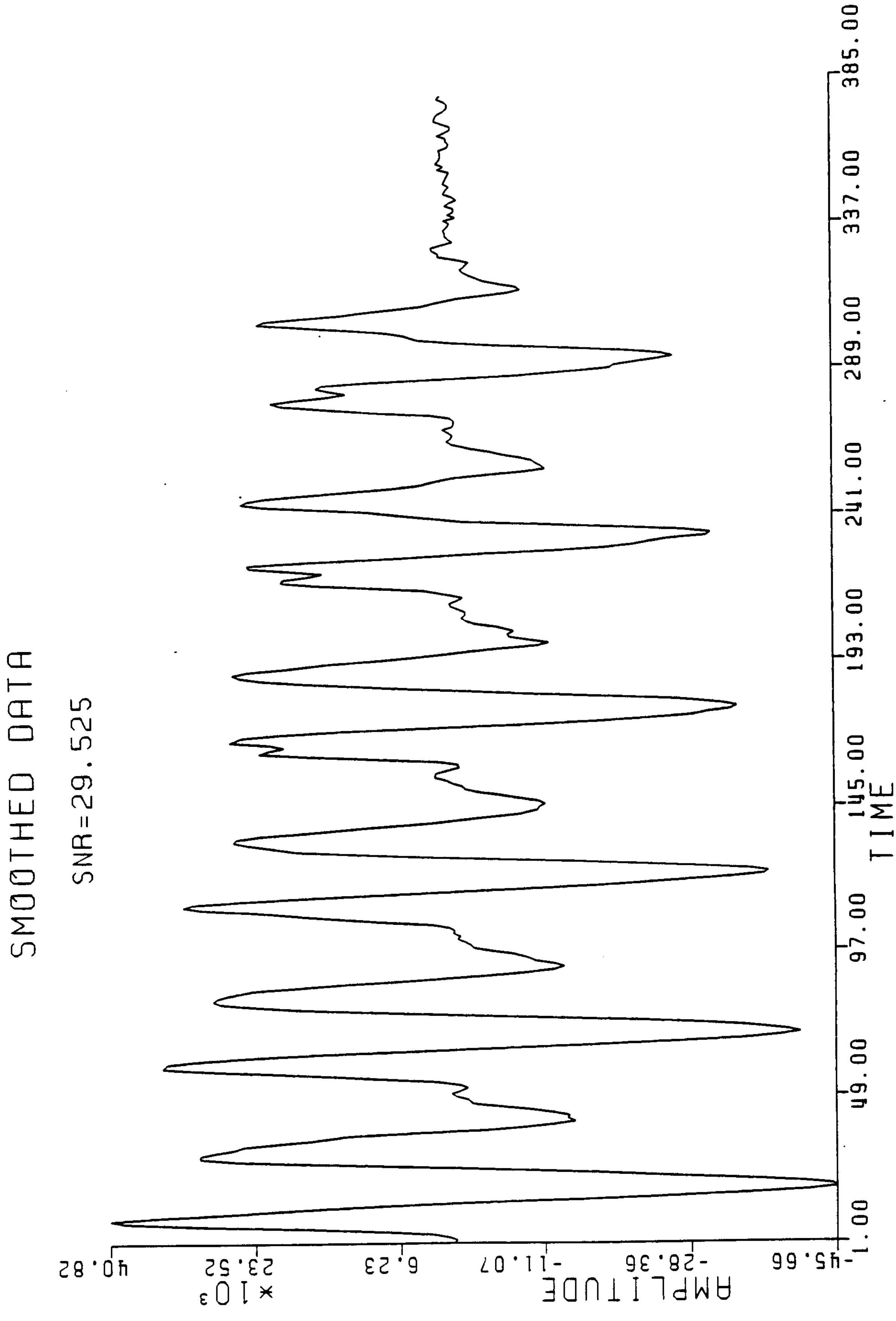

NØISY DATA, H
SNR=19.68
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-46.43
-29.06
-11.70
5.67
23.04
40.41

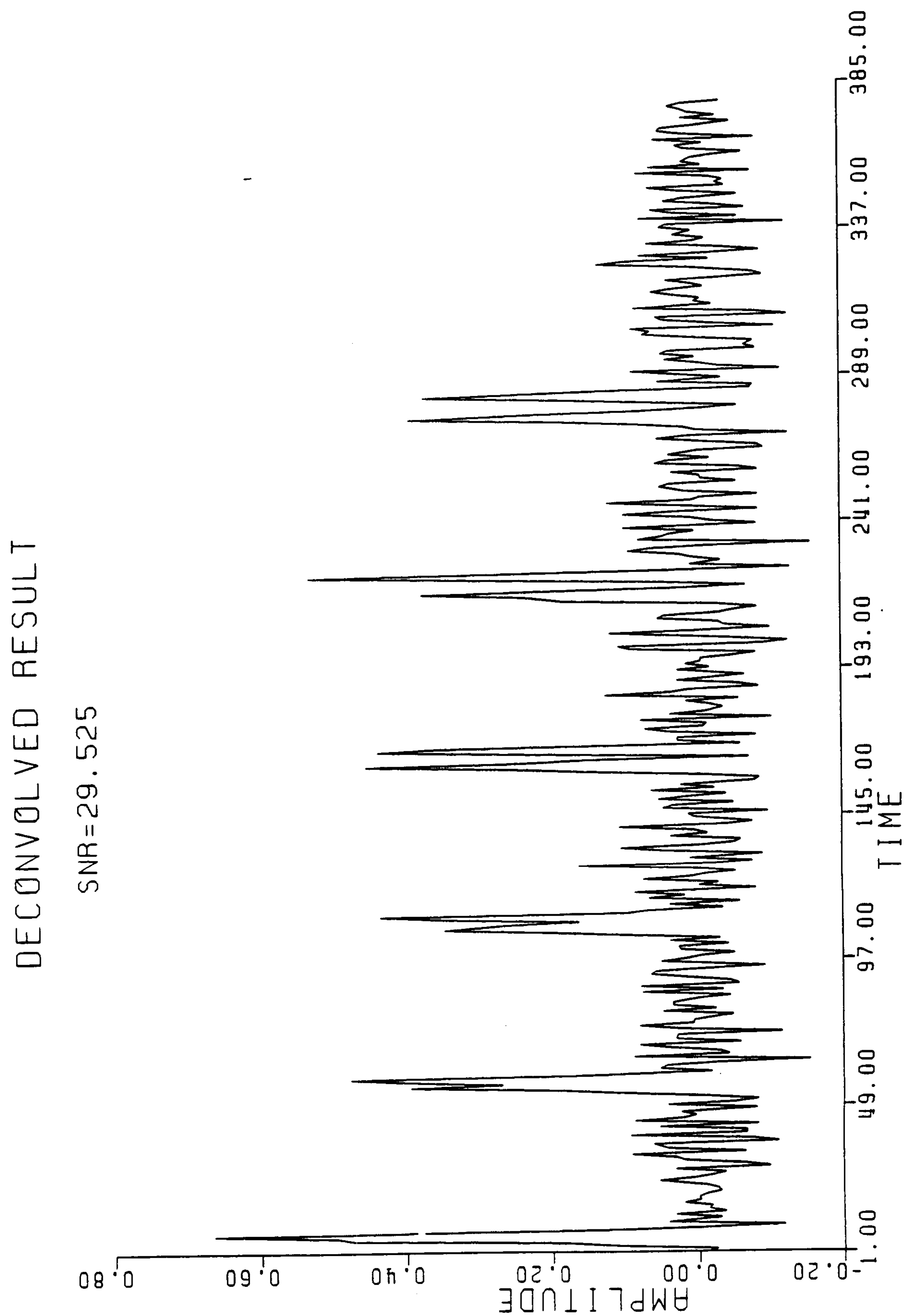

SMOOTHED DATA
SNR=19.68
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
38.36
21.60
4.84
-11.92
-28.68
-45.44

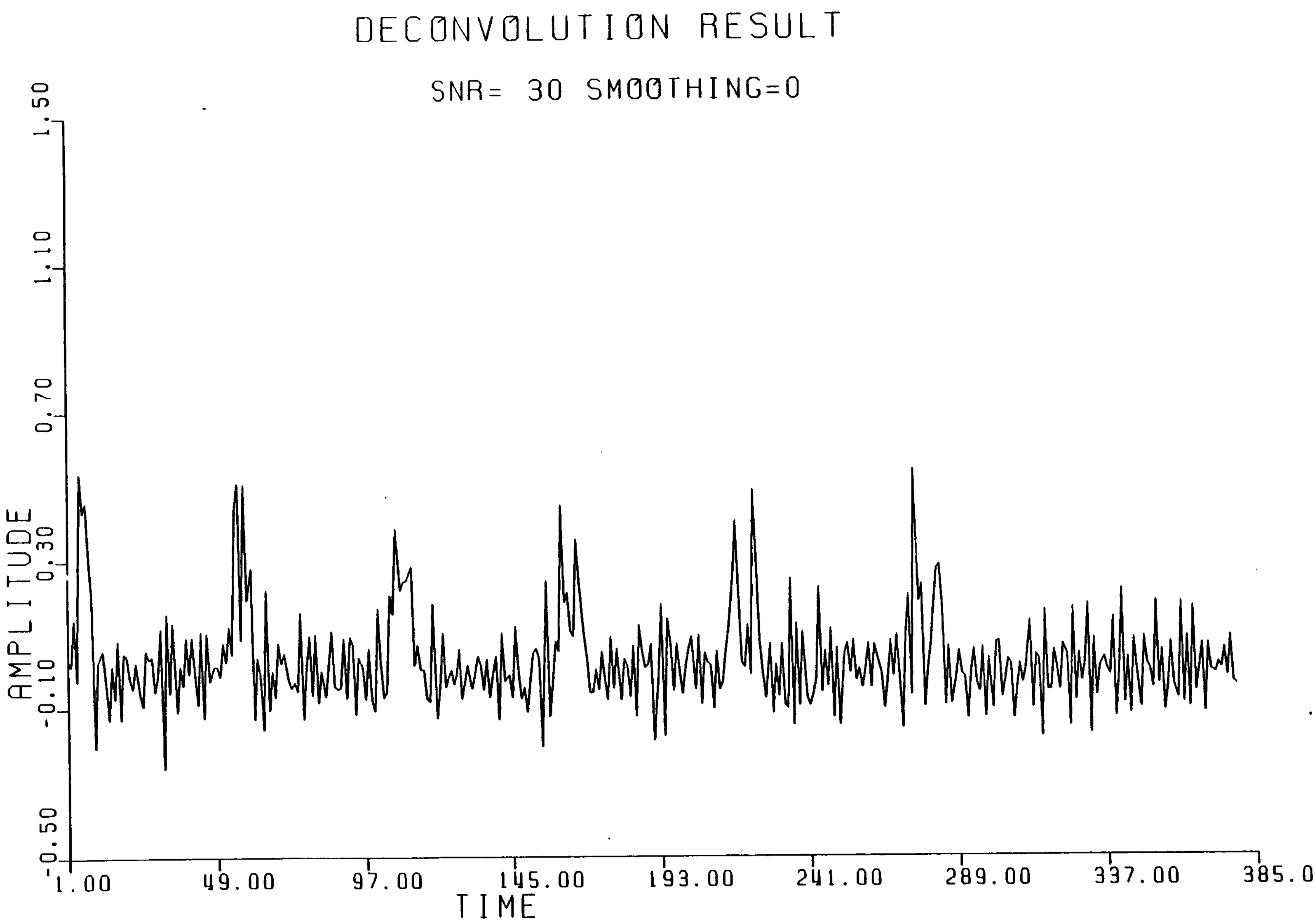

DECONVOLUTION RESULT
SNR= 20 SMOOTHING=0
AMPLITUDE
1.50
1.10
0.70
0.30
-0.10
-0.50
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME

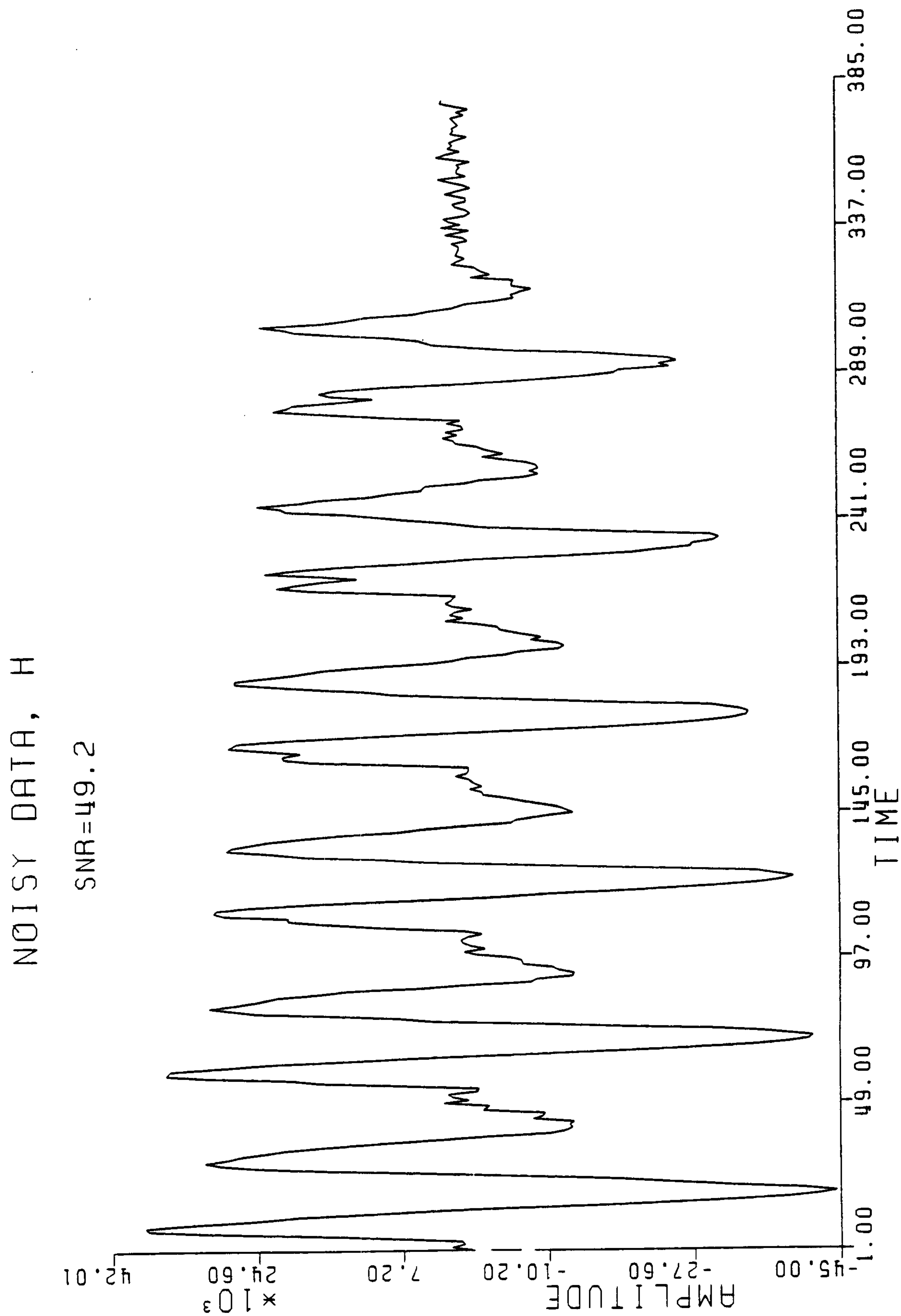

DECONVOLVED RESULT,
SNR=19.68
AMPLITUDE
0.80
0.60
0.40
0.20
0.00
-0.20
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

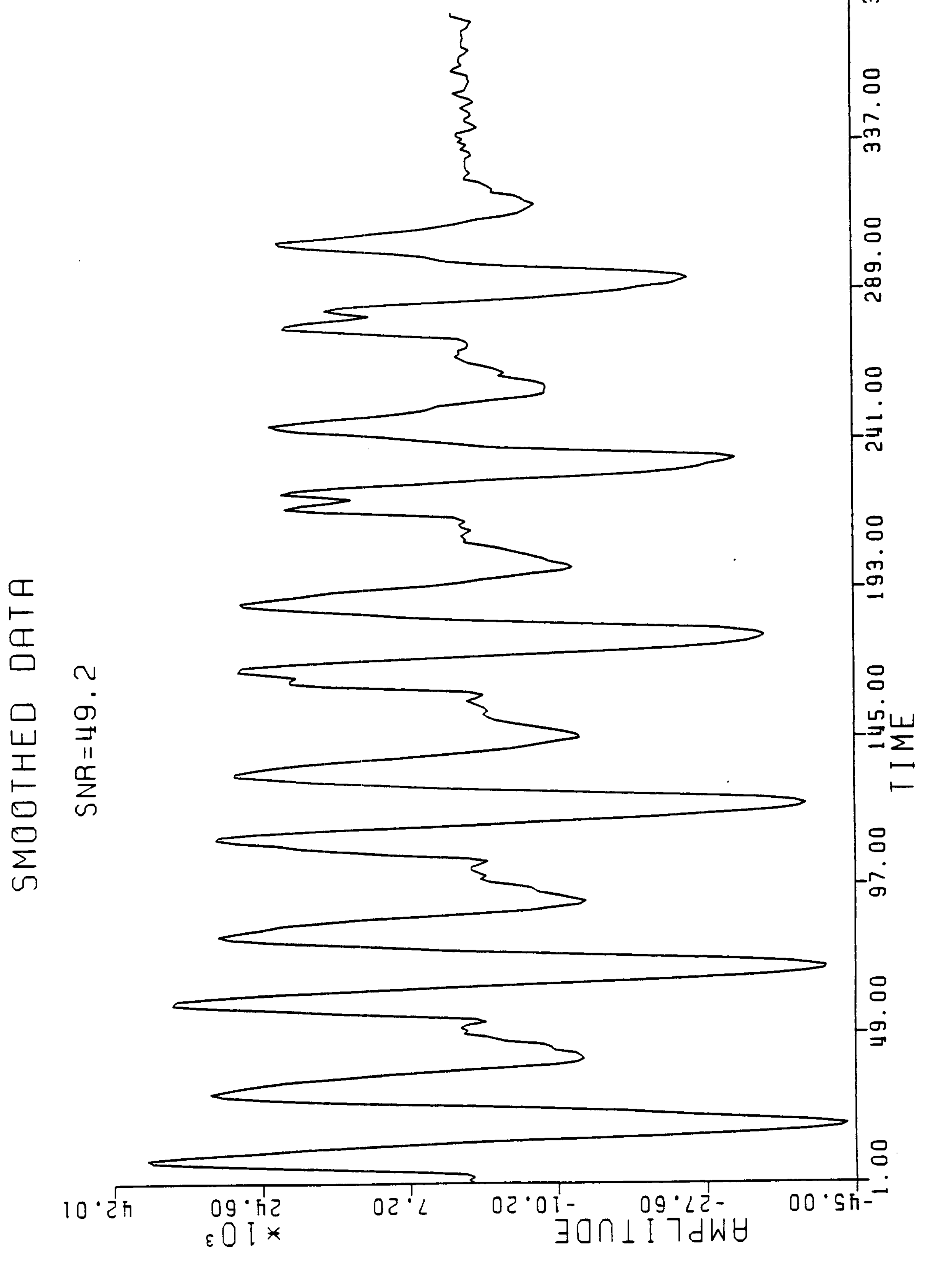

NØISY DATA, H
SNR=29.525
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-45.52
-27.97
-10.41
7.14
24.69
42.24

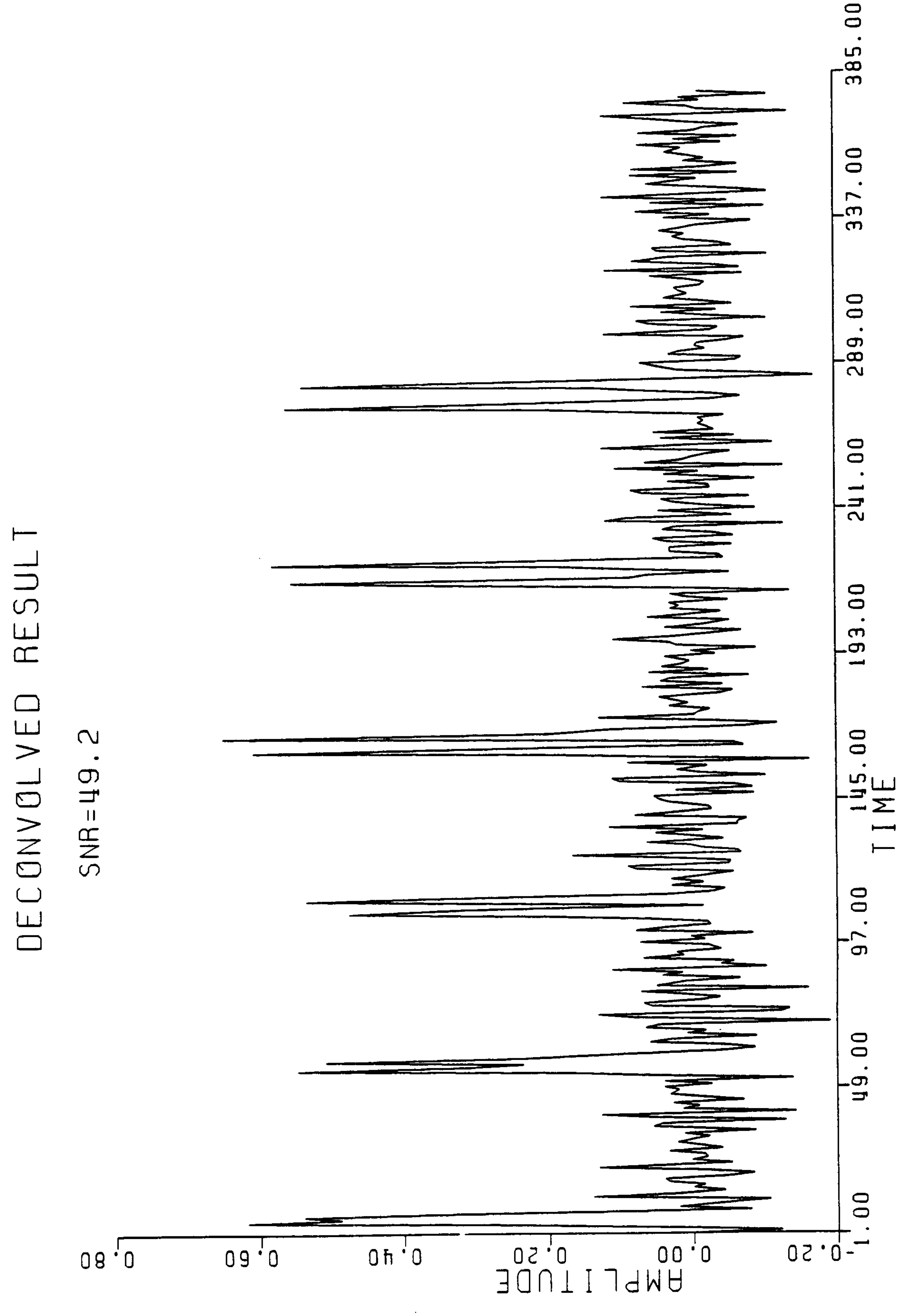

SMOOTHED DATA
SNR=29.525
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
40.82
23.52
6.23
-11.07
-28.36
-45.66

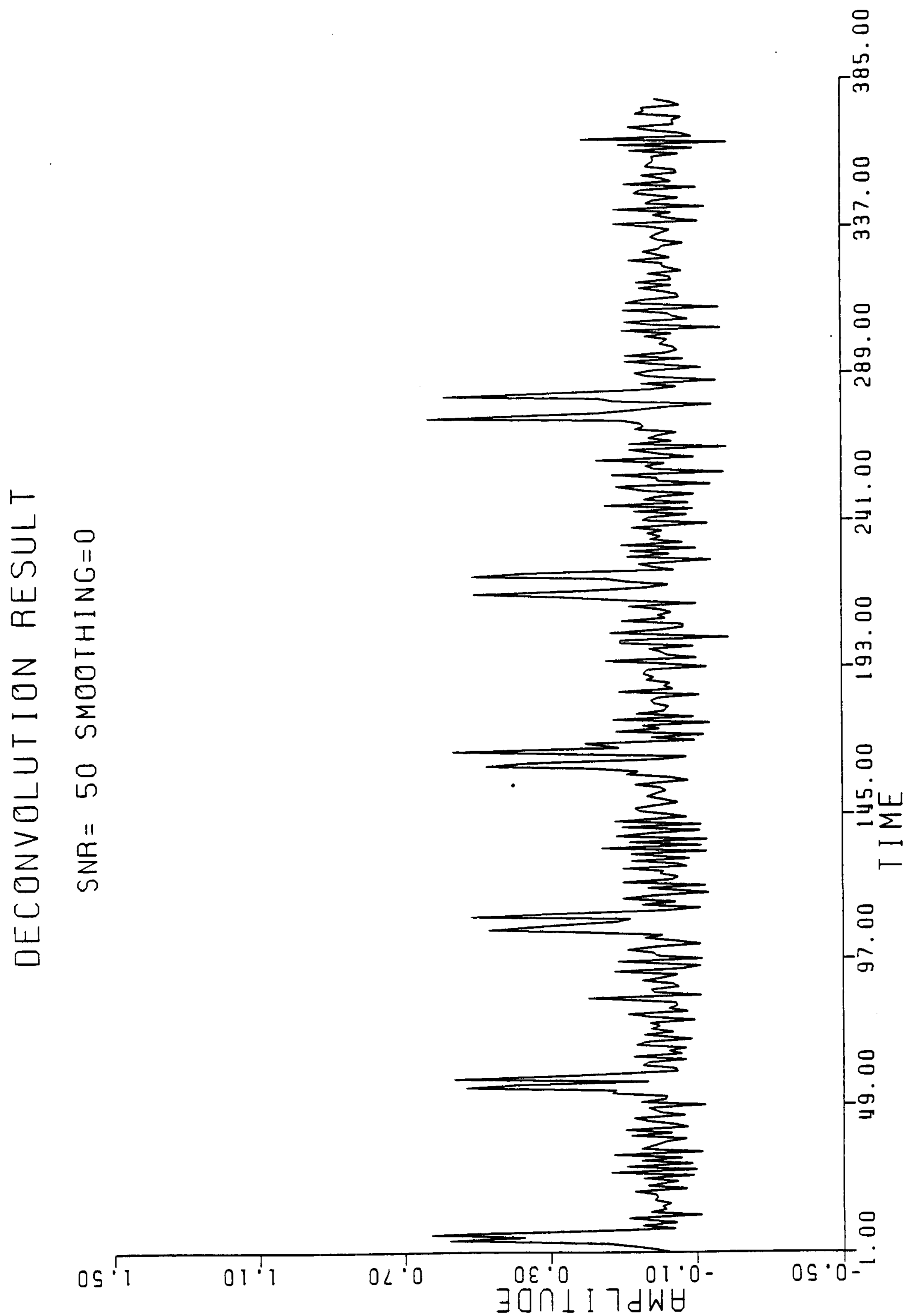

DECONVØLVED RESULT
SNR=29.525
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
-0.20
0.00
0.20
0.40
0.60
0.80

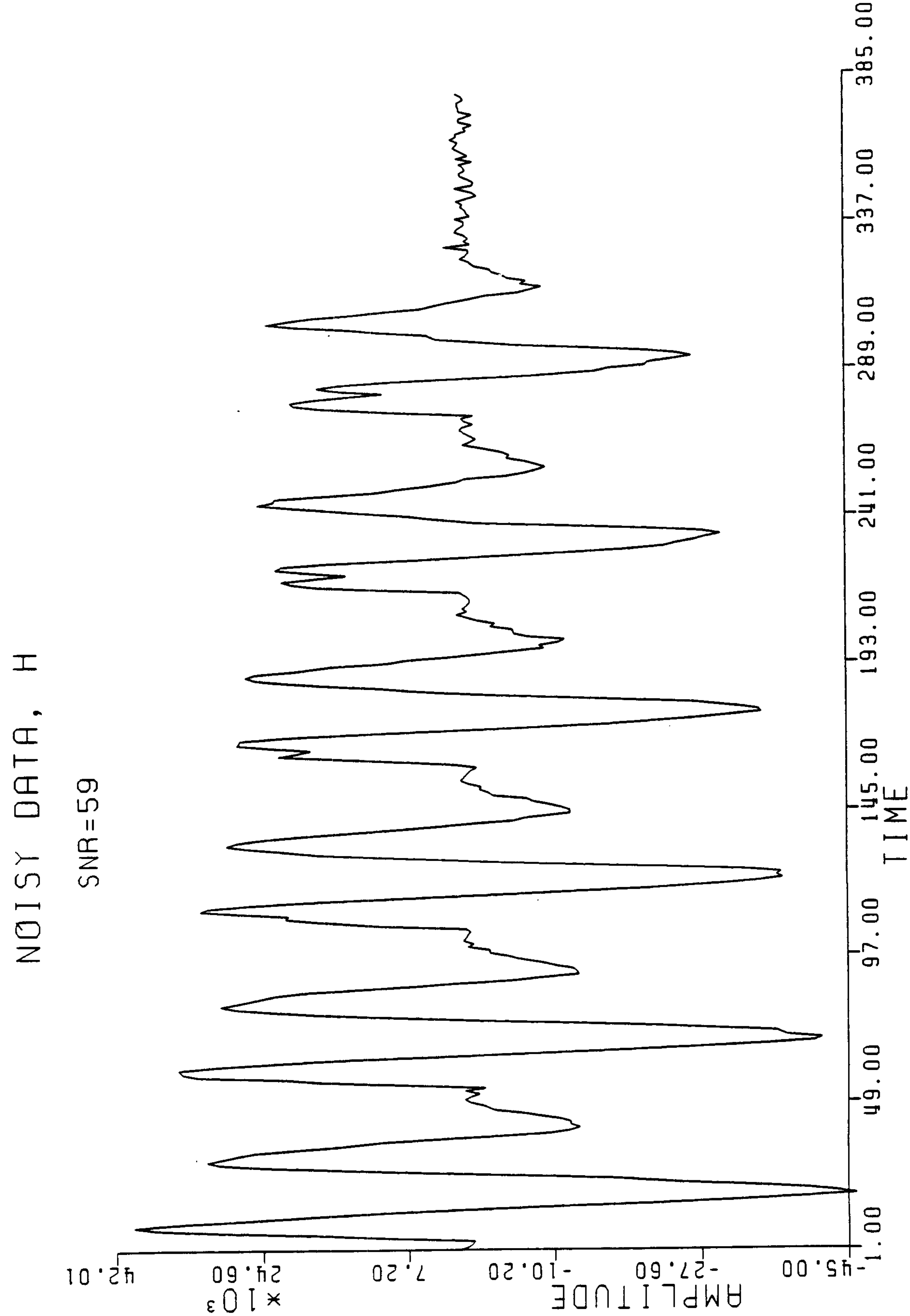

DECONVOLUTION RESULT
SNR= 30 SMOOTHING=0
AMPLITUDE
1.50
1.10
0.70
0.30
-0.10
-0.50
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME

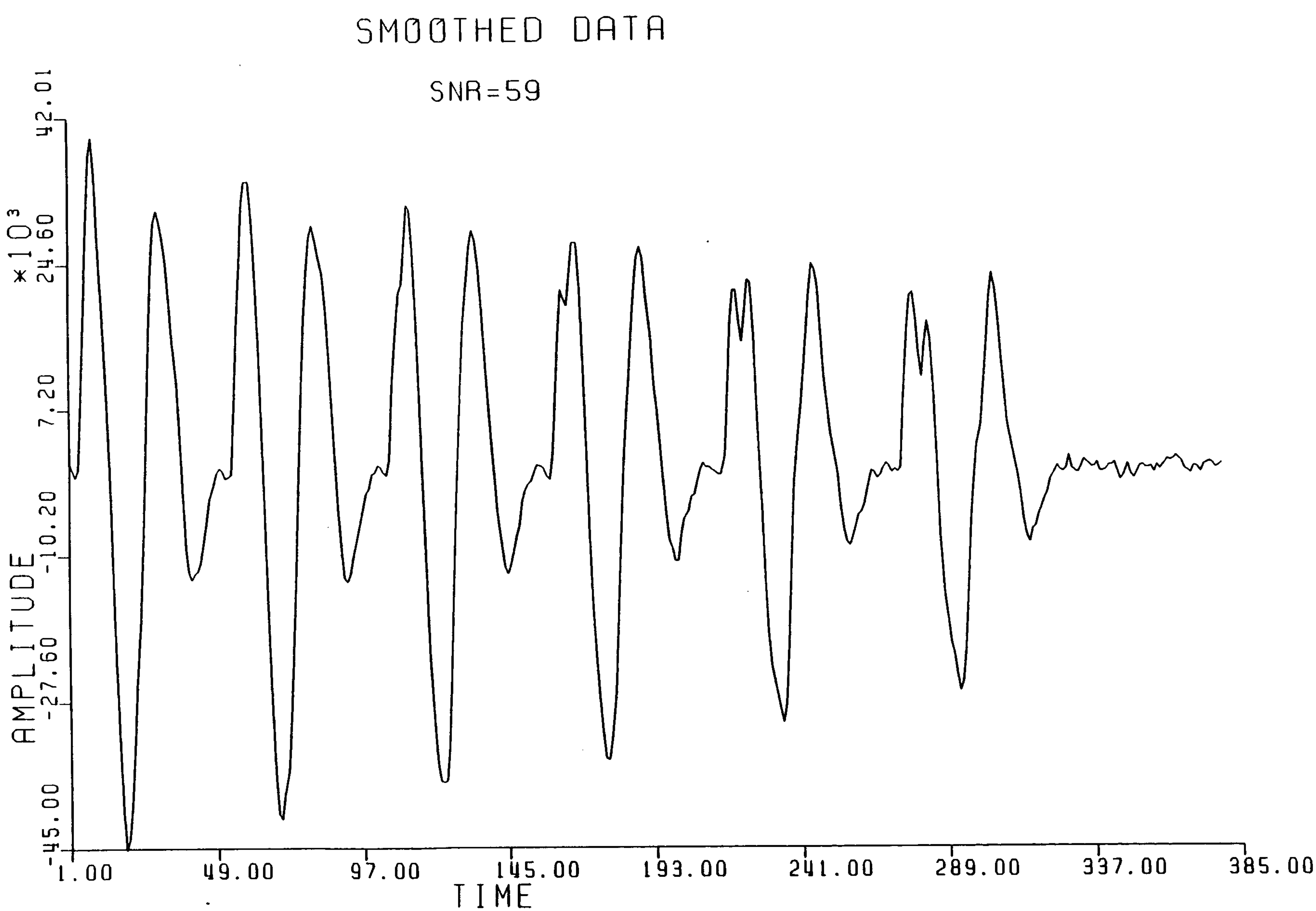

NØISY DATA, H
SNR=49.2
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-45.00
-27.60
-10.20
7.20
24.60
42.01

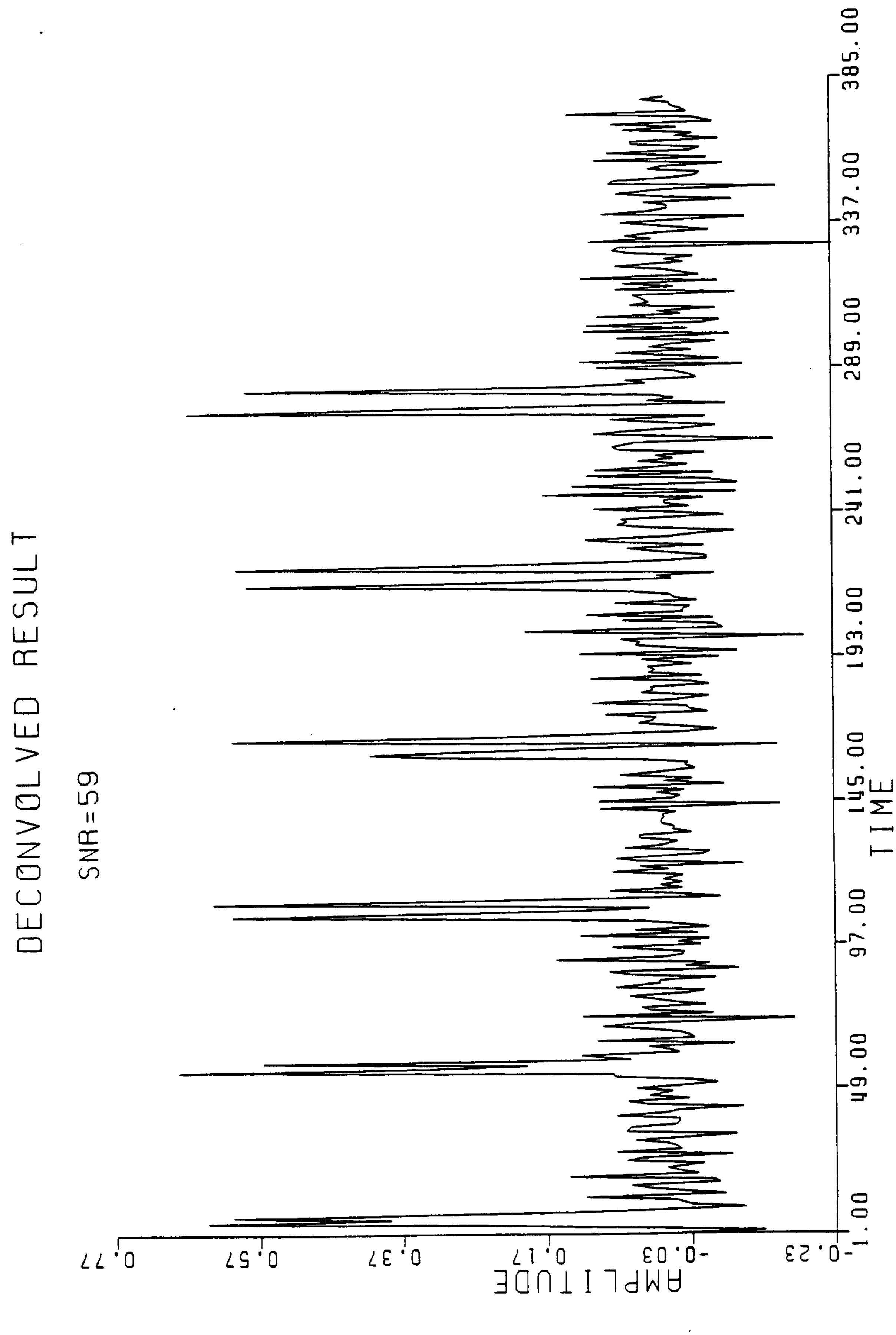

SMOOTHED DATA
SNR=49.2
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-45.00
-27.60
-10.20
7.20
24.60
42.01

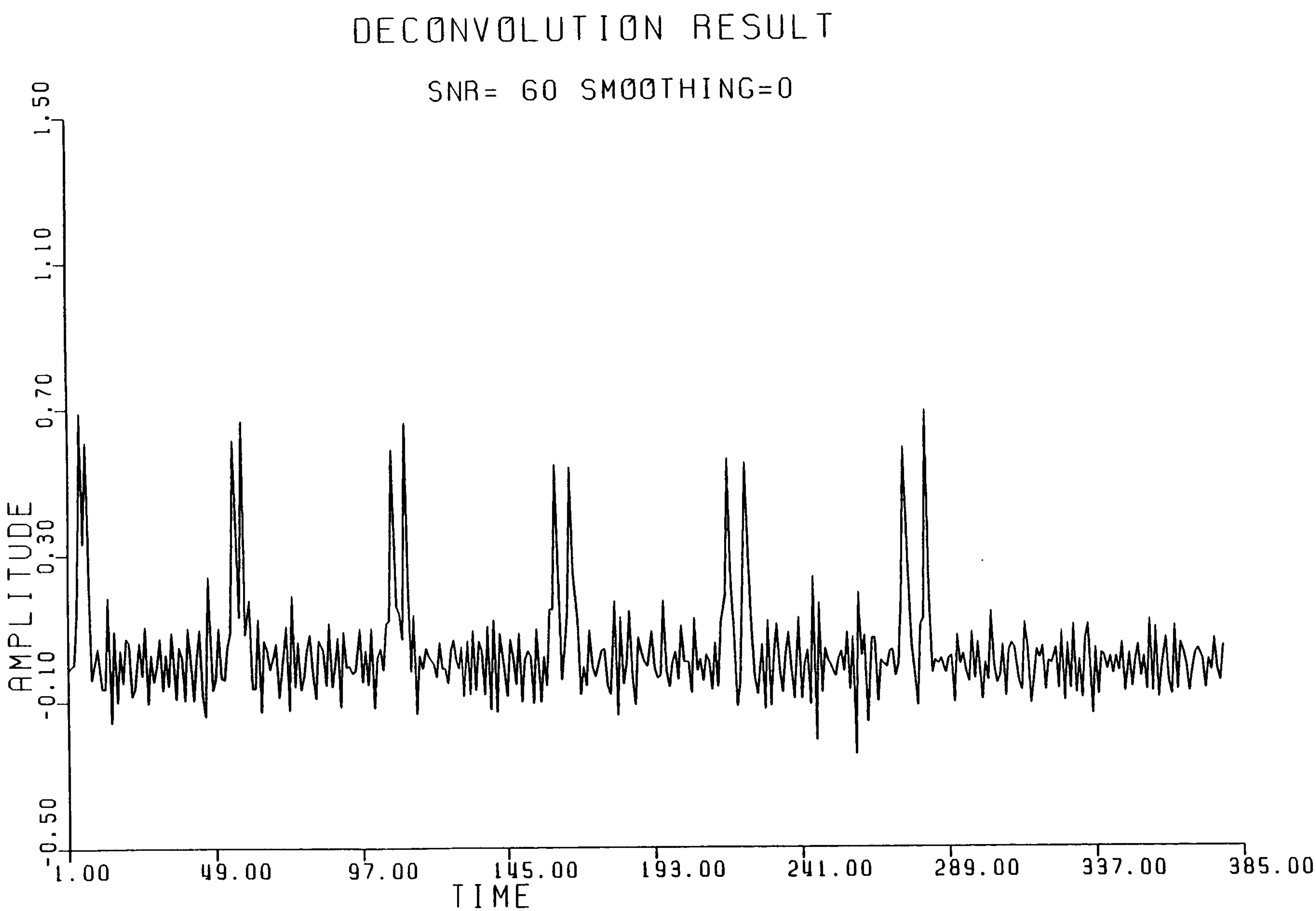

DECONVOLVED RESULT
SNR=49.2
AMPLITUDE
TIME
-0.20
0.00
0.20
0.40
0.60
0.80
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

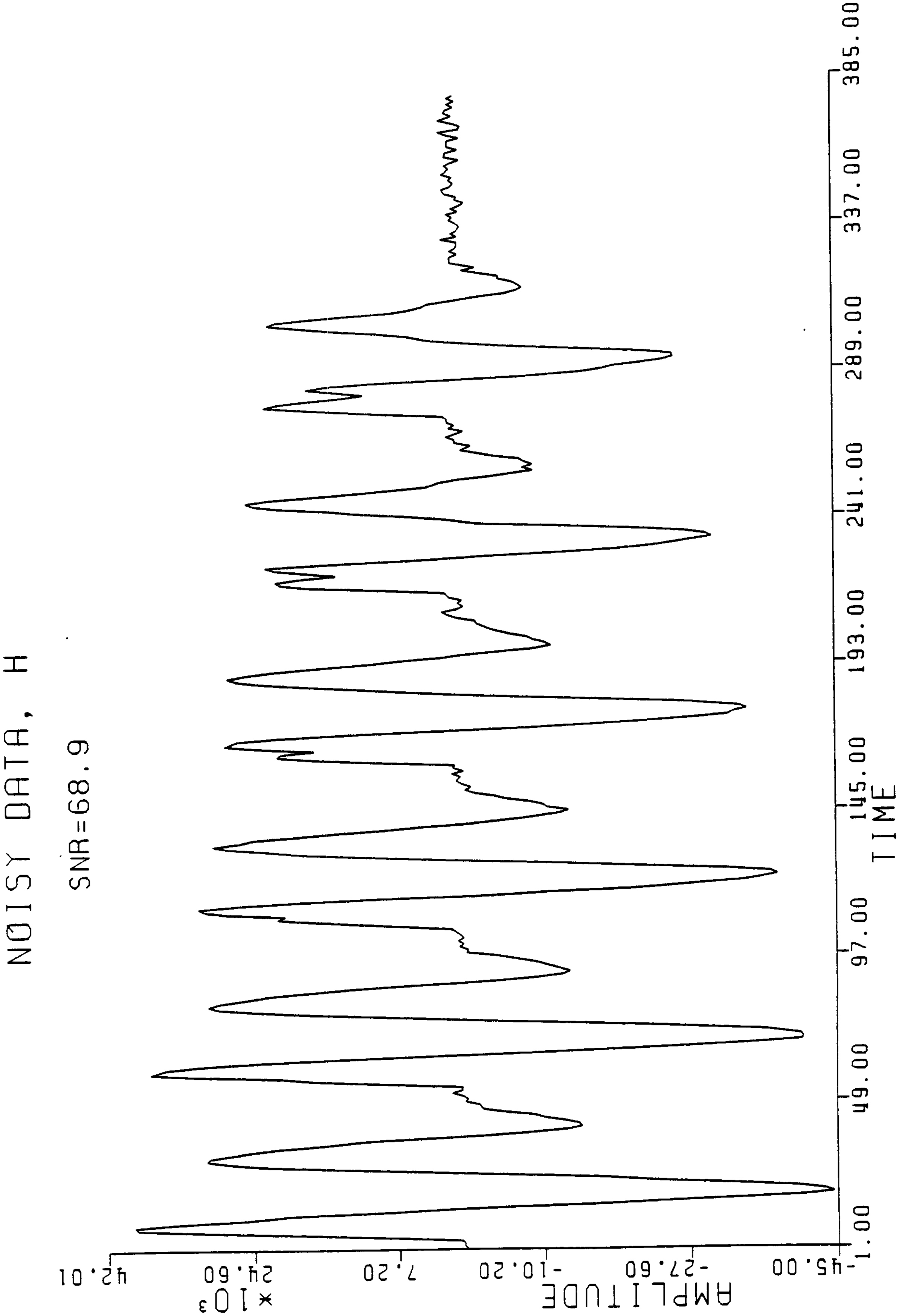

DECONVOLUTION RESULT
SNR= 50 SMOOTHING=0
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
-0.50
-0.10
0.30
0.70
1.10
1.50

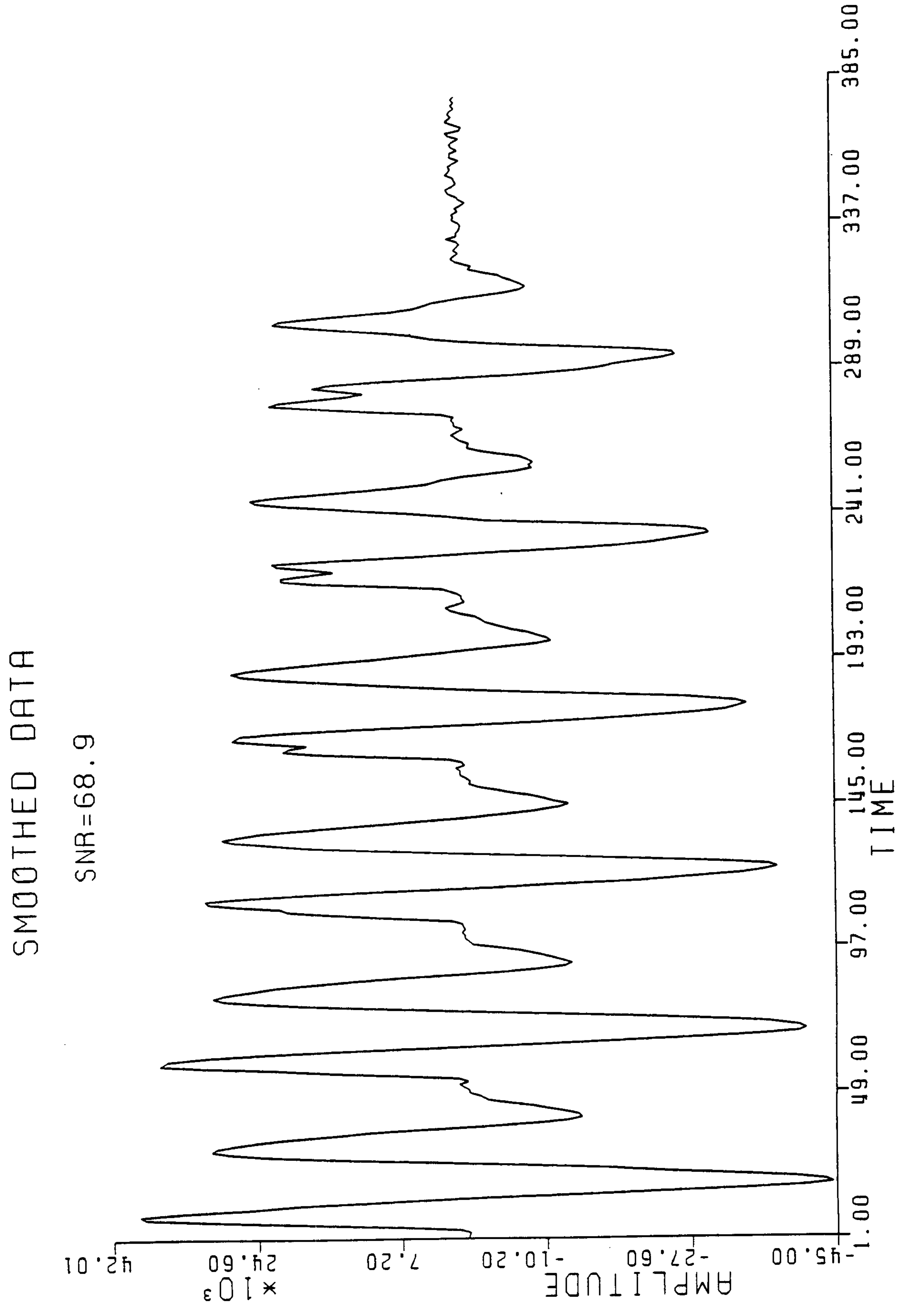

NOISY DATA, H
SNR=59
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-45.00
-27.60
-10.20
7.20
24.60
42.01

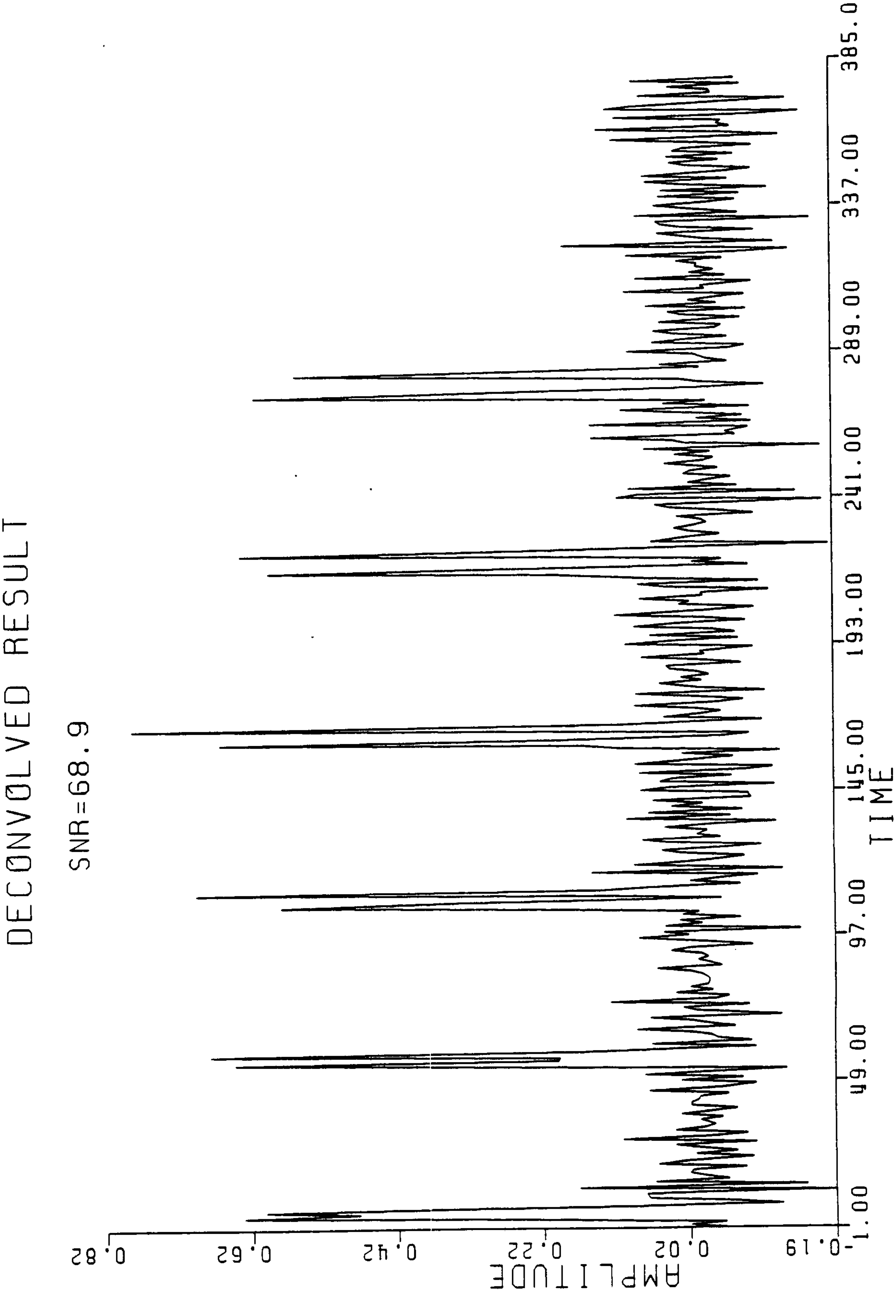

SMOOTHED DATA
SNR=59
AMPLITUDE
*10³
42.01
24.60
7.20
-10.20
-27.60
-45.00
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

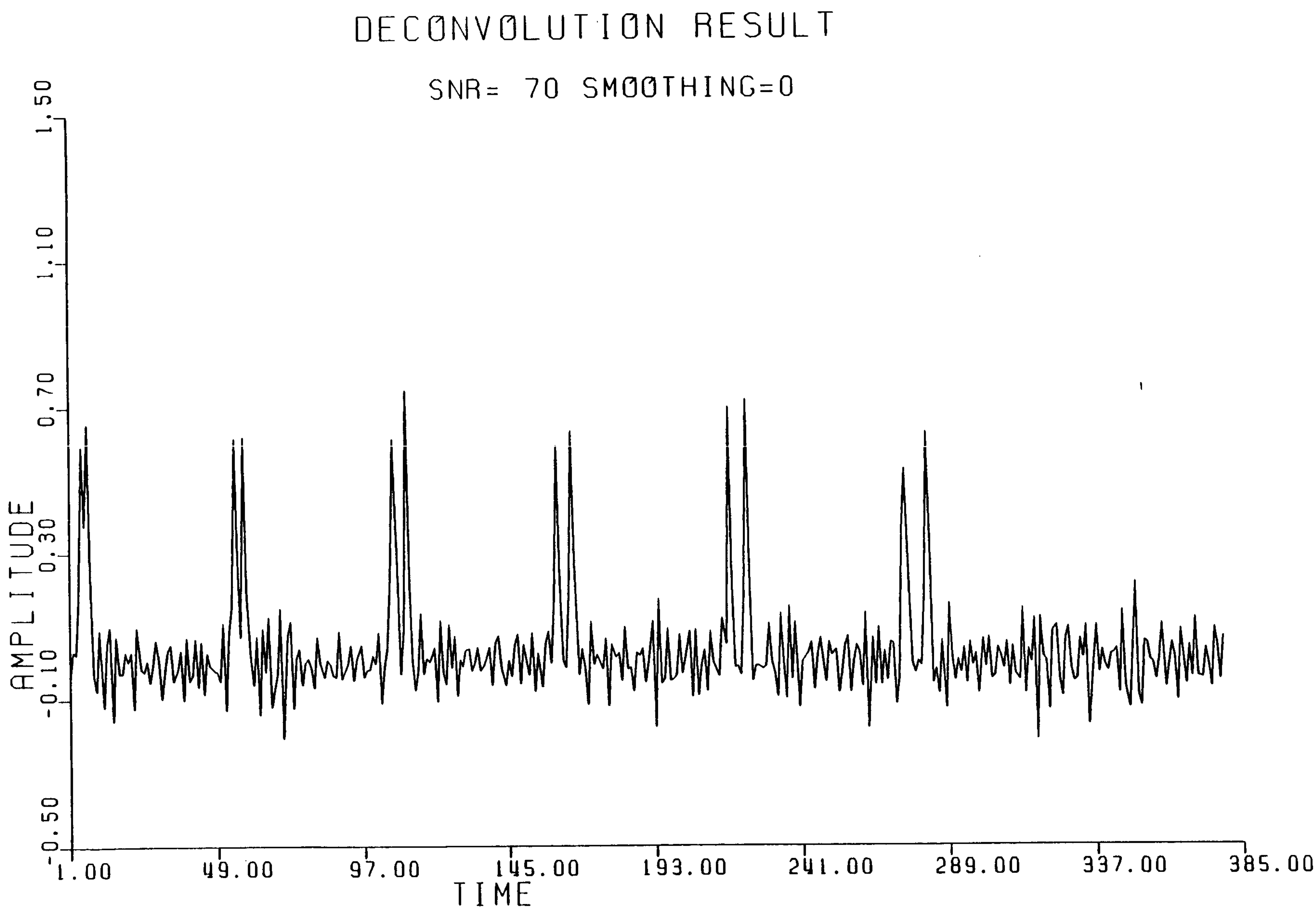

DECONVOLVED RESULT
SNR=59
TIME
AMPLITUDE
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
-0.23
-0.03
0.17
0.37
0.57
0.77

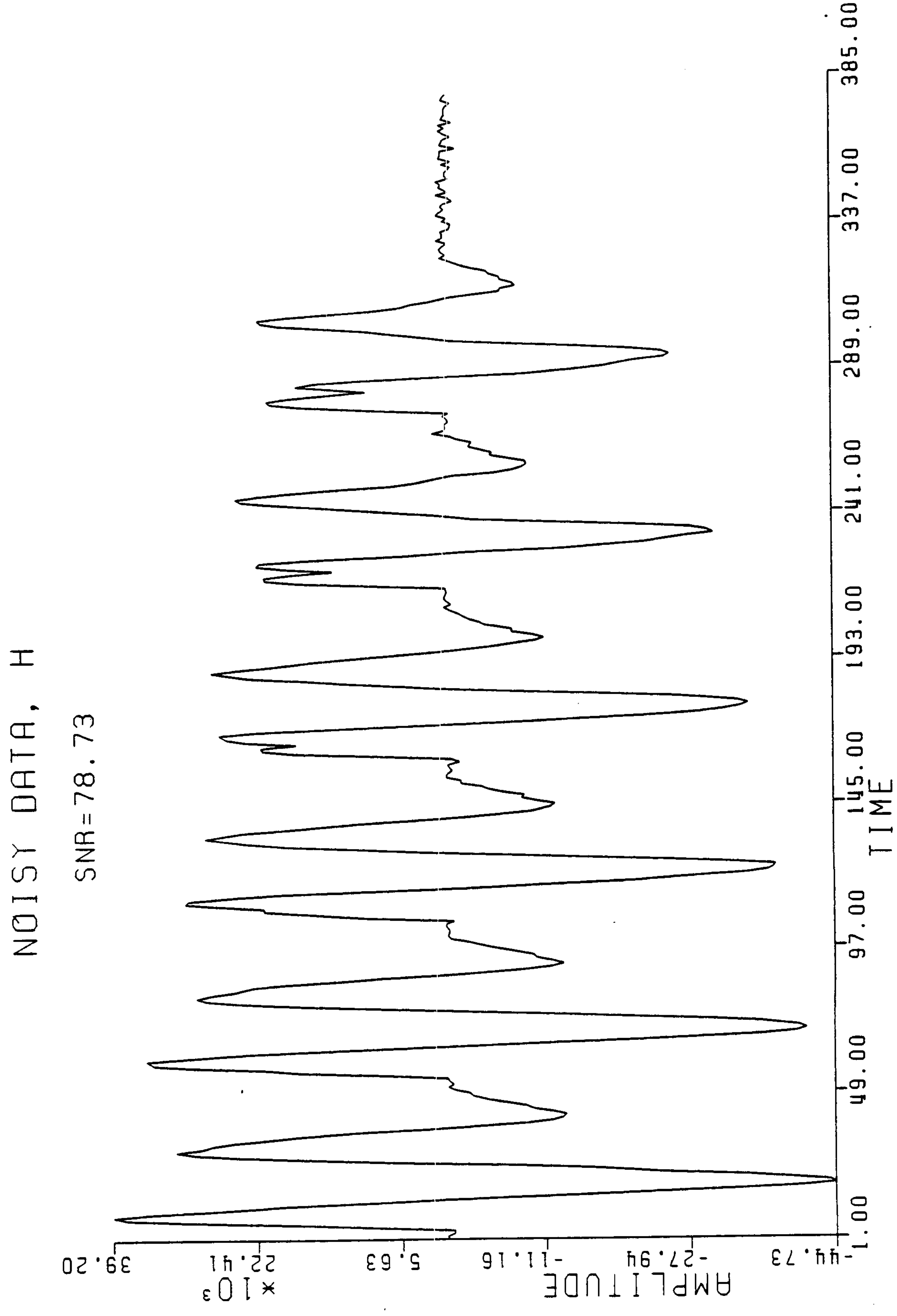

DECONVOLUTION RESULT
SNR= 60 SMOOTHING=0
AMPLITUDE
1.50
1.10
0.70
0.30
-0.10
-0.50
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME

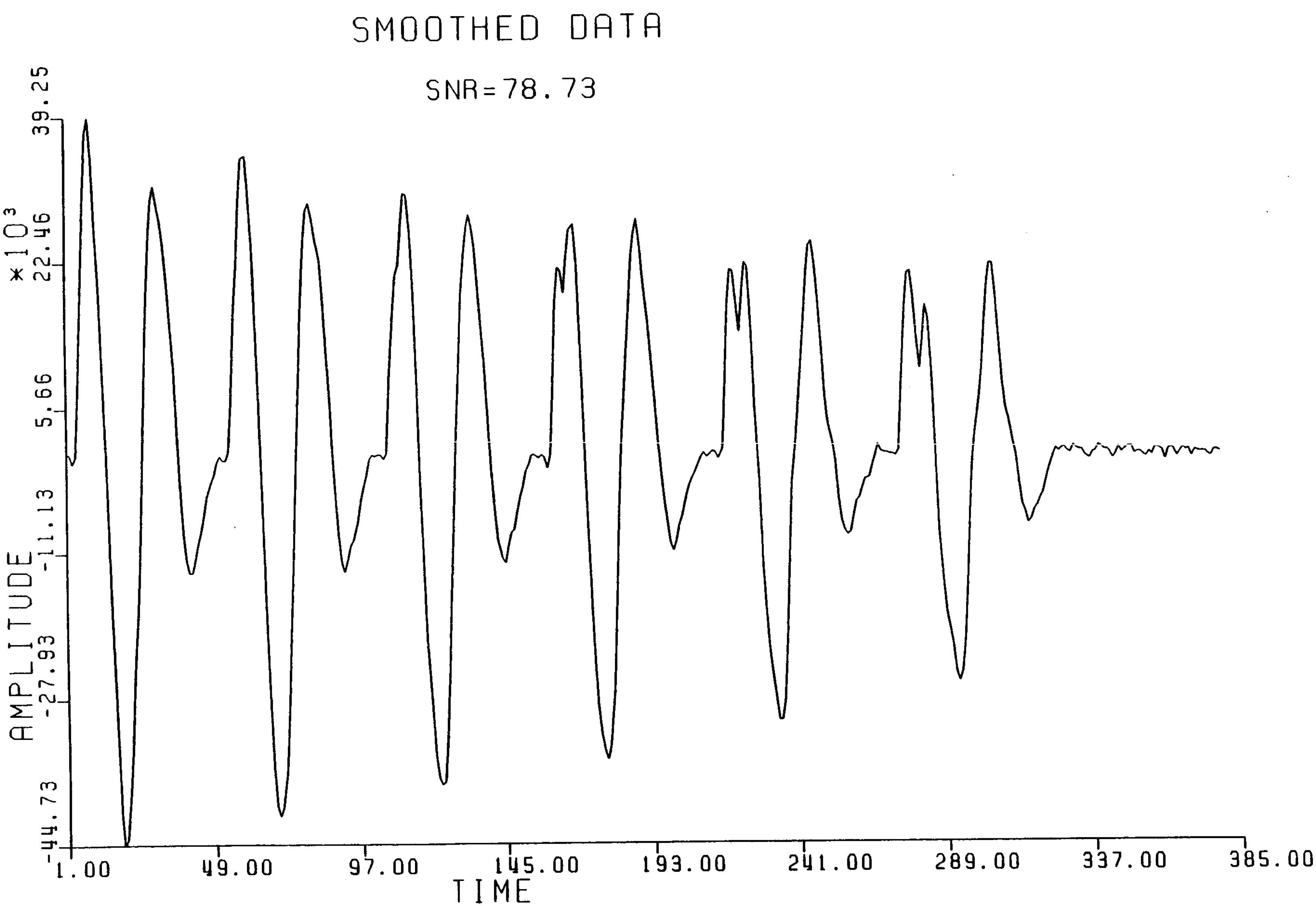

NOISY DATA, H
SNR=68.9
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
*10³
-45.00
-27.60
-10.20
7.20
24.60
42.01


SMOOTHED DATA
SNR=68.9
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
*10³
-45.00
-27.60
-10.20
7.20
24.60
42.01

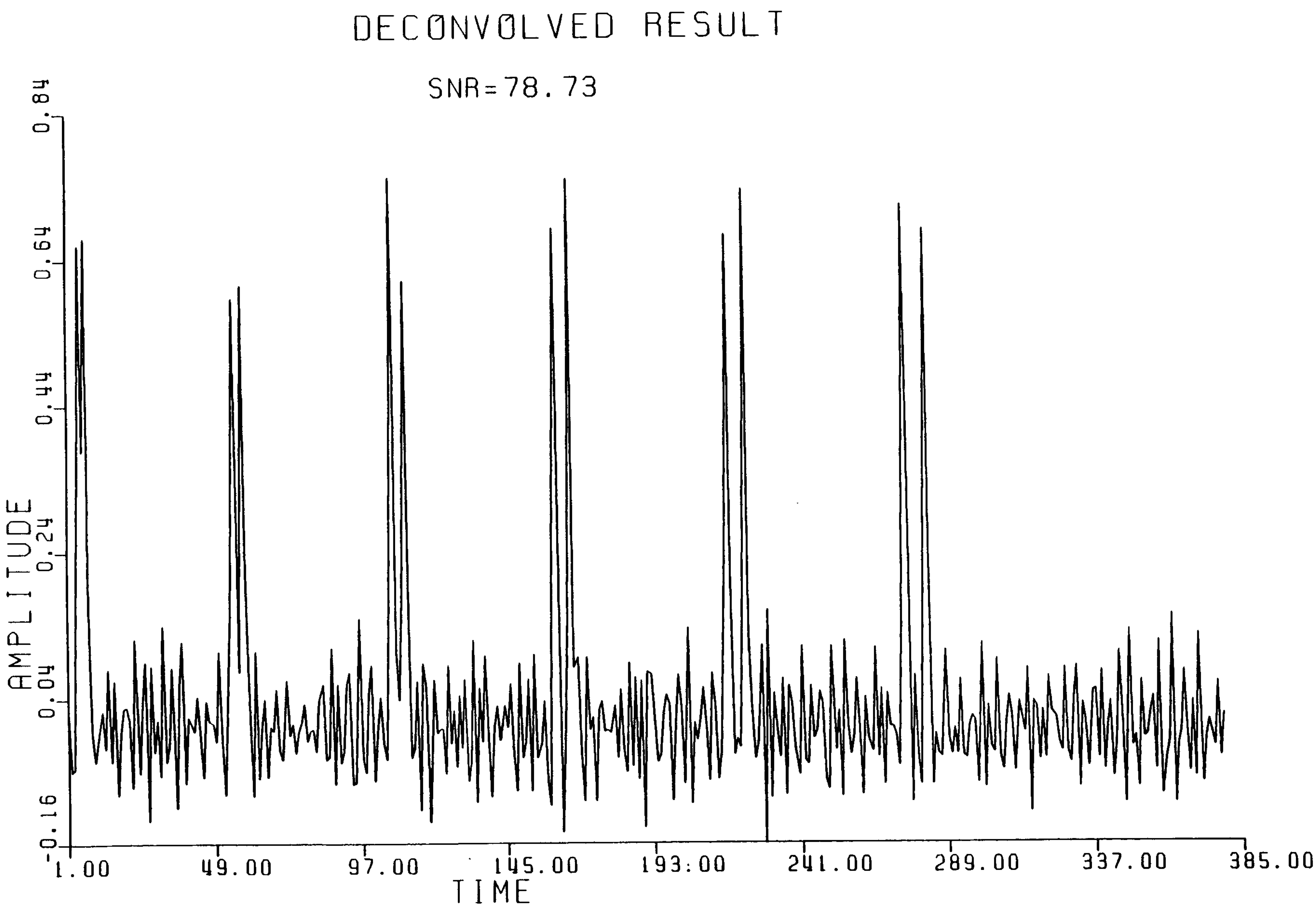

DECONVØLVED RESULT
SNR=68.9
TIME
AMPLITUDE
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
-0.19
0.02
0.22
0.42
0.62
0.82


DECONVOLUTION RESULT
SNR= 70 SMOOTHING=0
AMPLITUDE
1.50
1.10
0.70
0.30
-0.10
-0.50
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME


NØISY DATA, H
SNR=78.73
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-44.73
-27.94
-11.16
5.63
22.41
39.20

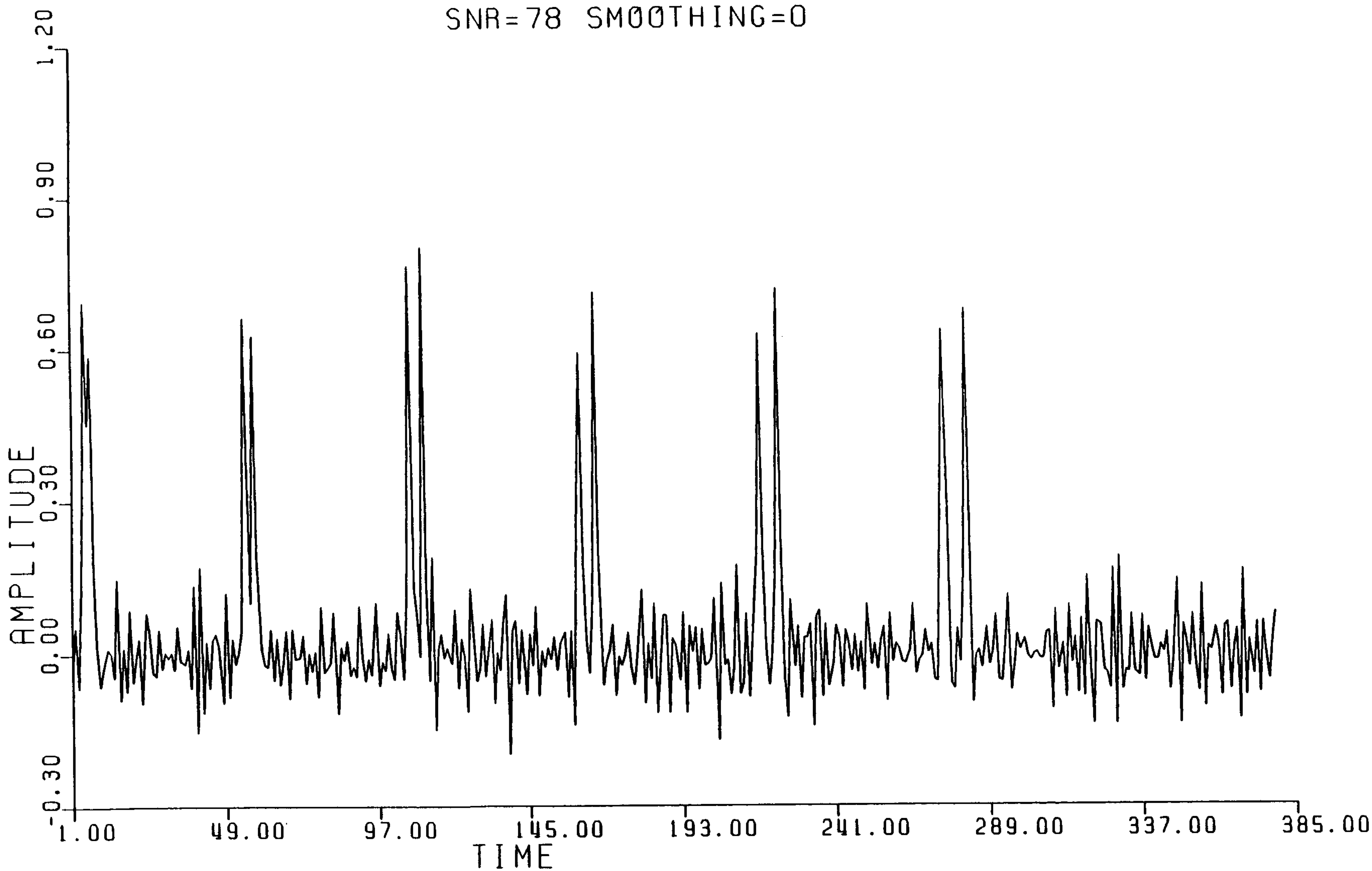


SMOOTHED DATA
SNR=78.73
AMPLITUDE
*10³
39.25
22.46
5.66
-11.13
-27.93
-44.73
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00


DECONVOLVED RESULT
SNR=78.73
AMPLITUDE
0.84
0.64
0.44
0.24
0.04
-0.16
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

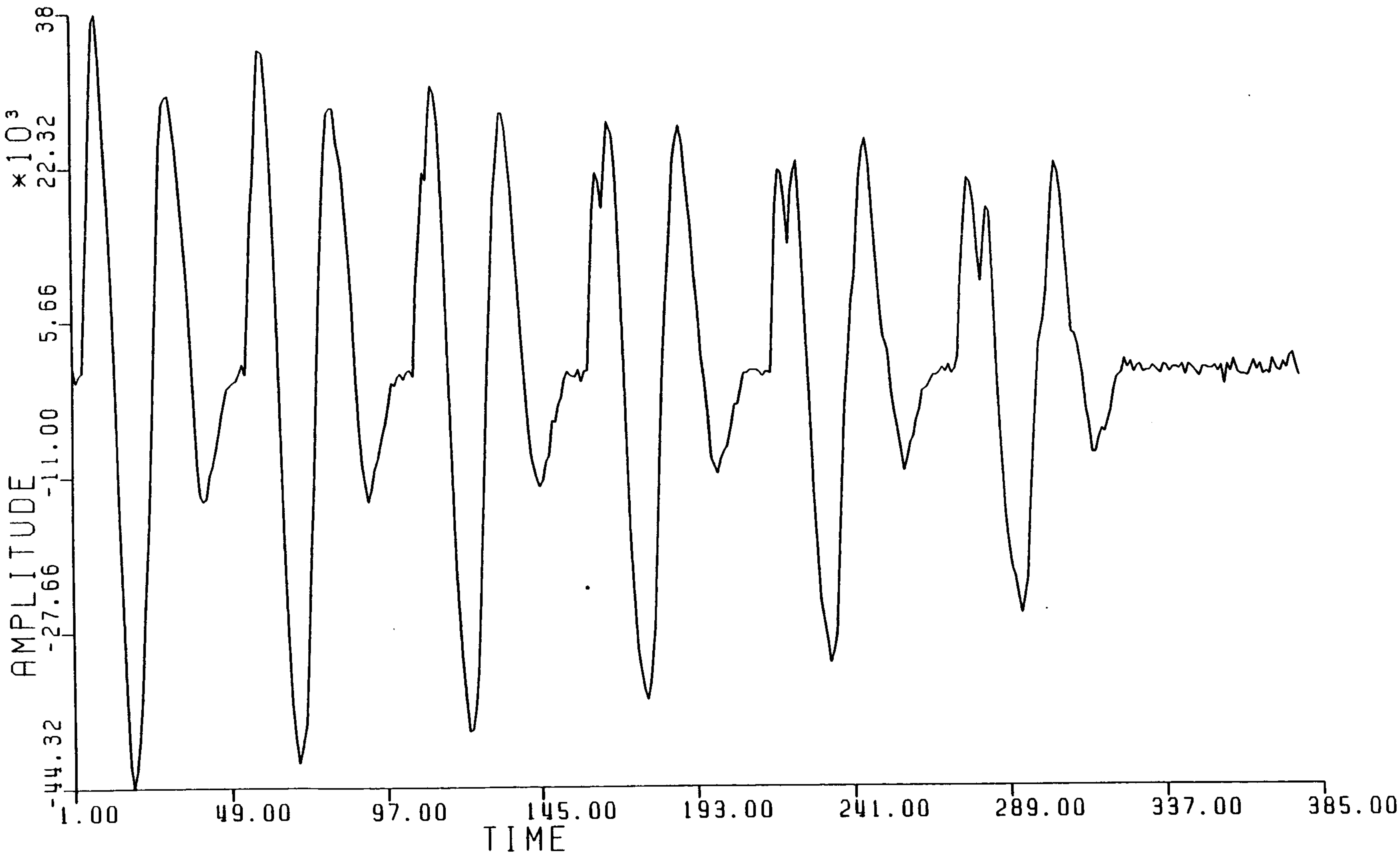
DECONVOLUTION RESULT

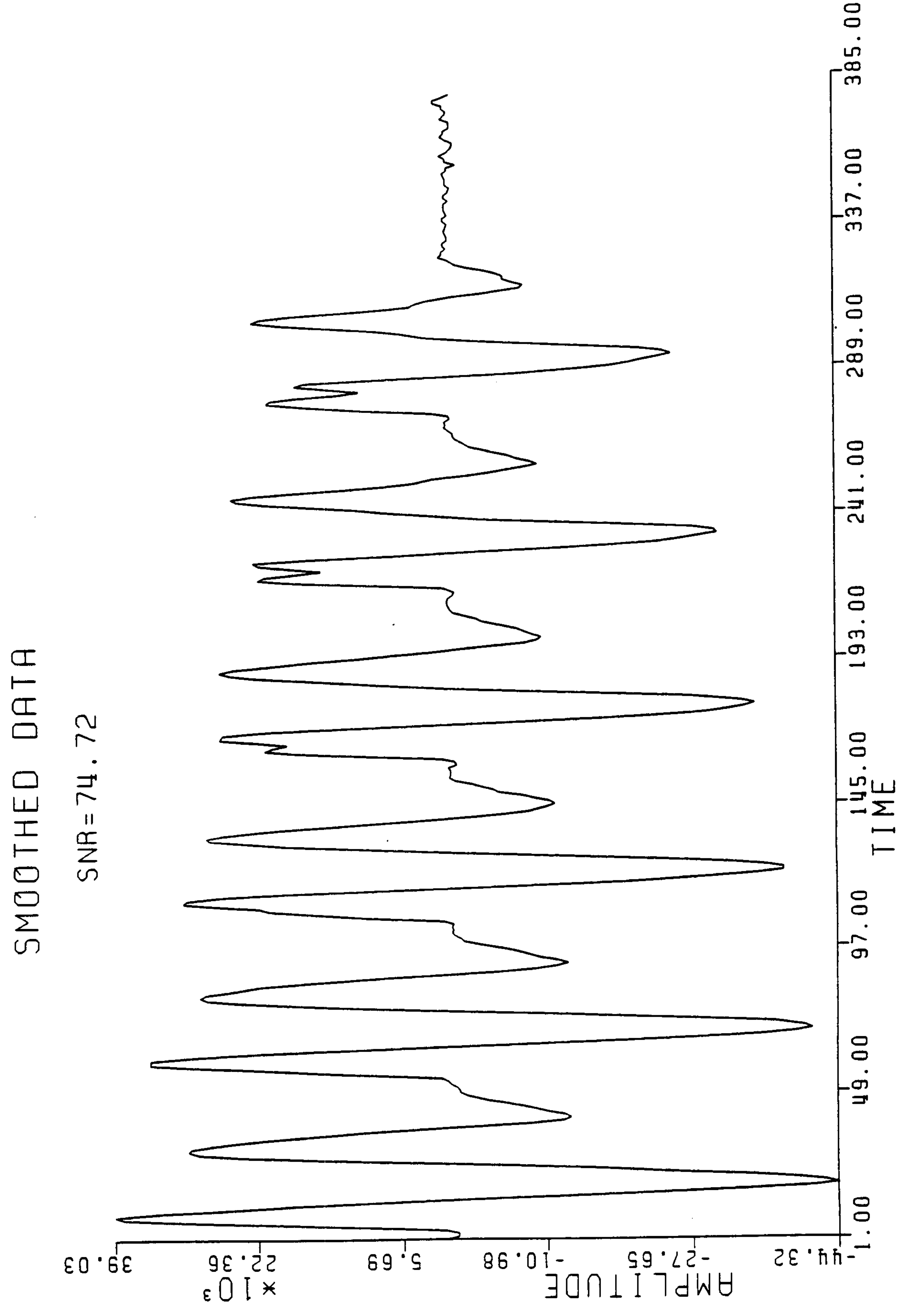
SNR=78 SMOOTHING=0

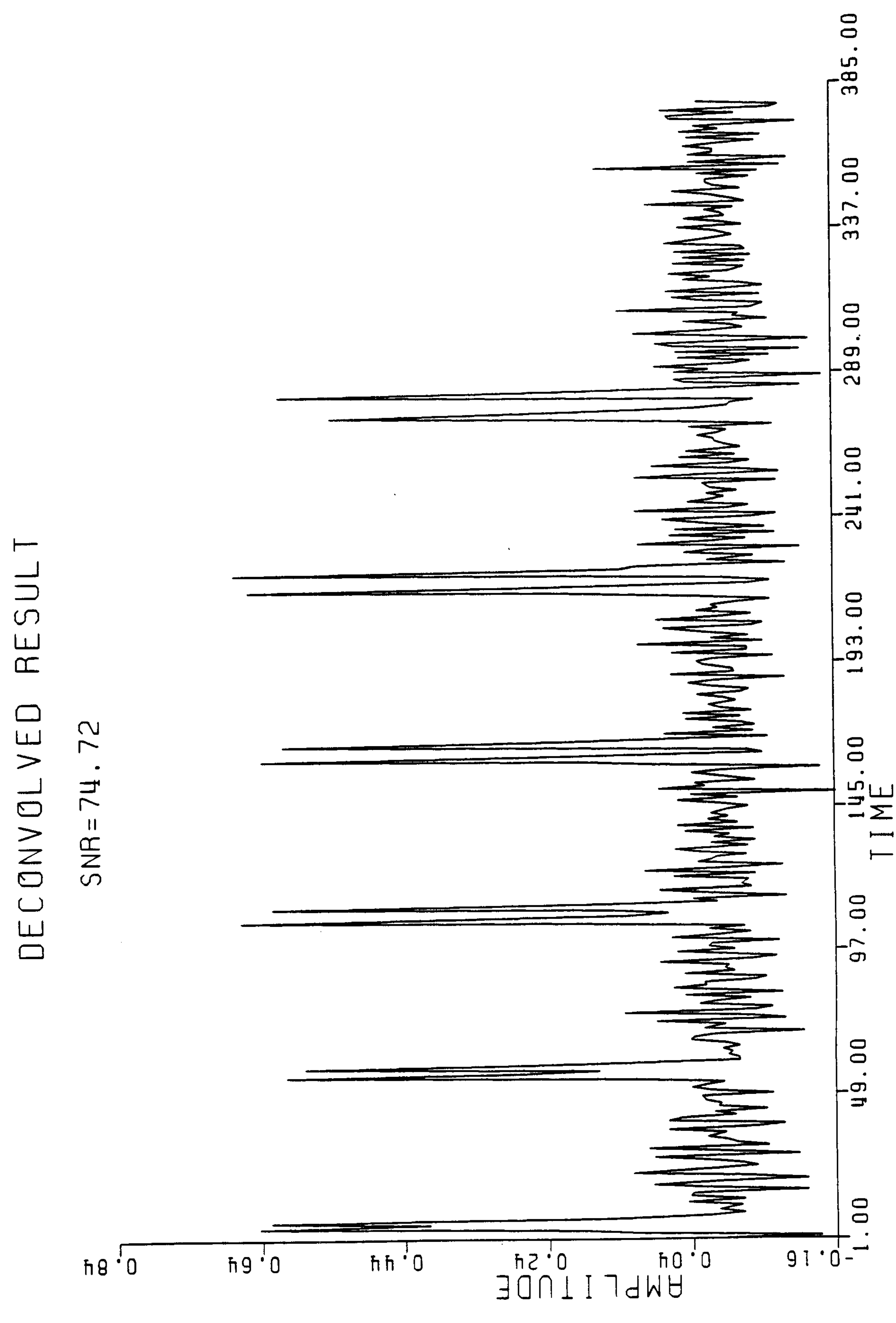


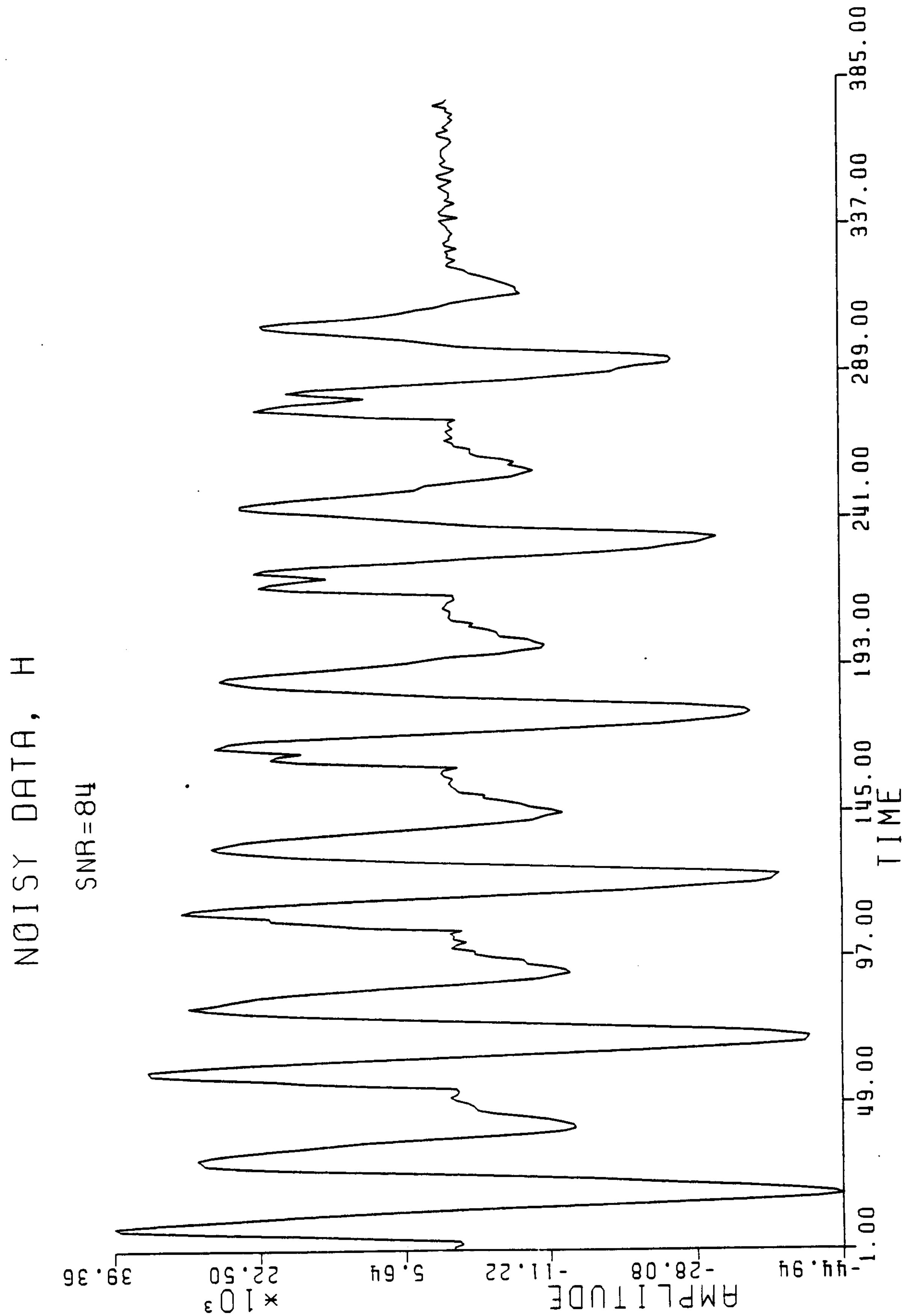
NØISY DATA, H

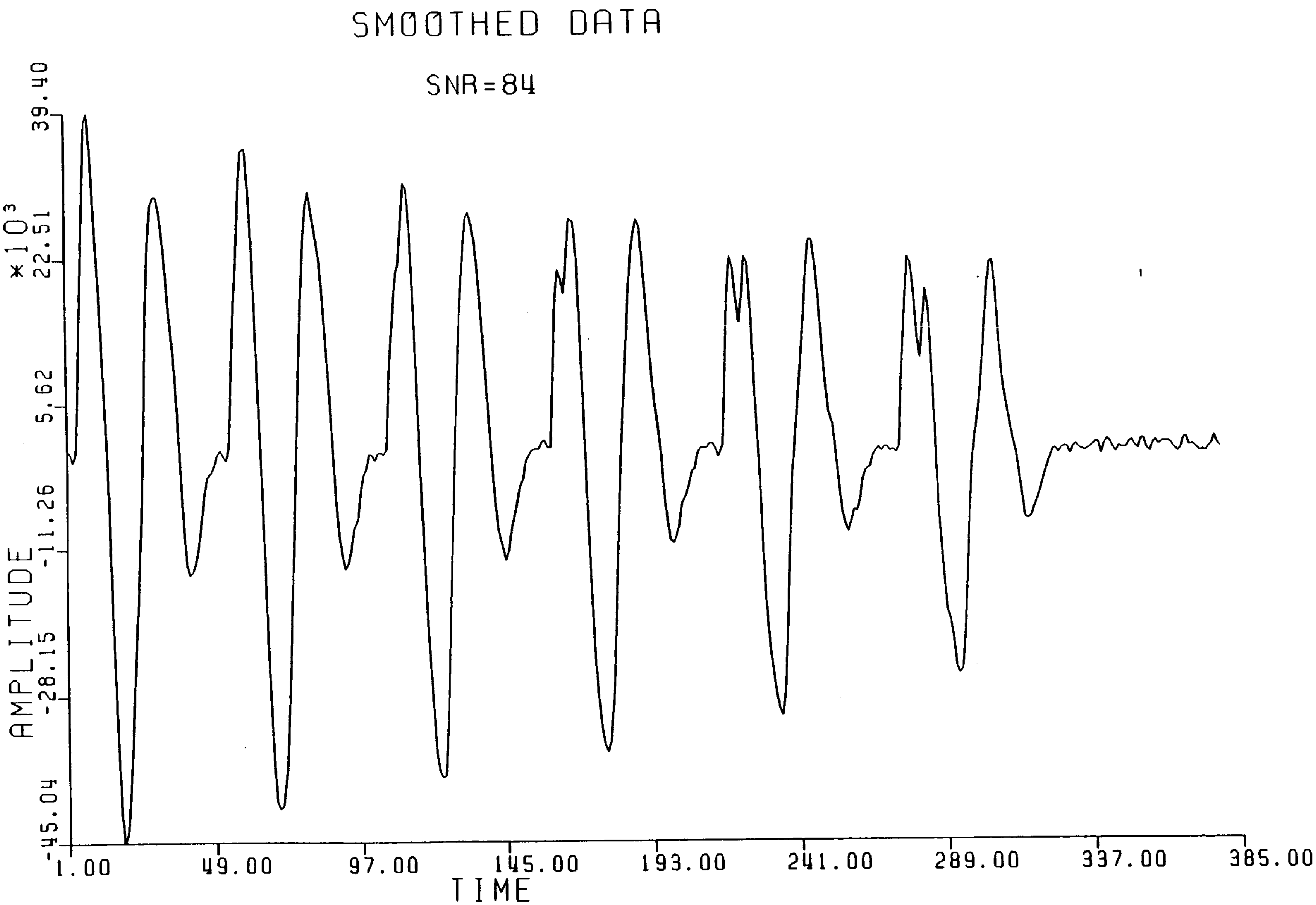
SNR=74.72

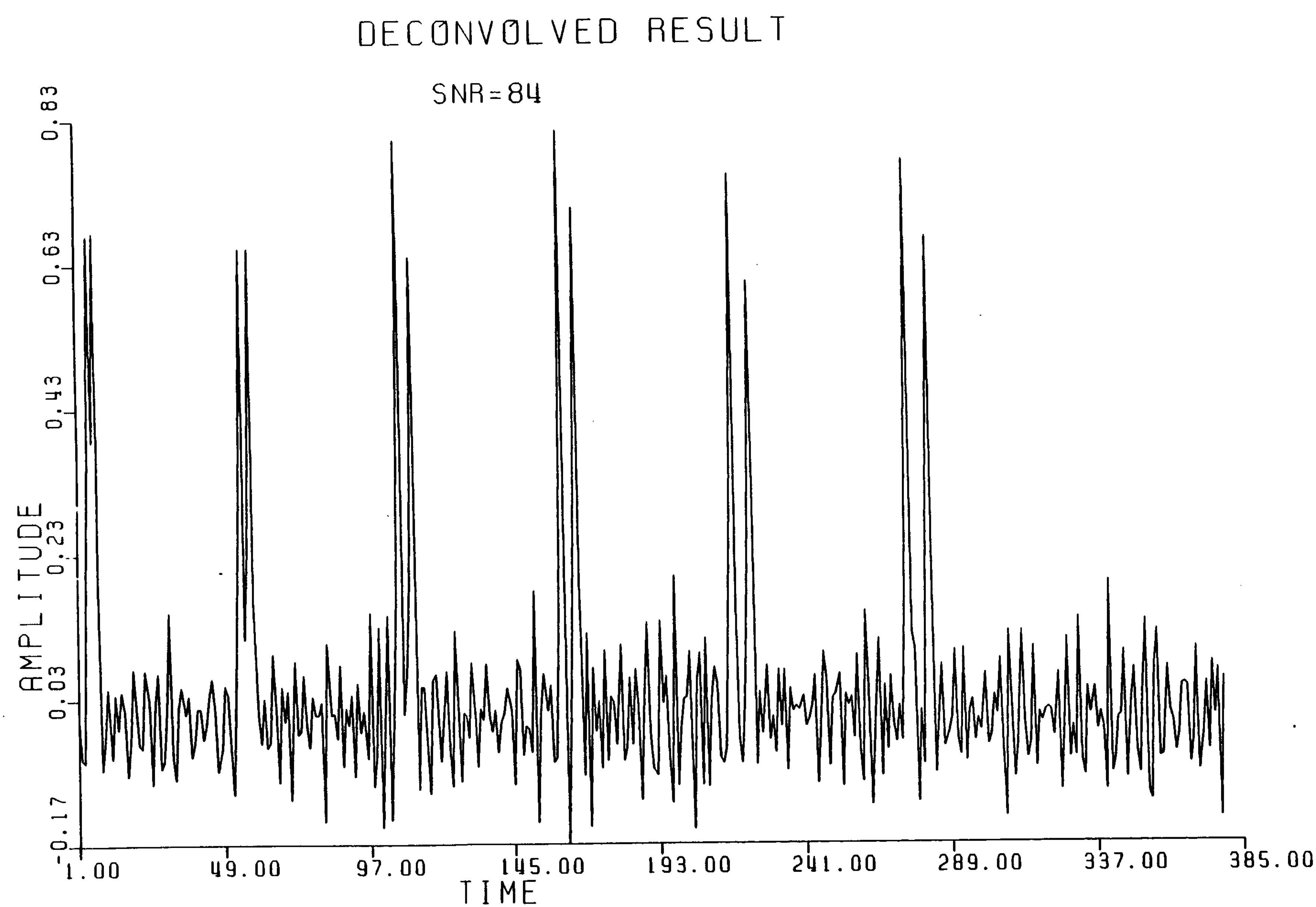


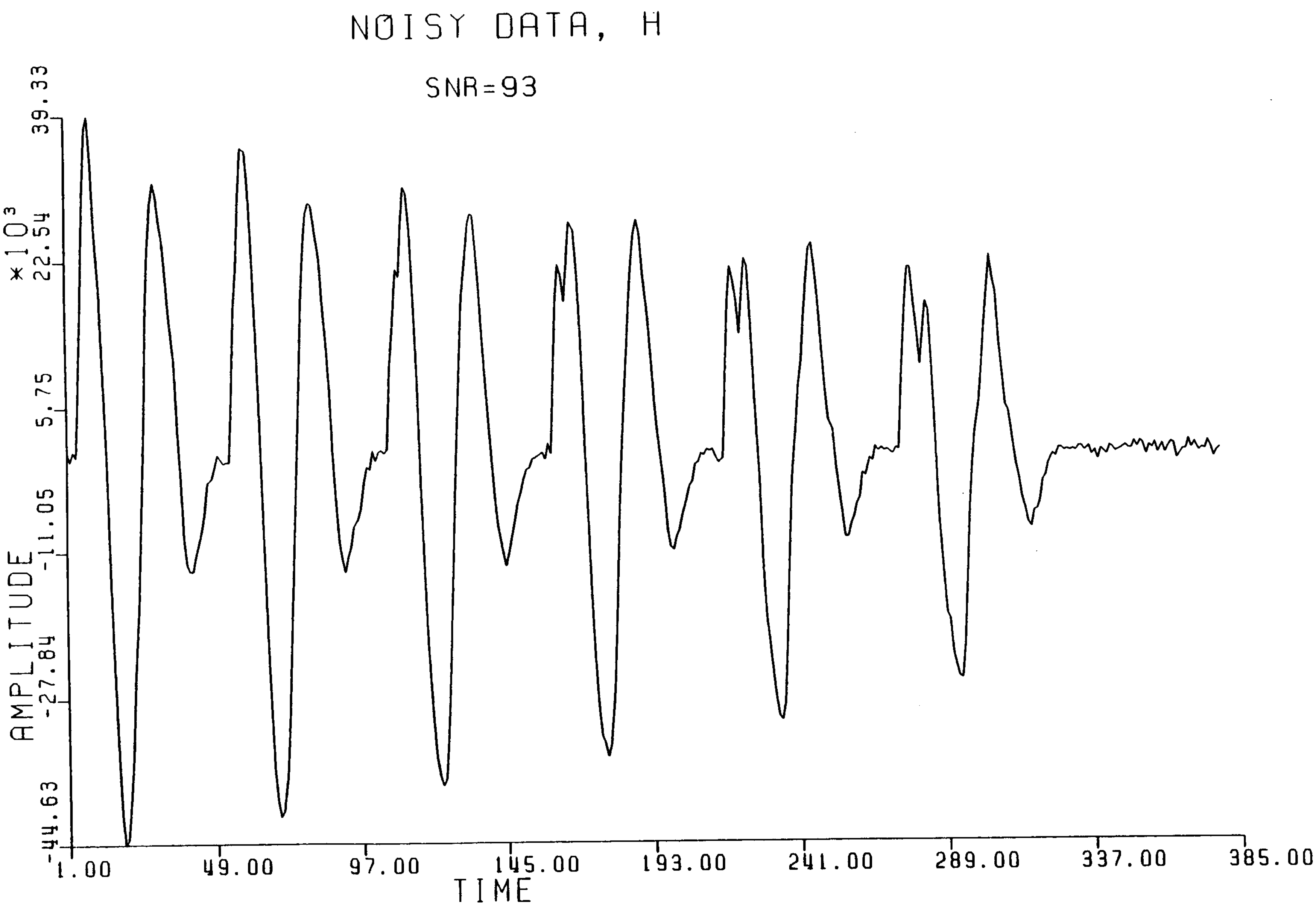

SMOOTHED DATA
SNR=74.72
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-44.32
-27.65
-10.98
5.69
22.36
39.03

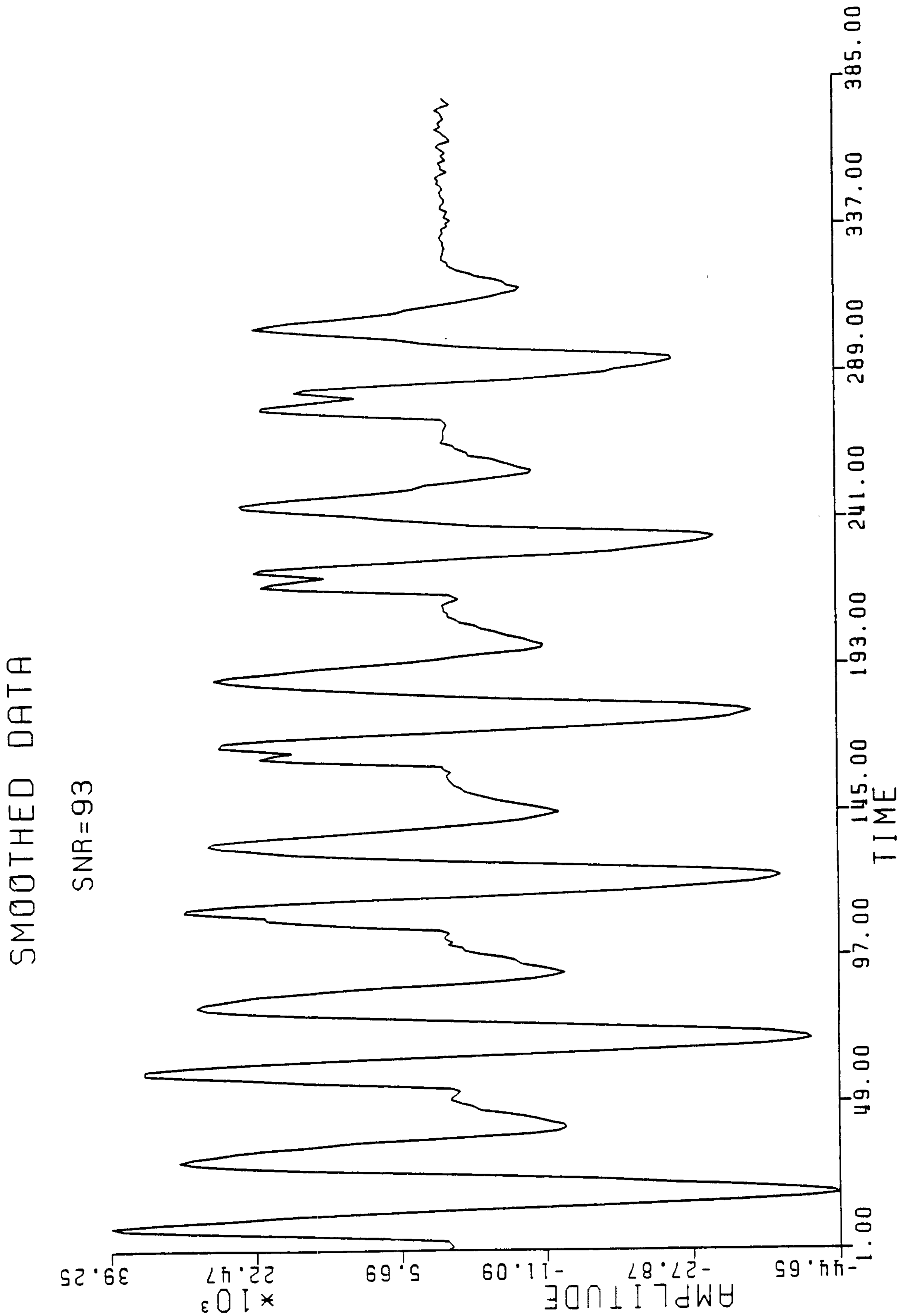

DECONVOLVED RESULT
SNR=74.72
AMPLITUDE
-0.16
0.04
0.24
0.44
0.64
0.84
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

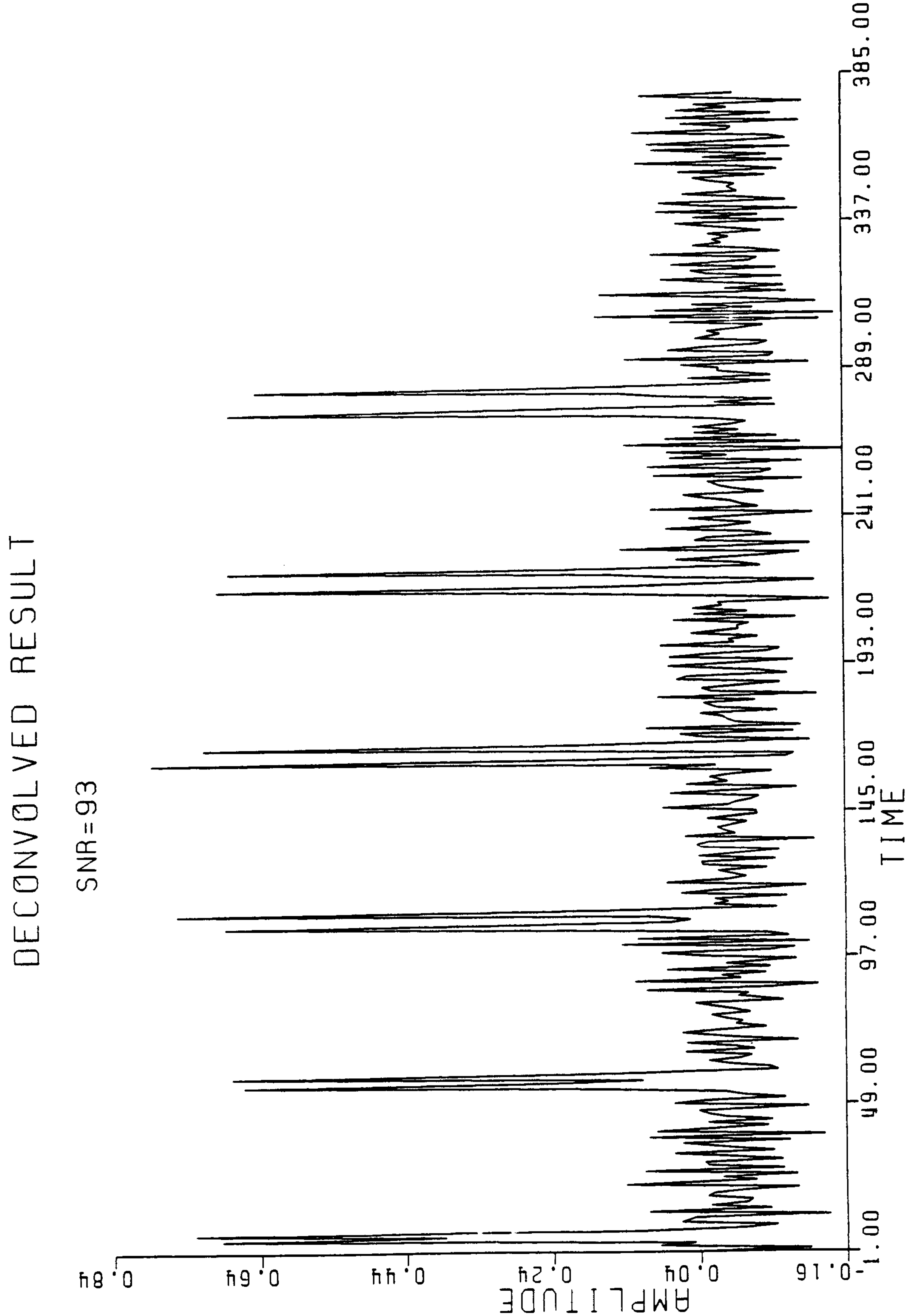

NOISY DATA, H
SNR=84
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
×10³
-44.94
-28.08
-11.22
5.64
22.50
39.36

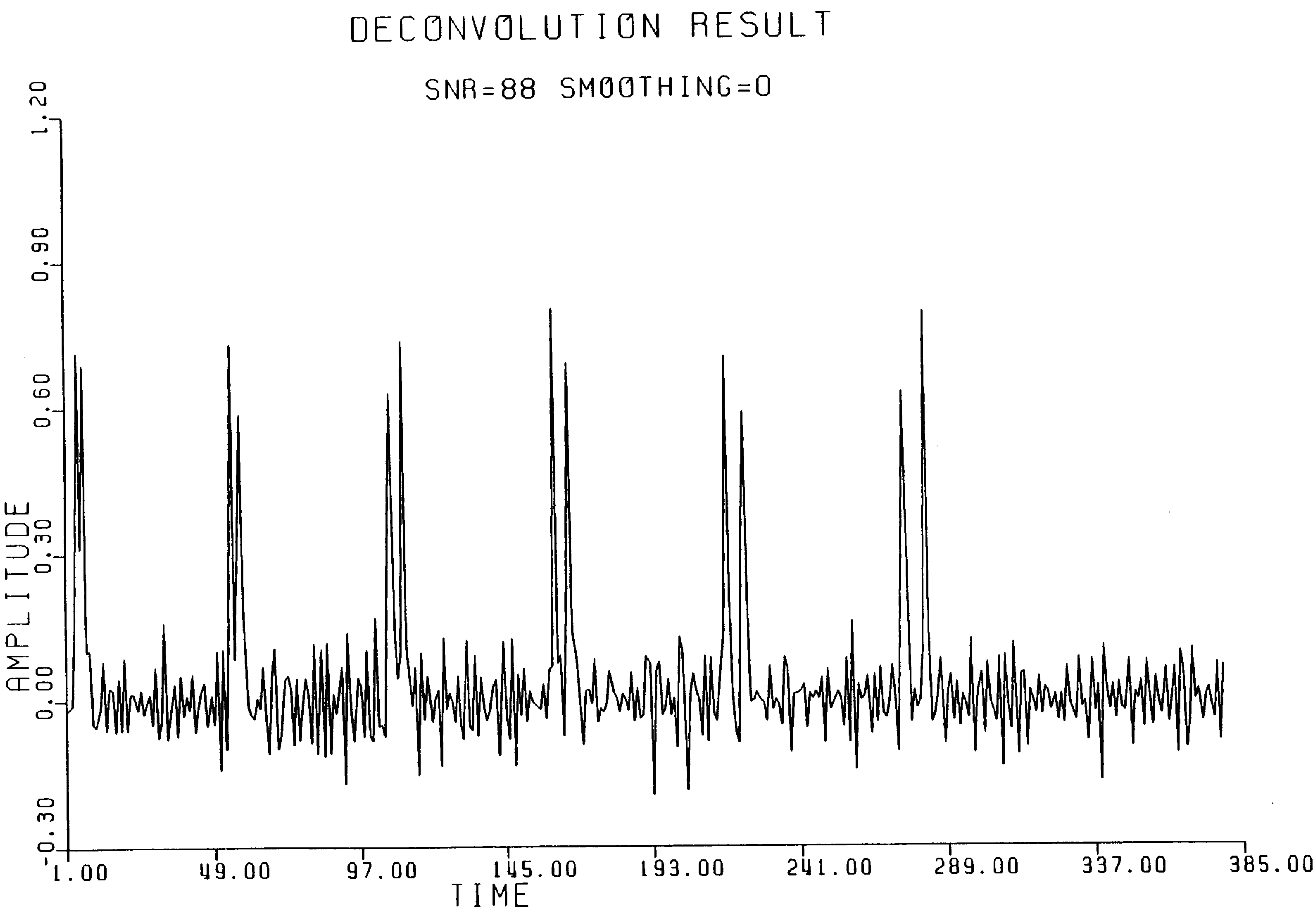

SMOOTHED DATA
SNR=84
AMPLITUDE
*10³
39.40
22.51
5.62
-11.26
-28.15
-45.04
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

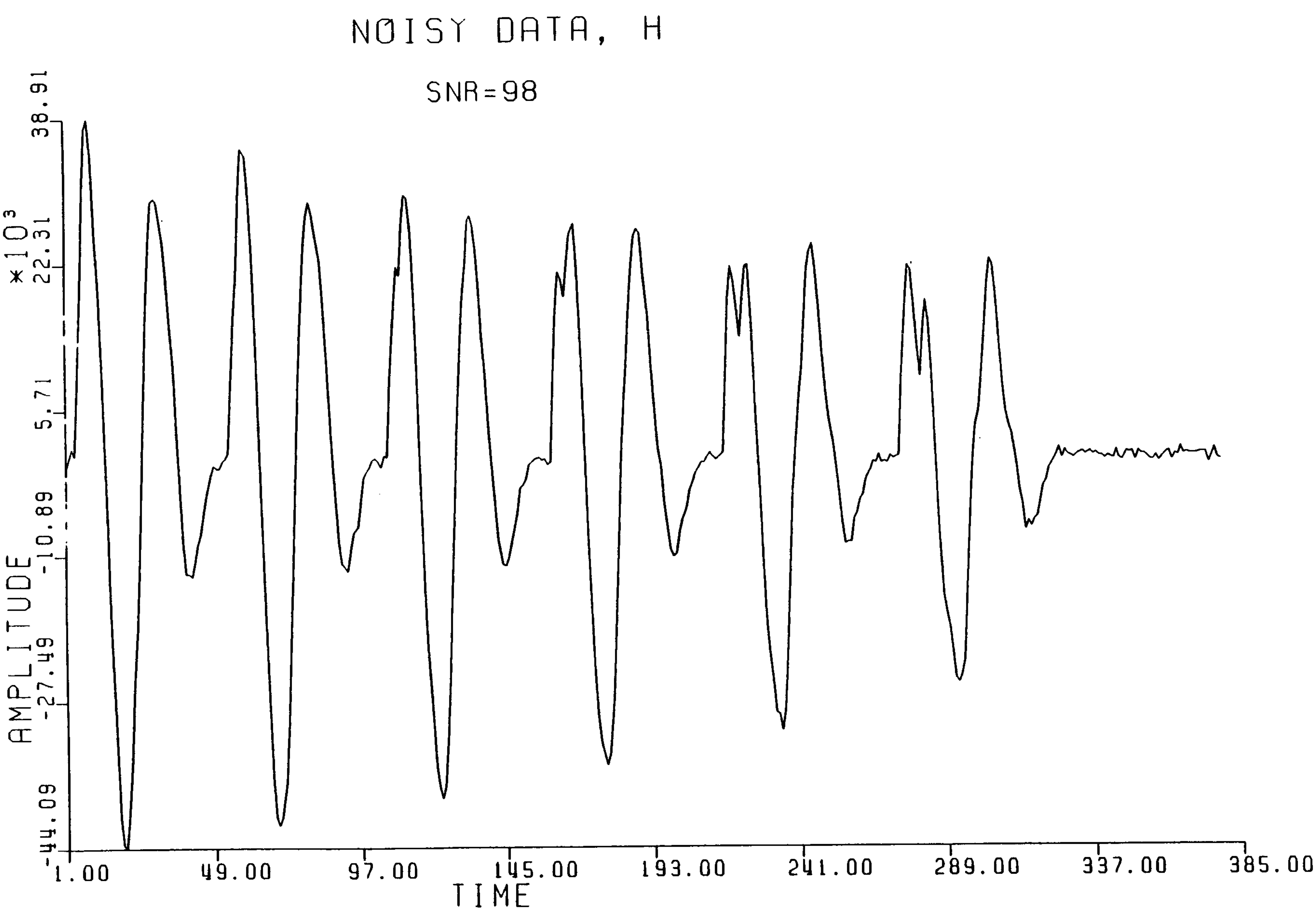

DECONVOLVED RESULT
SNR=84
AMPLITUDE
0.83
0.63
0.43
0.23
0.03
-0.17
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

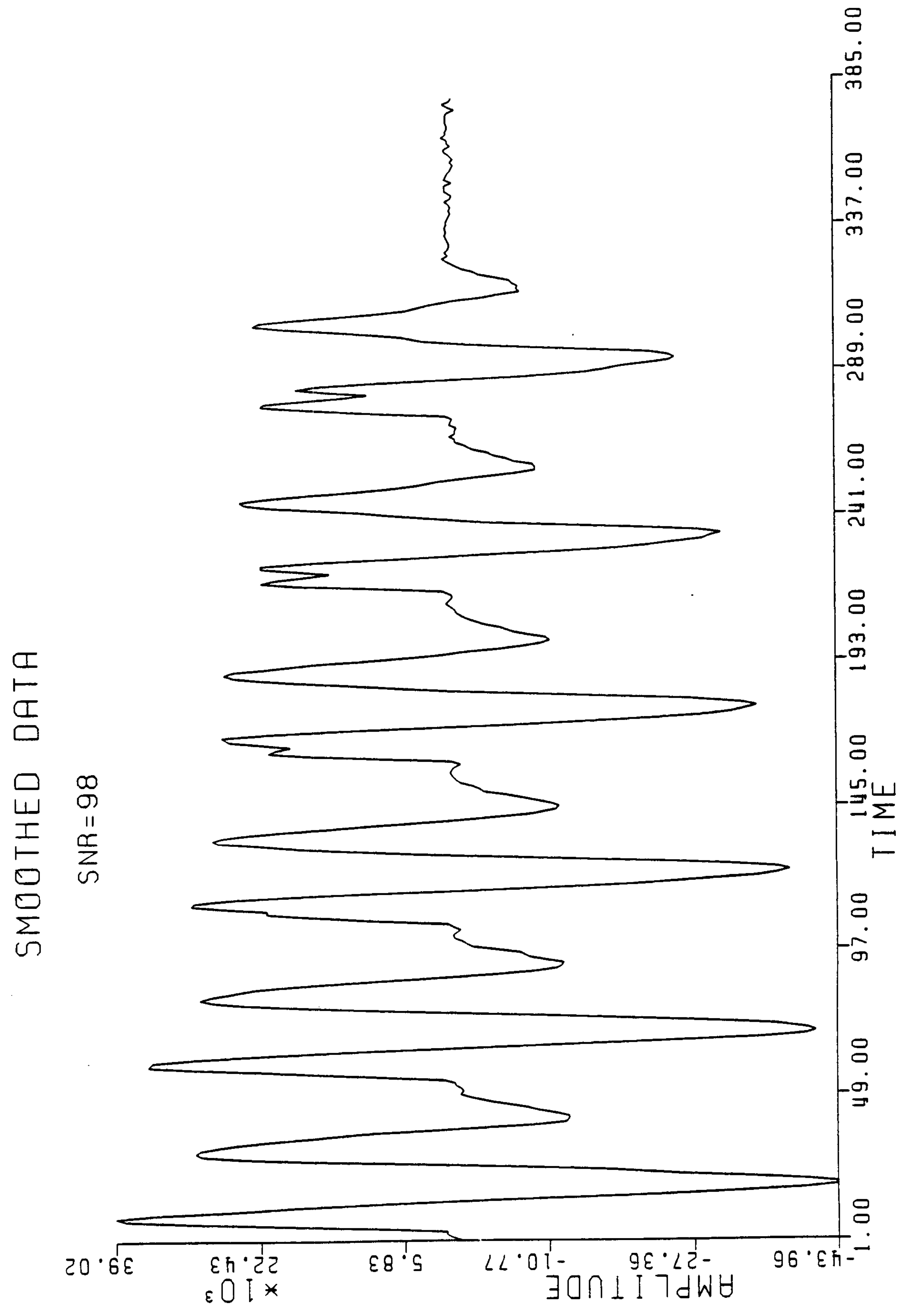

NØISY DATA, H
SNR=93
AMPLITUDE
*10³
39.33
22.54
5.75
-11.05
-27.84
-44.63
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

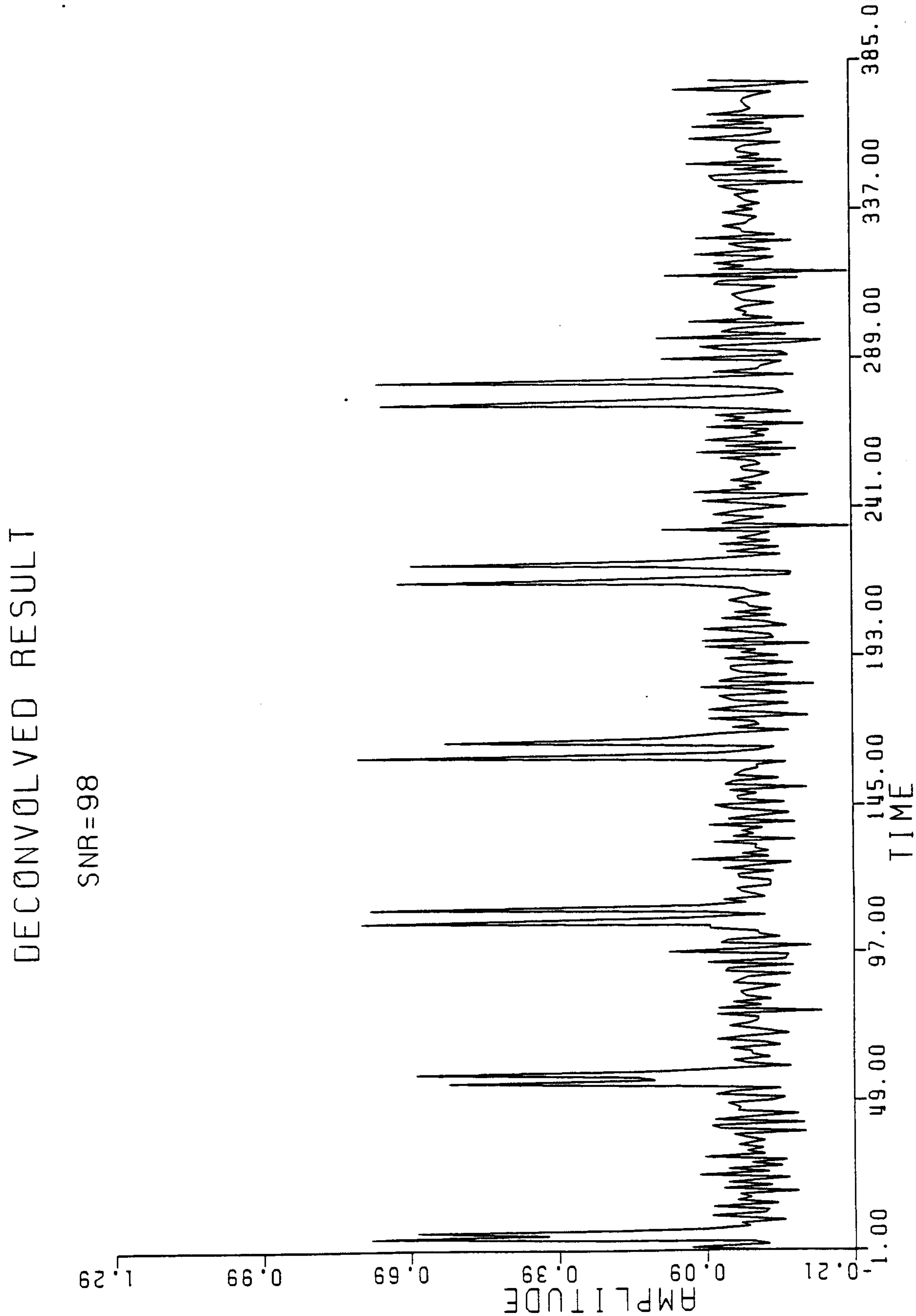

SMOOTHED DATA
SNR=93
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
*10³
39.25
22.47
5.69
-11.09
-27.87
-44.65

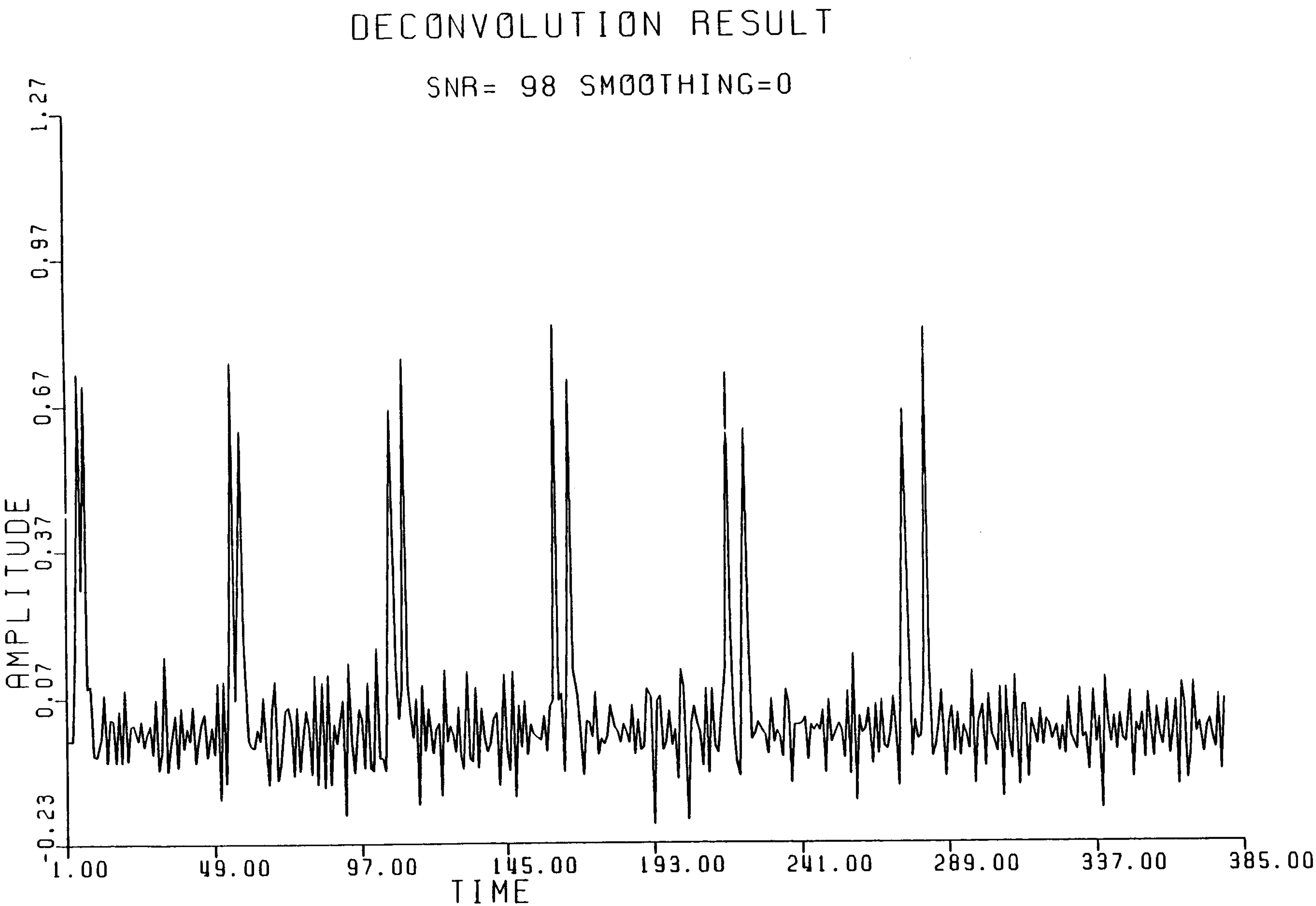

DECONVOLVED RESULT
SNR=93
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
-0.16
0.04
0.24
0.44
0.64
0.84

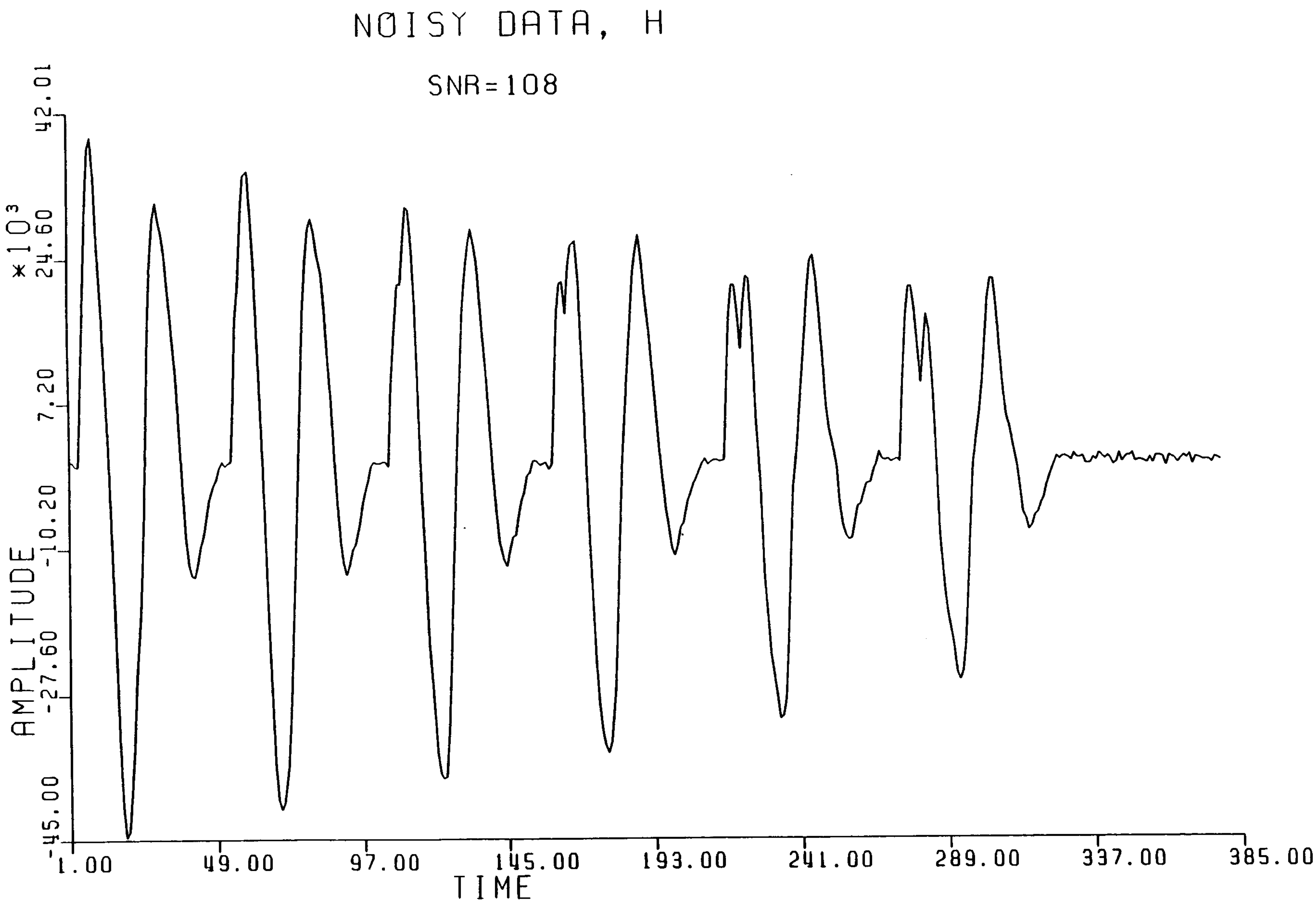

DECONVOLUTION RESULT
SNR=88 SMOOTHING=0
AMPLITUDE
1.20
0.90
0.60
0.30
0.00
-0.30
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

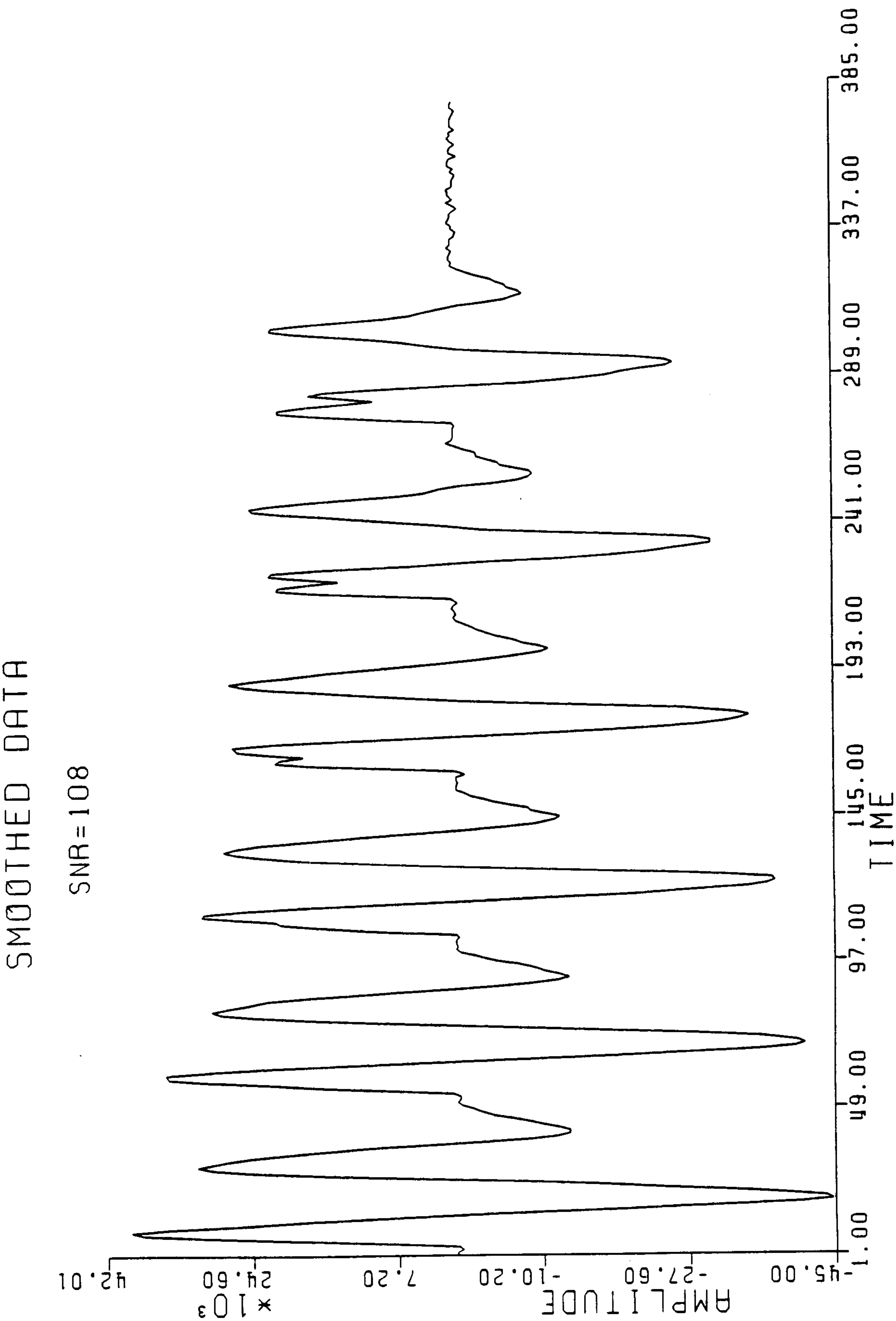

NØISY DATA, H
SNR=98
AMPLITUDE
*10³
38.91
22.31
5.71
-10.89
-27.49
-44.09
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME


SMOOTHED DATA
SNR=98
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
*10³
-43.96
-27.36
-10.77
5.83
22.43
39.02


DECONVOLVED RESULT
SNR=98
AMPLITUDE
-0.21
0.09
0.39
0.69
0.99
1.29
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

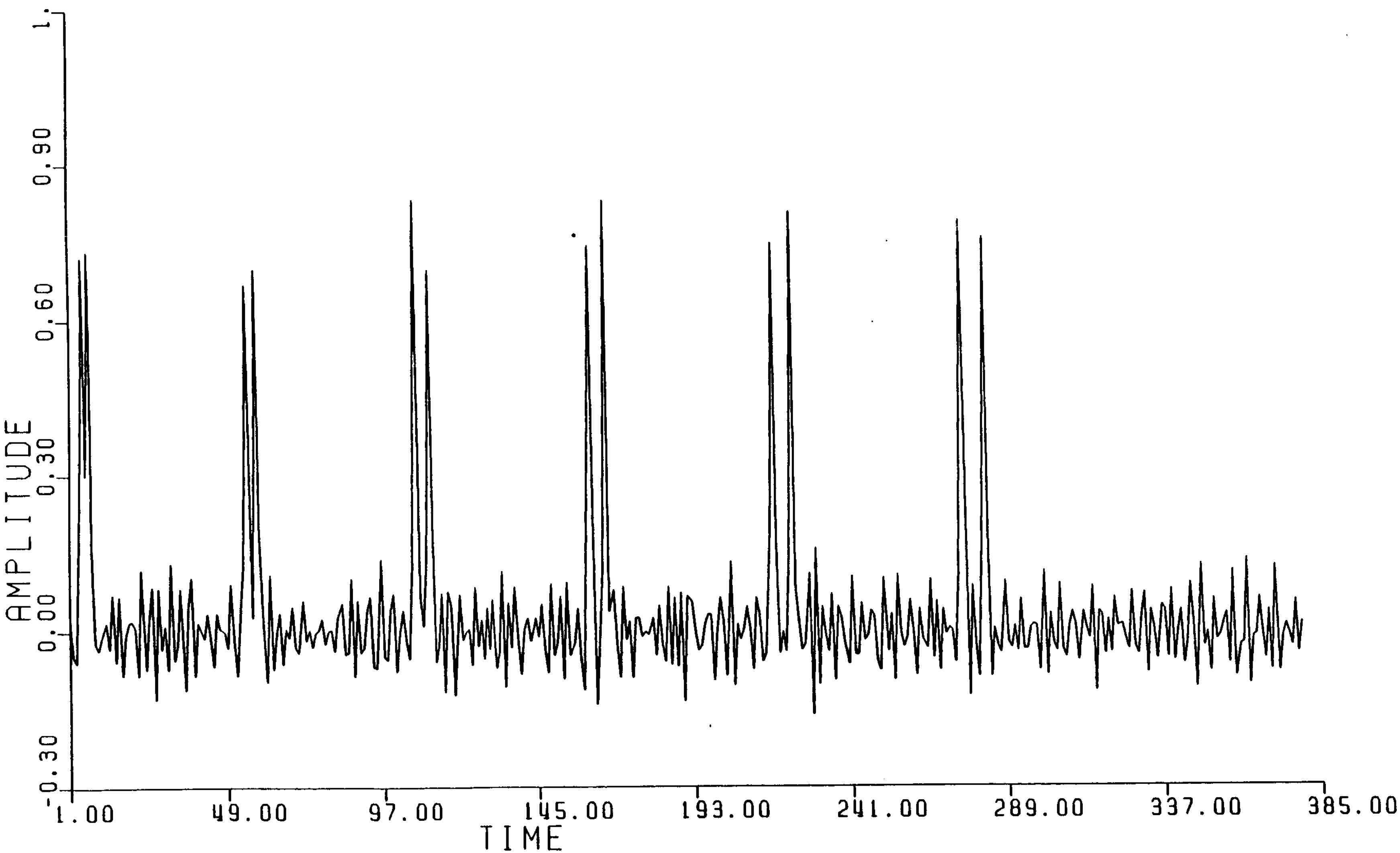

DECONVOLUTION RESULT
SNR= 98 SMOOTHING=0
AMPLITUDE
1.27
0.97
0.67
0.37
0.07
-0.23
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

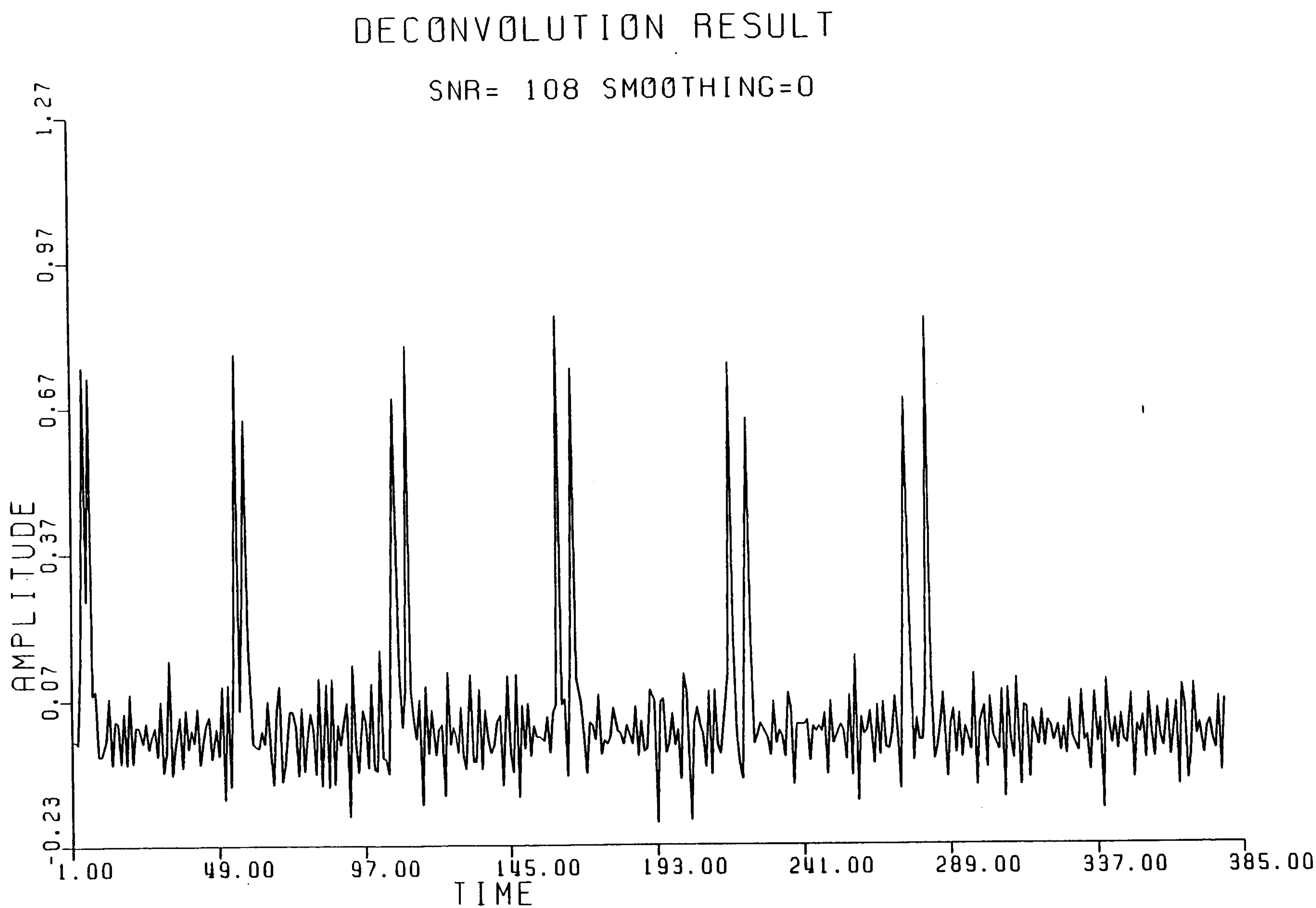

NØISY DATA, H
SNR=108
AMPLITUDE
*10³
42.01
24.60
7.20
-10.20
-27.60
-45.00
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00


SMOOTHED DATA
SNR=108
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
$\times 10^3$
-45.00
-27.60
-10.20
7.20
24.60
42.01

DECONVOLUTION RESULT

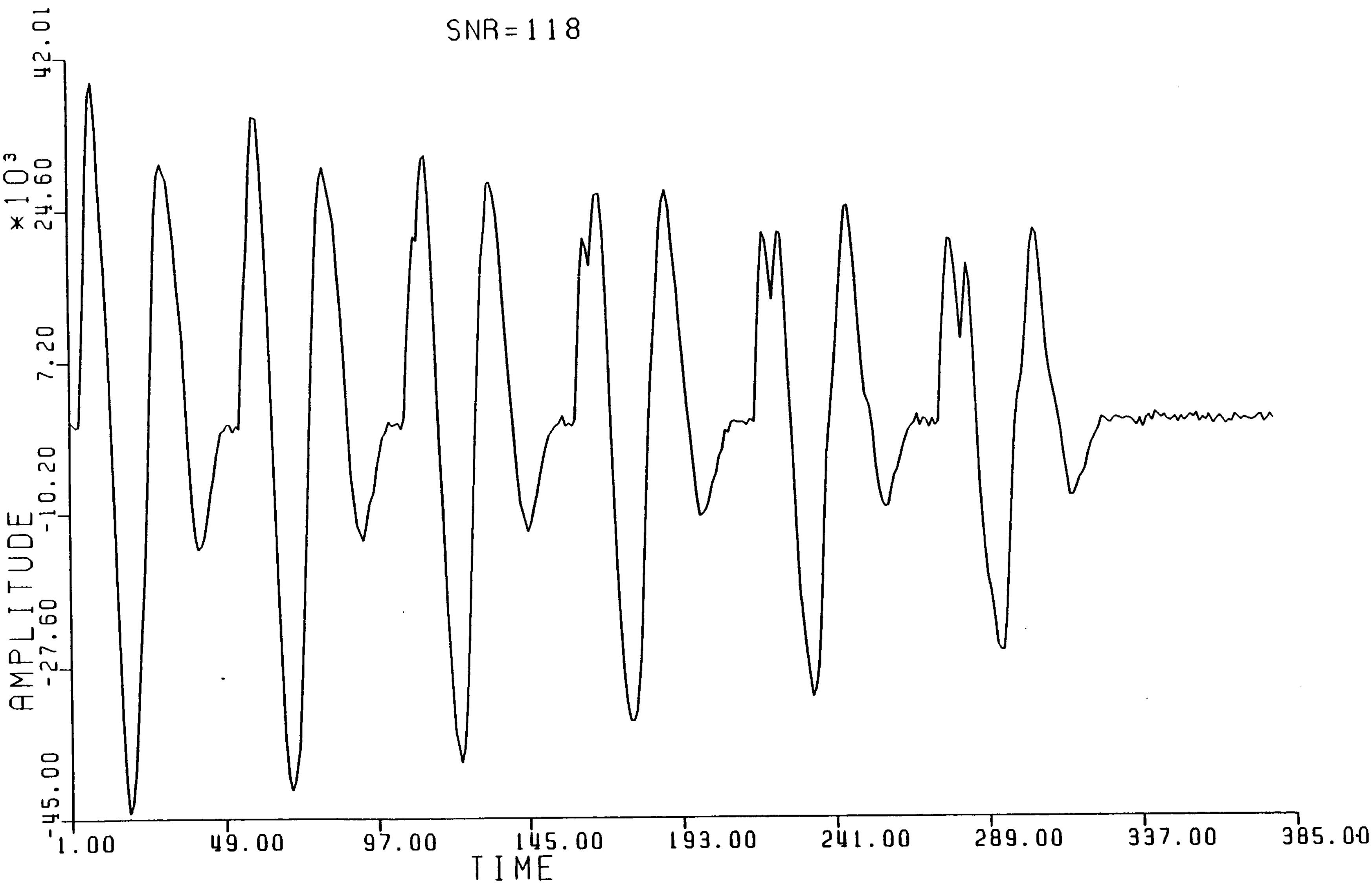
SNR=108

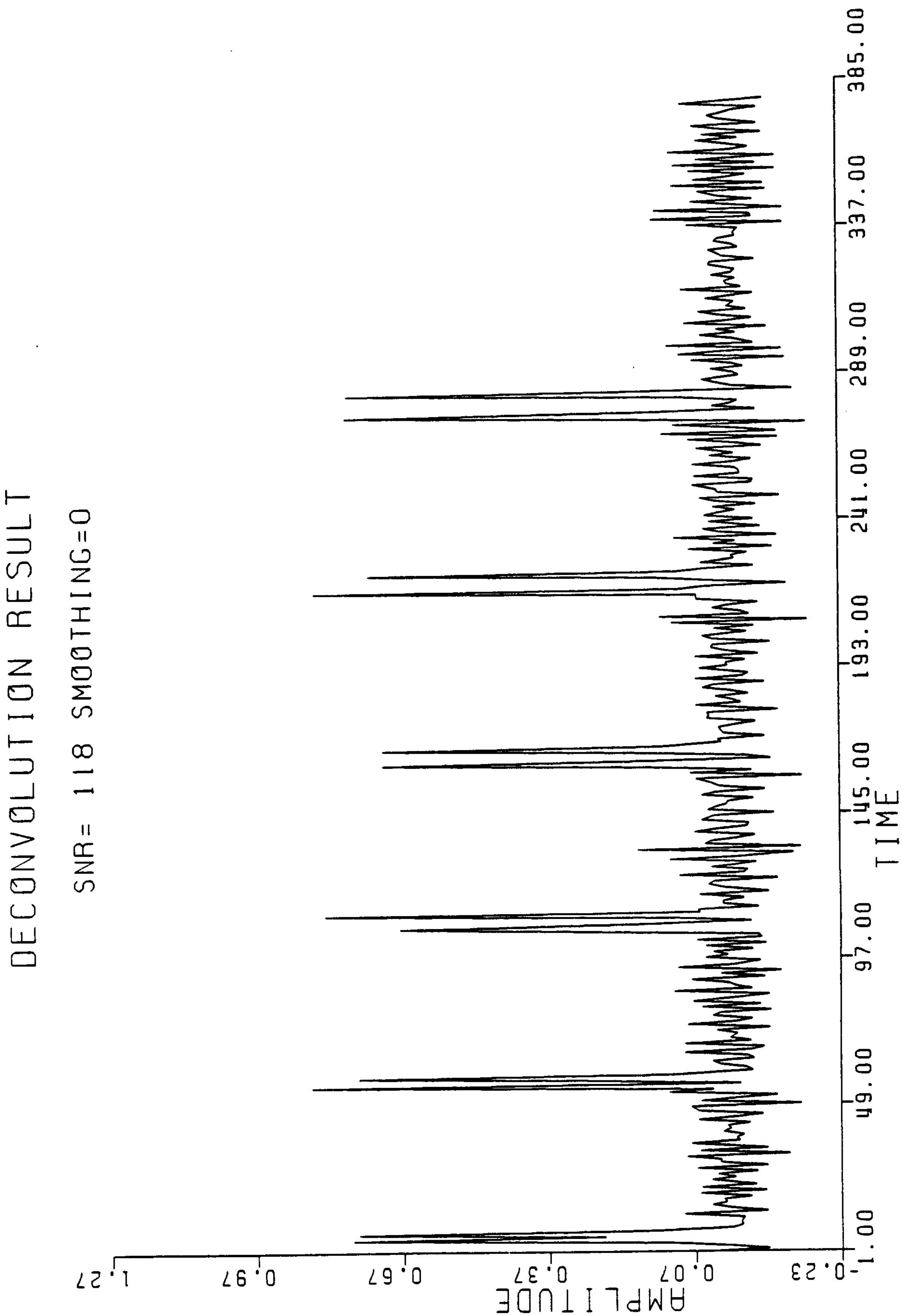


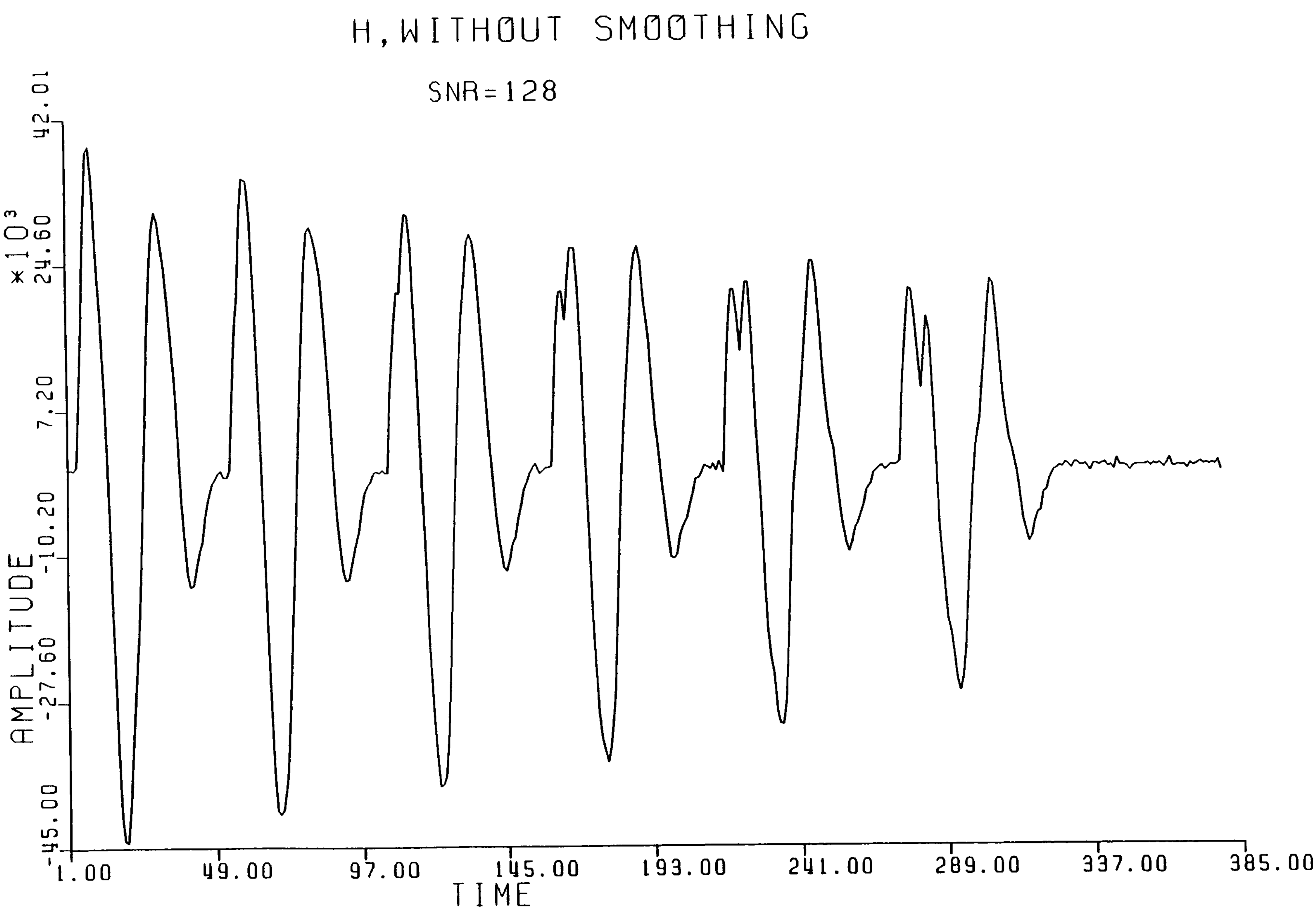

DECONVOLUTION RESULT
SNR= 108 SMOOTHING=0
AMPLITUDE
1.27
0.97
0.67
0.37
0.07
-0.23
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00

H, WITHOUT SMOOTHING

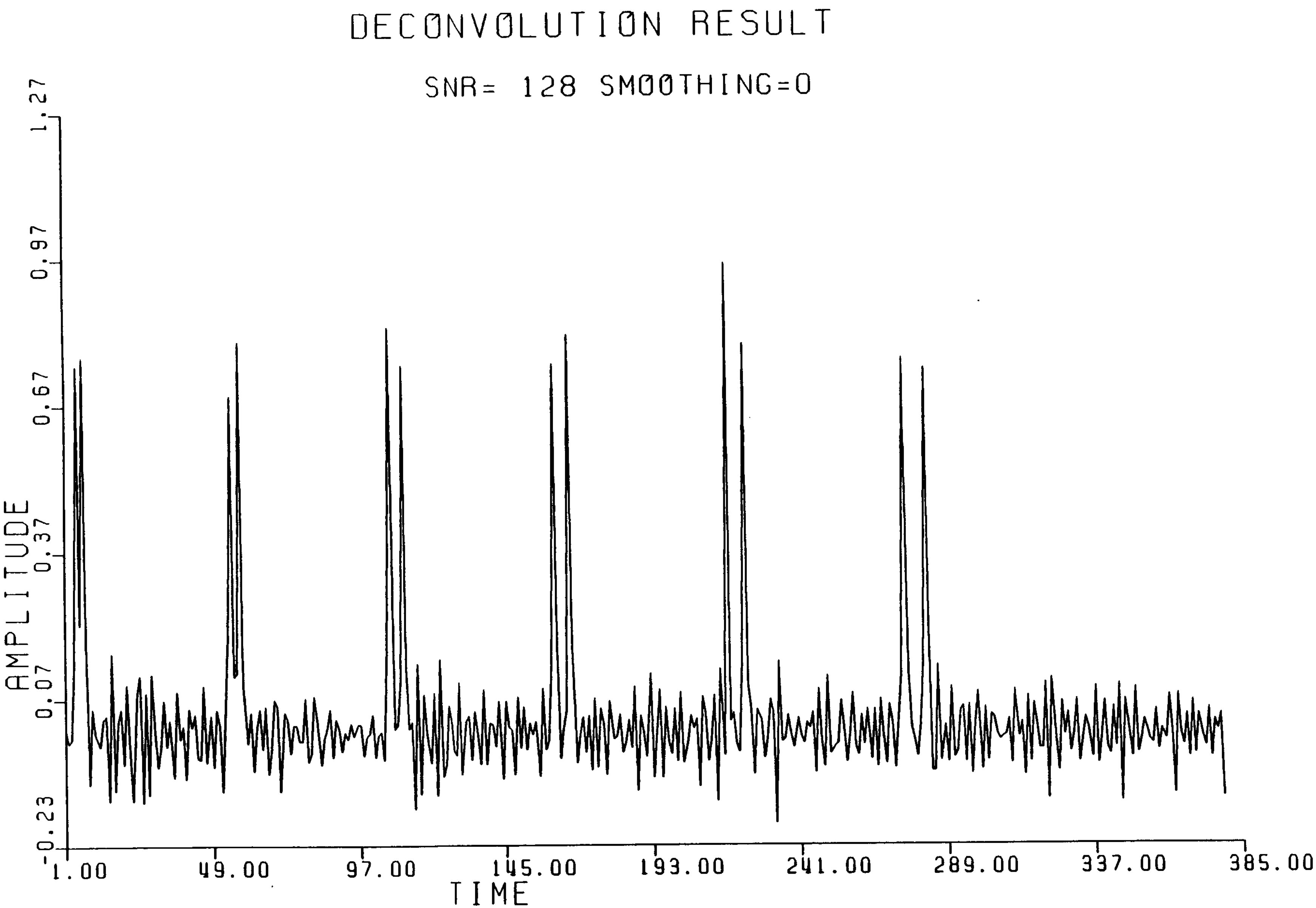
SNR=118

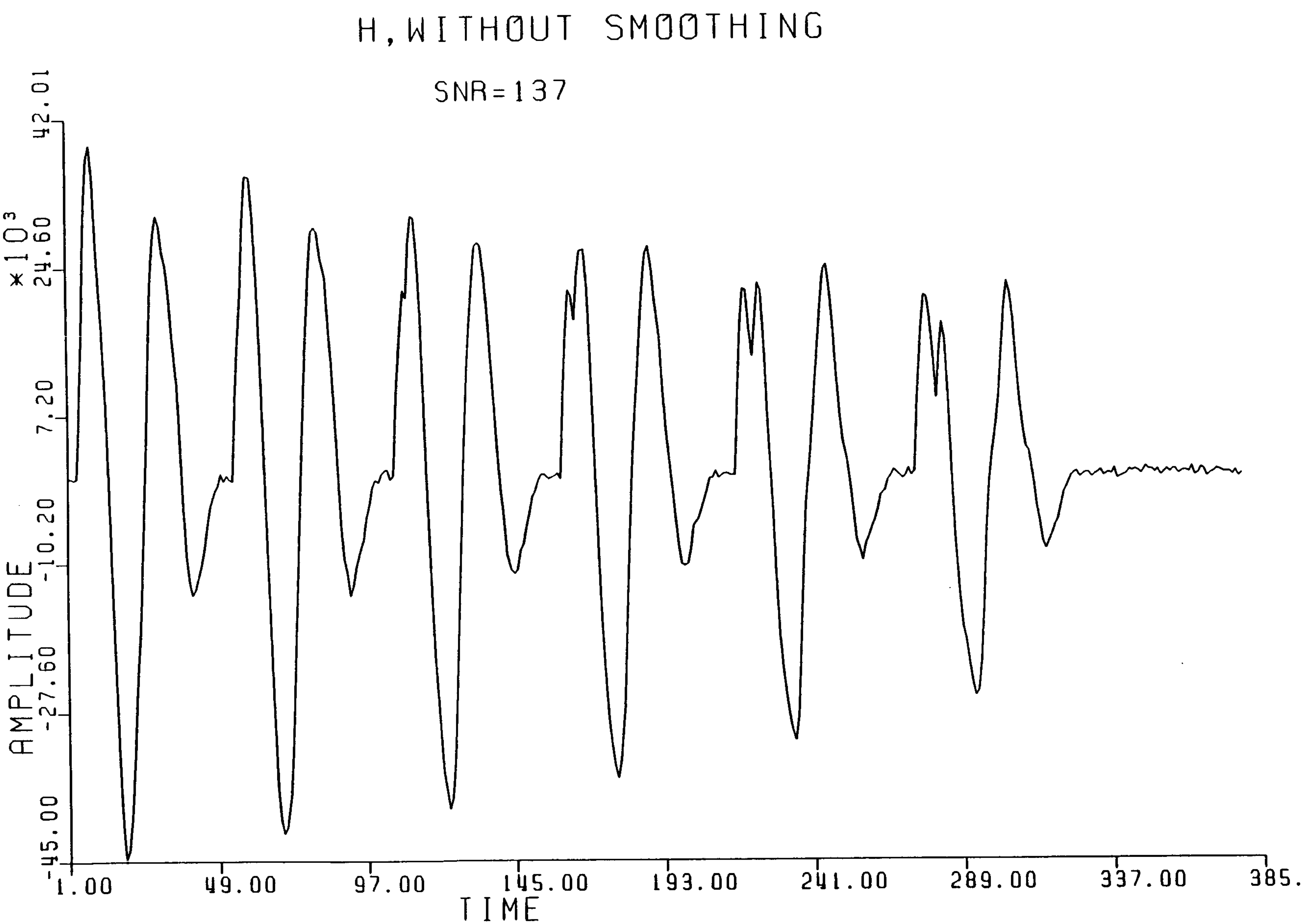


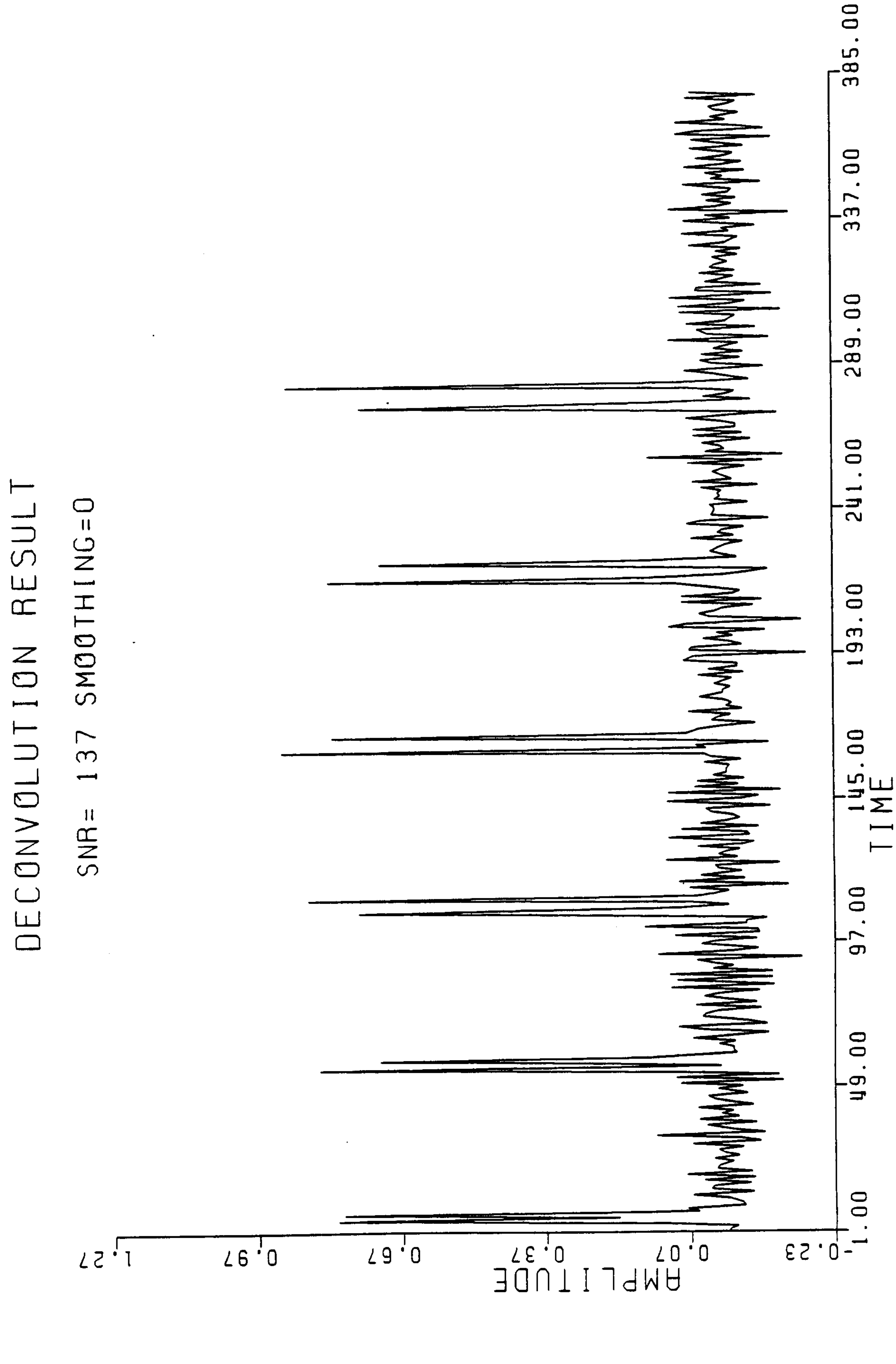

DECONVOLUTION RESULT
SNR= 118 SMOOTHING=0
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
-0.23
0.07
0.37
0.67
0.97
1.27



H, WITHOUT SMOOTHING
SNR=128
AMPLITUDE
*10³
42.01
24.60
7.20
-10.20
-27.60
-45.00
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME


DECONVOLUTION RESULT
SNR= 128 SMOOTHING=0
AMPLITUDE
1.27
0.97
0.67
0.37
0.07
-0.23
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME


H, WITHOUT SMOOTHING
SNR=137
AMPLITUDE
*10³
42.01
24.60
7.20
-10.20
-27.60
-45.00
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
TIME



DECØNVØLUTIØN RESULT
SNR= 137 SMØØTHING=0
TIME
1.00
49.00
97.00
145.00
193.00
241.00
289.00
337.00
385.00
AMPLITUDE
-0.23
0.07
0.37
0.67
0.97
1.27

TABLE SNR=150 REBLURRING PROCEDURE

MEAN SQURED ERROR	ITERATION NUMBER	CASE NUMBER	DIFFERENCE ERROR
1.846286	23920	1	0.1192093E-06
1.944813	24955	2	0.3576279E-06
2.085680	23377	3	0.2384186E-06
1.817714	26944	4	0.5960464E-06
1.789659	24631	5	0.3576279E-06
1.735373	27542	6	0.1192093E-06
1.736844	24850	7	0.2384186E-06
1.533371	25280	8	0.1192093E-06
1.633530	26106	9	0.2384186E-06
1.558898	24910	10	0.2384186E-06
1.450310	26241	11	0.2384186E-06
1.802192	23828	12	0.2384186E-06
1.948270	23732	13	0.9536743E-06
1.785398	28278	14	0.1192093E-06
1.538207	27742	15	0.4768372E-06
1.826279	22206	16	0.8344650E-06
1.468594	23599	17	0.1192093E-06
1.744612	31224	18	0.1192093E-06
1.903516	28178	19	0.2384186E-06
1.994772	22562	20	0.7152557E-06
1.948592	24223	21	0.3576279E-06
1.760069	29483	22	0.5960464E-06
1.769518	26532	23	0.2384186E-06
1.834149	25078	24	0.2384186E-06
1.717353	25692	25	0.3576279E-06
2.168625	25169	26	0.2384186E-06
1.496181	26215	27	0.4768372E-06
1.779979	29312	28	0.1192093E-06
1.931072	25359	29	0.3576279E-06
1.633508	26066	30	0.3576279E-06
1.929668	25713	31	0.1192093E-06
1.773549	23485	32	0.2384186E-06
1.872428	25239	33	0.1192093E-06
2.114362	21246	34	0.1192093E-05
1.551219	27702	35	0.3576279E-06
1.732943	26454	36	0.2384186E-06
1.820087	25655	37	0.1192093E-06
2.010833	23984	38	0.7152557E-06
1.926793	28354	39	0.2384186E-06
1.644376	25567	40	0.1192093E-06
1.622761	27002	41	0.2384186E-06
1.825098	24169	42	0.2384186E-06
2.034097	24479	43	0.7152557E-06
1.677921	27073	44	0.7152557E-06
1.564785	23186	45	0.3576279E-06
1.875742	22889	46	0.3576279E-06
1.992826	26103	47	0.5960464E-06
1.714245	25844	48	0.2384186E-06
1.866515	24584	49	0.1192093E-06
2.047117	22873	50	0.2384186E-06

TABLE SNR=40 REBLURRING PROCFDURE

MEAN SQURED ERROR	ITERATION NUBMER	CASE NUMBER	DIFFERRENCE ERROR
5.961245	2503	1	0.3814697E-05
6.193612	2284	2	0.4768372E-06
6.198378	2238	3	0.2861023E-05
6.420467	2057	4	0.1430511E-05
6.148540	2387	5	0.2861023E-05
5.809091	2814	6	0.1430511E-05
5.592218	2789	7	0.2384186E-05
5.480690	3111	8	0.4768372E-06
5.942793	2839	9	0.1430511E-05
5.437190	3542	10	0.9536743E-06
5.572175	3640	11	0.4768372E-06
5.679753	2949	12	0.3337860E-05
6.083924	2215	13	0.4768372E-06
6.161426	2400	14	0.1907349E-05
5.346950	3286	15	0.2384186E-05
5.542289	2742	16	0.4768372E-05
5.190651	3376	17	0.4768372E-06
6.073435	2383	18	0.9536743E-06
6.480808	1876	19	0.2861023E-05
6.152118	2231	20	0.9536743E-06
5.958267	2463	21	0.4768372E-06
6.179560	2314	22	0.3814697E-05
5.834317	2398	23	0.1907349E-05
5.797348	2463	24	0.9536743E-06
6.170175	2762	25	0.2384186E-05
6.034193	2096	26	0.9536743E-06
6.128828	2196	27	0.4768372E-06
5.837134	2816	28	0.4768372E-06
5.816765	2757	29	0.3337860E-05
5.637455	2921	30	0.9536743E-06
6.272642	2038	31	0.4768372E-06
5.855428	2588	32	0.1430511E-05
6.192252	2354	33	0.9536743E-06
6.577339	1820	34	0.9536743E-06
5.801851	2619	35	0.2384186E-05
5.768342	2363	36	0.1430511E-05
5.962425	2185	37	0.4768372E-06
6.161114	2227	38	0.4768372E-06
6.094741	2043	39	0.9536743E-06
6.018786	2274	40	0.4768372E-06
6.056442	2324	41	0.4768372E-06
5.930193	2630	42	0.1430511E-05
5.754459	2226	43	0.2861023E-05
5.953099	2346	44	0.4768372E-06
5.809452	2396	45	0.1907349E-05
6.036535	2167	46	0.1430511E-05
5.785913	2658	47	0.5722046E-05
5.830714	2524	48	0.1907349E-05
5.912695	2709	49	0.4768372E-06
5.627799	2885	50	0.9536743E-06

TABLE SNR=10 REBLURRING PROCEDURE

MEAN SQURED ERROR	ITERATION NUMBER	CASE NUMBER	DIFFERENCE ERROR
8.683937	132	1	0.3814697E-05
9.201220	108	2	0.5435944E-04
8.807170	138	3	0.4005432E-04
9.152944	109	4	0.7057190E-04
8.610974	156	5	0.1907349E-04
8.831291	130	6	0.1335144E-04
9.000823	126	7	0.1049042E-04
8.736782	132	8	0.2670288E-04
8.725792	115	9	0.1716614E-04
8.738132	158	10	0.1811981E-04
8.719207	143	11	0.9536743E-05
8.819816	160	12	0.1907349E-05
8.761172	133	13	0.1716614E-04
8.805182	135	14	0.2861023E-05
8.518571	201	15	-0.4148483E-03
8.368540	180	16	0.1335144E-04
8.503117	170	17	0.2574921E-04
8.753452	134	18	0.4482269E-04
8.878529	114	19	0.3623962E-04
8.598200	151	20	0.2384186E-04
8.620333	136	21	0.2288818E-04
8.623242	148	22	0.1049042E-04
8.513889	168	23	0.1525879E-04
8.669896	154	24	0.2479553E-04
8.871683	101	25	0.2002716E-04
8.591412	142	26	0.1144409E-04
8.893261	118	27	0.2098083E-04
8.735319	113	28	0.6675720E-05
8.639936	163	29	0.2670288E-04
8.492802	160	30	0.9536743E-06
8.751306	115	31	0.3242493E-04
8.453496	162	32	0.3337860E-04
8.678980	138	33	0.6675720E-05
8.691607	118	34	0.2002716E-04
8.613602	142	35	0.3242493E-04
8.498462	147	36	0.2956390E-04
8.632406	158	37	0.1716614E-04
8.605199	135	38	0.4386902E-04
8.713999	156	39	0.3528595E-04
8.535895	172	40	0.2288818E-04
8.690619	132	41	0.6675720E-05
8.665134	138	42	0.2574921E-04
8.381021	191	43	0.2861023E-04
8.615179	150	44	0.2002716E-04
8.511600	155	45	0.3242493E-04
8.638710	136	46	0.2956390E-04
8.660035	155	47	0.1907349E-05
8.680061	146	48	0.1907349E-05
8.749016	114	49	0.3147125E-04
8.780081	197	50	0.5722046E-05

TABLE(1) AVERAGE SNR = 9.841928

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
8.708630	23.	11.	1.	-0.001101
9.261088	19.	9.	2.	0.000751
8.412957	24.	10.	3.	-0.000413
8.588684	31.	10.	4.	0.000476
8.859292	31.	9.	5.	0.000611
8.756749	26.	10.	6.	-0.000397
8.734849	32.	9.	7.	0.000555
8.597588	31.	9.	8.	0.000740
8.678025	31.	9.	9.	0.000737
9.022989	22.	10.	10.	-0.001411
8.886079	39.	8.	11.	0.000899
9.038413	24.	9.	12.	-0.000591
8.933695	23.	10.	13.	0.000134
8.437884	34.	9.	14.	0.000980
9.002299	25.	8.	15.	0.000010
8.594122	32.	9.	16.	0.000435
8.691161	23.	10.	17.	-0.001687
8.486436	36.	9.	18.	0.000853
8.415577	26.	11.	19.	-0.000031
8.397182	30.	9.	20.	-0.000192
8.694945	33.	8.	21.	0.000278
8.852404	19.	11.	22.	-0.002861
8.763515	27.	10.	23.	-0.000001
8.650586	19.	10.	24.	0.000019
8.810864	29.	8.	25.	-0.000175
8.185898	27.	11.	26.	-0.000366
9.128948	23.	8.	27.	0.000893
8.723063	31.	9.	28.	0.000443
8.744484	21.	10.	29.	-0.002308
8.755471	29.	8.	30.	0.000075
8.594473	27.	10.	31.	0.000318
9.096992	27.	9.	32.	0.000083
8.974359	21.	10.	33.	-0.001815
9.015691	28.	8.	34.	-0.000163
8.912660	20.	9.	35.	0.000996
8.792315	28.	8.	36.	0.000611
8.679976	32.	9.	37.	0.000264
9.020429	22.	9.	38.	0.000984
8.783730	25.	10.	39.	-0.000944
8.331797	24.	13.	40.	0.000073
9.047639	26.	8.	41.	0.000279
8.824574	30.	8.	42.	0.000426
8.889532	23.	11.	43.	-0.001390
8.026690	25.	14.	44.	-0.001446
8.455950	22.	12.	45.	-0.001910
8.896874	23.	9.	46.	0.000357
8.317252	31.	11.	47.	0.000484
8.270308	38.	10.	48.	0.000786
9.346716	20.	9.	49.	0.000130
8.765975	20.	11.	50.	-0.001713

TABLE(2) AVERAGE SNR =19.683861

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
7.338927	53.	20.	1.	0.000759
8.068066	30.	21.	2.	0.000097
7.307953	33.	23.	3.	0.000924
7.141337	54.	23.	4.	0.000871
7.436351	46.	21.	5.	0.000655
7.407320	41.	23.	6.	0.000648
7.399758	50.	19.	7.	0.000966
7.350255	49.	18.	8.	0.000670
7.330608	62.	18.	9.	0.000984
7.592187	39.	23.	10.	0.000653
7.425316	56.	19.	11.	0.000884
7.772296	44.	18.	12.	0.000702
7.673055	35.	24.	13.	0.000961
7.102782	55.	21.	14.	0.000916
7.782703	49.	17.	15.	0.000772
7.352423	53.	18.	16.	0.000729
7.556736	34.	22.	17.	0.000205
7.211708	63.	18.	18.	0.000815
7.060783	68.	18.	19.	0.000836
7.258268	52.	17.	20.	0.000810
7.564574	46.	17.	21.	0.000697
7.584249	31.	27.	22.	0.000649
7.393219	46.	21.	23.	0.000773
7.596375	30.	23.	24.	0.000006
7.584871	60.	15.	25.	0.000929
6.991838	34.	28.	26.	0.000148
7.809992	35.	20.	27.	0.000813
7.530498	54.	17.	28.	0.000739
7.676629	33.	20.	29.	0.000331
7.528740	51.	17.	30.	0.000682
7.246883	35.	27.	31.	0.000057
7.684171	41.	21.	32.	0.000696
7.708984	45.	19.	33.	0.000898
7.772242	45.	17.	34.	0.000757
7.791096	40.	18.	35.	0.000906
7.641953	52.	16.	36.	0.000833
7.367406	52.	19.	37.	0.000688
7.782211	39.	19.	38.	0.000714
7.439094	36.	23.	39.	0.000738
7.060203	35.	28.	40.	0.000030
7.720122	58.	16.	41.	0.000954
7.722177	45.	16.	42.	0.000574
7.548825	37.	24.	43.	0.000129
6.829368	33.	33.	44.	0.000622
7.281810	31.	27.	45.	0.000665
7.738607	37.	19.	46.	0.000730
6.847265	54.	23.	47.	0.000743
6.891400	63.	21.	48.	0.000824
8.772583	21.	18.	49.	-0.000298
7.616624	36.	22.	50.	0.000690

TABLE(3) AVERAGE SNR =29.525789

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
6.351572	89.	29.	1.	0.000914
7.206611	44.	35.	2.	0.000581
6.528731	36.	46.	3.	0.000408
6.133978	64.	41.	4.	0.000849
6.533053	60.	33.	5.	0.000923
6.475711	55.	37.	6.	0.000976
6.512217	68.	30.	7.	0.000914
6.540751	66.	27.	8.	0.000920
6.356598	111.	25.	9.	0.000997
6.605123	59.	35.	10.	0.000766
6.508080	72.	31.	11.	0.000788
6.883022	65.	28.	12.	0.001000
6.814991	47.	39.	13.	0.000507
6.165030	60.	40.	14.	0.000887
6.840886	83.	26.	15.	0.000972
6.511253	81.	26.	16.	0.000942
6.777543	48.	34.	17.	0.000899
6.329338	84.	29.	18.	0.000946
6.100187	111.	26.	19.	0.000958
6.454587	85.	24.	20.	0.000981
6.813840	63.	26.	21.	0.000937
6.638523	51.	40.	22.	0.000942
6.493078	62.	33.	23.	0.000895
6.801062	41.	38.	24.	0.000529
6.711045	87.	24.	25.	0.000969
6.149081	40.	51.	26.	0.000642
6.943799	46.	33.	27.	0.000993
6.693546	78.	26.	28.	0.000886
6.902631	48.	31.	29.	0.000789
6.679087	72.	26.	30.	0.000832
6.348399	49.	42.	31.	0.000979
6.772192	56.	33.	32.	0.000993
6.729747	72.	30.	33.	0.000893
6.936660	59.	28.	34.	0.000720
6.868730	66.	29.	35.	0.000877
6.771721	76.	26.	36.	0.000955
6.511921	68.	30.	37.	0.000903
6.908458	61.	29.	38.	0.000985
6.595612	43.	41.	39.	0.000425
6.276983	44.	44.	40.	0.000659
6.780301	77.	27.	41.	0.000947
6.969264	64.	24.	42.	0.000966
6.667900	52.	36.	43.	0.000978
5.996190	40.	59.	44.	0.000815
6.477370	38.	46.	45.	0.000929
6.948769	51.	30.	46.	0.000851
5.894585	90.	31.	47.	0.000986
5.960738	104.	29.	48.	0.000998
8.561893	21.	25.	49.	0.000950
6.750287	59.	33.	50.	0.000842

TABLE(4) AVERAGE SNR =39.367710

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
5.545340	115.	41.	1.	0.000946
6.448089	64.	48.	2.	0.000948
5.872640	42.	70.	3.	0.000944
5.366885	76.	58.	4.	0.000933
5.833010	70.	48.	5.	0.000947
5.728393	69.	52.	6.	0.000950
5.798020	89.	40.	7.	0.000938
5.897536	85.	36.	8.	0.000890
5.558312	144.	35.	9.	0.000998
5.817141	73.	51.	10.	0.000875
5.789332	90.	43.	11.	0.000987
6.157364	79.	41.	12.	0.000855
6.116104	58.	56.	13.	0.000687
5.429409	76.	54.	14.	0.000968
6.018780	125.	35.	15.	0.000998
5.815888	109.	35.	16.	0.000948
6.124685	68.	43.	17.	0.000906
5.608205	107.	40.	18.	0.000992
5.333006	133.	37.	19.	0.000992
5.779417	102.	35.	20.	0.000986
6.188972	83.	35.	21.	0.000997
5.839504	65.	58.	22.	0.000992
5.785165	77.	46.	23.	0.000905
6.124846	51.	55.	24.	0.000829
5.973745	112.	35.	25.	0.000990
5.459580	48.	74.	26.	0.000937
6.264639	57.	47.	27.	0.000986
5.994065	98.	37.	28.	0.000989
6.236394	60.	45.	29.	0.000924
5.995539	88.	37.	30.	0.000990
5.620078	54.	68.	31.	0.000957
6.036593	70.	48.	32.	0.000896
5.909581	93.	43.	33.	0.000960
6.264862	74.	39.	34.	0.000875
6.062999	83.	43.	35.	0.000985
6.026481	92.	39.	36.	0.000991
5.836045	88.	40.	37.	0.000999
6.177999	86.	39.	38.	0.000985
5.921844	61.	51.	39.	0.000970
5.646498	51.	65.	40.	0.000953
6.021209	95.	39.	41.	0.000967
6.337640	80.	34.	42.	0.000973
5.966160	66.	49.	43.	0.000983
5.302580	49.	85.	44.	0.000903
5.827960	45.	67.	45.	0.000993
6.295580	68.	40.	46.	0.000885
5.152321	128.	39.	47.	0.000982
5.206808	135.	40.	48.	0.000987
8.460456	21.	30.	49.	-0.002297
5.995512	85.	44.	50.	0.000992

TABLE(5) AVERAGE SNR =49.209648

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
4.859326	137.	54.	1.	0.000987
5.751388	88.	61.	2.	0.000968
5.364193	106.	45.	3.	0.000998
4.747822	93.	71.	4.	0.000955
5.243860	84.	61.	5.	0.000944
5.091815	85.	66.	6.	0.000956
5.187953	111.	50.	7.	0.000975
5.343029	102.	46.	8.	0.000969
4.880616	166.	47.	9.	0.000999
5.156663	106.	57.	10.	0.000991
5.178987	111.	54.	11.	0.000983
5.534201	96.	53.	12.	0.000911
5.507786	69.	74.	13.	0.000902
4.815241	94.	67.	14.	0.000988
5.292534	145.	49.	15.	0.000999
5.207727	134.	45.	16.	0.000970
5.543026	87.	54.	17.	0.000988
4.987315	125.	53.	18.	0.000951
4.688622	142.	51.	19.	0.000991
5.186535	125.	45.	20.	0.000972
5.621023	103.	46.	21.	0.000962
5.159598	83.	72.	22.	0.000997
5.183424	95.	58.	23.	0.000893
5.526213	60.	75.	24.	0.000891
5.318564	133.	48.	25.	0.000987
4.864296	56.	100.	26.	0.000890
5.682859	77.	55.	27.	0.000959
5.377396	118.	49.	28.	0.000969
5.639555	71.	61.	29.	0.000993
5.403643	118.	45.	30.	0.000996
5.013740	108.	56.	31.	0.000973
5.399240	100.	55.	32.	0.000999
5.208829	109.	58.	33.	0.000998
5.679126	90.	51.	34.	0.000896
5.369892	103.	55.	35.	0.000999
5.373924	98.	57.	36.	0.000952
5.252666	109.	51.	37.	0.000956
5.531154	104.	53.	38.	0.000979
5.331197	104.	51.	39.	0.000951
5.086815	58.	91.	40.	0.000911
5.372299	112.	52.	41.	0.000978
5.773079	100.	43.	42.	0.000985
5.361551	71.	71.	43.	0.000823
4.704453	60.	108.	44.	0.000957
5.266391	52.	91.	45.	0.000926
5.720006	83.	52.	46.	0.000911
4.535335	147.	51.	47.	0.000957
4.563576	163.	52.	48.	0.000995
8.403978	21.	34.	49.	-0.002639
5.329252	98.	61.	50.	0.000973

TABLE(6) AVERAGE SNR =59.051571

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
4.268250	146.	71.	1.	0.000977
5.110024	113.	75.	2.	0.000969
4.841166	144.	52.	3.	0.000997
4.225272	110.	84.	4.	0.000972
4.725863	95.	77.	5.	0.000966
4.537367	102.	79.	6.	0.000999
4.653394	144.	57.	7.	0.000999
4.848901	120.	56.	8.	0.000982
4.298657	179.	61.	9.	0.000994
4.584485	130.	68.	10.	0.000984
4.641416	118.	72.	11.	0.000937
4.984305	116.	64.	12.	0.000999
4.962205	80.	94.	13.	0.000959
4.285584	112.	80.	14.	0.000988
4.655509	168.	62.	15.	0.000998
4.666865	145.	59.	16.	0.000956
5.014203	106.	66.	17.	0.000956
4.444520	155.	62.	18.	0.000999
4.139613	149.	66.	19.	0.000983
4.659448	131.	60.	20.	0.000989
5.093057	123.	58.	21.	0.000983
4.574582	106.	82.	22.	0.000959
4.655677	111.	71.	23.	0.000964
4.998540	86.	76.	24.	0.000982
4.732336	148.	63.	25.	0.000997
4.387926	120.	67.	26.	0.000996
5.160929	107.	60.	27.	0.000993
4.825956	136.	62.	28.	0.000990
5.103209	89.	72.	29.	0.000968
4.871598	138.	57.	30.	0.001000
4.473477	133.	66.	31.	0.000999
4.820234	106.	76.	32.	0.000978
4.606806	136.	68.	33.	0.000988
5.149992	117.	59.	34.	0.000985
4.768734	107.	75.	35.	0.000990
4.805202	126.	65.	36.	0.000995
4.732457	137.	60.	37.	0.000961
4.949416	113.	72.	38.	0.000993
4.792654	127.	62.	39.	0.000992
4.614918	123.	64.	40.	0.000970
4.804296	132.	64.	41.	0.000981
5.256889	110.	57.	42.	0.000996
4.834378	95.	76.	43.	0.000991
4.226316	127.	73.	44.	0.000993
4.767610	60.	115.	45.	0.000924
5.200059	99.	64.	46.	0.000947
4.011203	168.	62.	47.	0.001000
4.008428	185.	65.	48.	0.000984
8.453753	50.	15.	49.	0.000925
4.744222	131.	68.	50.	0.000999

TABLE(7) AVERAGE SNR =68.893509

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.760494	167.	83.	1.	0.000998
4.529139	136.	90.	2.	0.000970
4.365361	169.	62.	3.	0.000995
3.774784	131.	94.	4.	0.000996
4.266692	113.	88.	5.	0.000981
4.051329	120.	91.	6.	0.000980
4.176980	152.	72.	7.	0.000998
4.403984	138.	66.	8.	0.000974
3.796349	186.	77.	9.	0.000997
4.085845	153.	79.	10.	0.000983
4.166319	135.	85.	11.	0.000961
4.493429	136.	75.	12.	0.000998
4.467311	91.	116.	13.	0.000973
3.823727	131.	92.	14.	0.000983
4.098202	174.	80.	15.	0.000997
4.185543	162.	71.	16.	0.000980
4.535934	137.	72.	17.	0.000997
3.963573	161.	79.	18.	0.000997
3.669138	162.	79.	19.	0.000980
4.190782	150.	71.	20.	0.000979
4.603064	144.	70.	21.	0.000987
4.063638	123.	96.	22.	0.000990
4.188155	139.	78.	23.	0.000999
4.518237	104.	87.	24.	0.000972
4.208547	167.	77.	25.	0.000995
3.929424	139.	78.	26.	0.000988
4.677483	114.	78.	27.	0.000951
4.331723	157.	74.	28.	0.000995
4.615726	105.	85.	29.	0.000967
4.389132	160.	69.	30.	0.000979
3.998625	152.	78.	31.	0.000997
4.305084	125.	90.	32.	0.000988
4.084811	157.	80.	33.	0.000988
4.664434	142.	69.	34.	0.000991
4.252906	123.	88.	35.	0.000980
4.299731	129.	85.	36.	0.000994
4.263037	157.	72.	37.	0.000984
4.425909	130.	88.	38.	0.000973
4.307644	147.	74.	39.	0.000992
4.153526	146.	75.	40.	0.000984
4.301148	141.	81.	41.	0.000959
4.785040	125.	69.	42.	0.000932
4.359969	111.	89.	43.	0.000978
3.757203	121.	100.	44.	0.000992
4.319714	69.	138.	45.	0.000958
4.725494	116.	76.	46.	0.000953
3.560675	187.	73.	47.	0.000994
3.528780	204.	78.	48.	0.000995
8.437807	61.	14.	49.	0.000989
4.221049	132.	91.	50.	0.000998

TABLE(8) AVERAGE SNR =78.735428

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.317247	158.	109.	1.	0.000976
4.011607	154.	107.	2.	0.000979
3.935492	189.	73.	3.	0.000993
3.379414	149.	106.	4.	0.000985
3.852702	129.	101.	5.	0.000974
3.626014	138.	102.	6.	0.000981
3.754831	172.	83.	7.	0.000986
4.002509	150.	78.	8.	0.000997
3.363765	198.	91.	9.	0.000997
3.644741	150.	102.	10.	0.000982
3.744874	151.	98.	11.	0.000983
4.055869	164.	82.	12.	0.000993
4.019399	104.	136.	13.	0.000969
3.418980	147.	105.	14.	0.000986
3.614404	171.	103.	15.	0.001000
3.757840	175.	84.	16.	0.000996

TABLE(17) AVERAGE SNR = 74.726807

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.395554	155.	106.	1.	0.000976
3.812774	142.	93.	2.	0.000960
4.077936	136.	88.	3.	0.000989
4.080888	154.	95.	4.	0.000997
3.429931	181.	89.	5.	0.000985
3.697706	155.	80.	6.	0.000993
3.096177	195.	81.	7.	0.000999
4.015673	130.	107.	8.	0.000998
4.330874	156.	86.	9.	0.000999
4.172592	150.	79.	10.	0.000997
4.049789	140.	87.	11.	0.000986
4.041737	163.	88.	12.	0.001000
3.865810	191.	74.	13.	0.000997
3.876207	163.	80.	14.	0.000986
3.868444	139.	103.	15.	0.000985
4.339361	106.	95.	16.	0.000994
4.321587	114.	97.	17.	0.000989
3.849030	129.	104.	18.	0.001000
3.894280	142.	92.	19.	0.000993
3.650421	172.	85.	20.	0.000999
4.218463	165.	78.	21.	0.000990
4.059209	135.	87.	22.	0.000977
3.990735	176.	90.	23.	0.000995
4.520427	138.	87.	24.	0.000974
3.843392	158.	82.	25.	0.000998
3.691988	198.	75.	26.	0.000999
4.189553	156.	74.	27.	0.000990
4.052091	167.	81.	28.	0.001000
4.045865	160.	76.	29.	0.000982
4.001598	160.	78.	30.	0.000984
4.060649	168.	78.	31.	0.000993
4.016409	127.	90.	32.	0.000956
4.065069	138.	74.	33.	0.000992
3.984455	148.	85.	34.	0.000997
4.102486	151.	76.	35.	0.000983
4.113132	166.	79.	36.	0.000997
3.848848	151.	84.	37.	0.000996
3.962167	151.	80.	38.	0.000994
3.878361	141.	94.	39.	0.000979
3.776527	135.	96.	40.	0.000987
3.992266	165.	83.	41.	0.000996
4.083763	127.	90.	42.	0.000988
3.721014	163.	80.	43.	0.000997
4.224907	162.	73.	44.	0.000991
4.172873	149.	93.	45.	0.000979
4.514537	138.	76.	46.	0.000997
3.989830	144.	89.	47.	0.000988
3.950598	162.	83.	48.	0.000990
8.662059	18.	70.	49.	0.000782
4.067629	162.	81.	50.	0.000999

TABLE(18) AVERAGE SNR = 84.067673

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.021733	167.	120.	1.	0.000999
3.446605	154.	106.	2.	0.000978
3.698222	170.	90.	3.	0.000999
3.656251	171.	109.	4.	0.000989
3.075177	194.	102.	5.	0.000994
3.355496	167.	91.	6.	0.000993
2.771654	193.	96.	7.	0.000997
3.602528	151.	120.	8.	0.000988
3.888824	162.	106.	9.	0.000989
3.781230	148.	99.	10.	0.000983
3.675700	156.	98.	11.	0.000979
3.624150	166.	109.	12.	0.000982
3.483428	194.	90.	13.	0.000987
3.509586	179.	91.	14.	0.000992
3.459683	153.	117.	15.	0.000981
3.980025	126.	103.	16.	0.000996
3.934175	133.	107.	17.	0.000985
3.466334	143.	118.	18.	0.000990
3.524656	155.	105.	19.	0.000982
3.279536	182.	99.	20.	0.000995
3.808535	179.	91.	21.	0.000995
3.694003	147.	100.	22.	0.000980
3.548167	167.	120.	23.	0.000990
4.083356	152.	102.	24.	0.000999
3.470236	149.	106.	25.	0.000975
3.329963	206.	88.	26.	0.000996
3.818757	162.	89.	27.	0.000999
3.647607	184.	93.	28.	0.000997
3.661803	177.	86.	29.	0.000990
3.620004	164.	94.	30.	0.000997
3.667289	178.	92.	31.	0.000997
3.650563	140.	101.	32.	0.000994
3.729050	156.	82.	33.	0.000996
3.600101	170.	94.	34.	0.000999
3.740960	167.	86.	35.	0.000999
3.719209	187.	90.	36.	0.000994
3.486450	152.	102.	37.	0.000991
3.595068	145.	102.	38.	0.000994
3.496950	156.	106.	39.	0.000977
3.413874	148.	109.	40.	0.000981
3.593056	163.	104.	41.	0.000986
3.713061	143.	100.	42.	0.000998
3.361726	174.	92.	43.	0.000999
3.828975	178.	84.	44.	0.000982
3.748263	162.	109.	45.	0.000978
4.107911	140.	95.	46.	0.000992
3.609820	161.	100.	47.	0.000974
3.550092	153.	108.	48.	0.000977
8.612576	18.	70.	49.	-0.006763
3.674625	161.	102.	50.	0.000971

TABLE(19) AVERAGE SNR = 93.408524

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.701527	183.	130.	1.	0.000995
3.123418	171.	115.	2.	0.000982
3.350323	164.	112.	3.	0.000991
3.280643	186.	123.	4.	0.000984
2.758510	187.	125.	5.	0.000990
3.047590	161.	111.	6.	0.000988
2.493113	202.	107.	7.	0.000996
3.232638	172.	132.	8.	0.000988
3.494541	175.	122.	9.	0.000988
3.434758	160.	111.	10.	0.000990
3.340736	169.	110.	11.	0.000984
3.254897	178.	125.	12.	0.000986
3.144088	207.	102.	13.	0.000999
3.177465	174.	112.	14.	0.000973
3.105422	169.	128.	15.	0.000988
3.646526	144.	113.	16.	0.000999
3.581006	152.	117.	17.	0.000994
3.130951	163.	126.	18.	0.000995
3.196333	168.	117.	19.	0.000993
2.951860	181.	118.	20.	0.000998
3.437624	177.	112.	21.	0.000979
3.365005	160.	112.	22.	0.000980
3.162249	185.	135.	23.	0.000993
3.690495	170.	114.	24.	0.000990
3.143560	164.	117.	25.	0.000981
3.008070	216.	100.	26.	0.000999
3.488896	188.	94.	27.	0.000998
3.281574	176.	117.	28.	0.000993
3.318369	185.	99.	29.	0.000998
3.279523	167.	111.	30.	0.000984
3.315232	180.	110.	31.	0.000974
3.323969	151.	113.	32.	0.000997
3.423938	173.	90.	33.	0.000998
3.257277	190.	103.	34.	0.000998
3.414912	184.	95.	35.	0.001000
3.364511	206.	101.	36.	0.001000
3.165940	166.	113.	37.	0.000981

TABLE(20) AVERAGE SNR = 98.419296

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.617830	184.	136.	1.	0.000992
3.162520	190.	136.	2.	0.000996
3.201327	201.	103.	3.	0.001000
2.738460	208.	114.	4.	0.000999
3.148264	162.	125.	5.	0.000990
2.926951	166.	126.	6.	0.000997
3.050243	203.	106.	7.	0.000999
3.312392	160.	109.	8.	0.000984
2.664902	202.	127.	9.	0.000996
2.927900	182.	127.	10.	0.000981
3.039490	180.	124.	11.	0.000983
3.308157	181.	113.	12.	0.000993
3.273428	168.	131.	13.	0.000998
2.755229	177.	129.	14.	0.000995
2.842124	197.	132.	15.	0.000989
3.042425	184.	117.	16.	0.001000
3.353795	171.	117.	17.	0.000981
2.841238	189.	127.	18.	0.000995
2.616894	183.	122.	19.	0.000992
3.075007	173.	116.	20.	0.000983
3.369231	174.	121.	21.	0.000995
2.894640	176.	131.	22.	0.000987
3.070945	176.	119.	23.	0.000999
3.348740	153.	121.	24.	0.000987
2.975874	194.	130.	25.	0.000992
2.852601	160.	125.	26.	0.000986
3.484564	188.	102.	27.	0.001000
3.135615	188.	124.	28.	0.000989
3.424960	159.	117.	29.	0.000984
3.197821	191.	120.	30.	0.000985
2.888950	180.	124.	31.	0.000998
3.082851	179.	129.	32.	0.000992
2.891891	185.	128.	33.	0.000987
3.440476	181.	116.	34.	0.000999
3.077373	167.	124.	35.	0.000990
3.118832	174.	125.	36.	0.000987
3.115471	190.	119.	37.	0.000995
3.175792	182.	131.	38.	0.000992
3.138712	175.	122.	39.	0.000999
3.023510	174.	124.	40.	0.000985
3.113745	183.	123.	41.	0.000987
3.609308	167.	105.	42.	0.000991
3.216776	165.	121.	43.	0.000984
2.697381	173.	134.	44.	0.000992
3.272591	143.	128.	45.	0.000993
3.540343	164.	113.	46.	0.000988
2.537032	188.	124.	47.	0.000992
2.438334	202.	138.	48.	0.000996
8.376616	19.	75.	49.	0.000783
3.016617	179.	132.	50.	0.000992

TABLE(30) AVERAGE SNR = 9.841928

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
19.226101	7.	0.	1.	-0.105171
21.047100	6.	0.	2.	-0.043852
21.770720	7.	0.	3.	-0.118877
19.629490	7.	0.	4.	-0.114338
21.853430	7.	0.	5.	-0.194771
21.055420	7.	0.	6.	-0.220104
22.337740	7.	0.	7.	-0.119179
24.593260	6.	0.	8.	-0.061039
20.764030	7.	0.	9.	-0.054441
20.709360	7.	0.	10.	-0.183603
22.742599	7.	0.	11.	-0.138123
24.214041	6.	0.	12.	-0.111889
20.775089	6.	0.	13.	-0.023972
19.790310	7.	0.	14.	-0.051283
21.295679	7.	0.	15.	-0.046953
23.150551	6.	0.	16.	-0.003626
23.152969	6.	0.	17.	-0.079046
21.412519	7.	0.	18.	-0.046980
20.385550	7.	0.	19.	-0.192974
23.275249	7.	0.	20.	-0.176338
23.667351	7.	0.	21.	-0.156557
19.801310	7.	0.	22.	-0.220175
22.005400	6.	0.	23.	-0.043421
22.744061	6.	0.	24.	-0.136856
21.678530	8.	0.	25.	-0.195791
21.203030	7.	0.	26.	-0.147413
23.972679	6.	0.	27.	-0.038589
22.745239	7.	0.	28.	-0.036505
23.404949	6.	0.	29.	-0.151316
22.231270	8.	0.	30.	-0.193779
20.863701	7.	0.	31.	-0.038145
21.155460	6.	0.	32.	-0.016468
21.169950	6.	0.	33.	-0.001968
24.003750	7.	0.	34.	-0.234383
21.795870	6.	0.	35.	-0.101829
22.679979	7.	0.	36.	-0.132013
22.077660	7.	0.	37.	-0.095732
21.629990	7.	0.	38.	-0.158812
21.915581	7.	0.	39.	-0.159691
20.291821	7.	0.	40.	-0.172621
22.761860	6.	0.	41.	-0.029436
26.952160	6.	0.	42.	-0.208326
21.465460	6.	0.	43.	-0.190754
18.319040	7.	0.	44.	-0.027361
21.310020	6.	0.	45.	-0.017860
24.234800	6.	0.	46.	-0.211664
19.398029	7.	0.	47.	-0.101019
17.762960	8.	0.	48.	-0.037178
22.756861	7.	0	49.	-0.225559
20.713470	7.	0.	50.	-0.226524

TABLE(31) AVERAGE SNR = 19.683861

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
9.843993	13.	0.	1.	-0.029004
11.201550	11.	0.	2.	-0.008267
10.530930	12.	0.	3.	-0.028964
10.045750	13.	0.	4.	-0.025162
10.978920	12.	0.	5.	-0.018272
10.480340	12.	0.	6.	-0.027701
11.094980	13.	0.	7.	-0.040694
11.778590	11.	0.	8.	-0.014932
10.486390	13.	0.	9.	-0.010529
10.613170	12.	0.	10.	-0.016668
11.486980	13.	0.	11.	-0.035267
12.206080	11.	0.	12.	-0.021389
10.948750	11.	0.	13.	-0.001121
9.950316	13.	0.	14.	-0.031156
10.943020	12.	0.	15.	-0.002595
11.485240	12.	0.	16.	-0.027514
11.630610	11.	0.	17.	-0.021804
10.732040	13.	0.	18.	-0.016435
10.033770	12.	0.	19.	-0.006404
11.140610	12.	0.	20.	-0.029387
11.835970	12.	0.	21.	-0.026890
10.241070	12.	0.	22.	-0.032406
11.104150	12.	0.	23.	-0.034019
11.156940	11.	0.	24.	-0.055010
10.989700	13.	0.	25.	-0.031626
10.039500	12.	0.	26.	-0.023050
11.831050	11.	0.	27.	-0.027351
11.565120	13.	0.	28.	-0.027321
11.582860	11.	0.	29.	-0.053346
11.206000	13.	0.	30.	-0.031703
10.347560	13.	0.	31.	-0.035898
10.972260	12.	0.	32.	-0.026159
10.853060	12.	0.	33.	-0.027996
12.145740	12.	0.	34.	-0.047365
11.014590	11.	0.	35.	-0.028947
11.401290	12.	0.	36.	-0.021420
11.215910	13.	0.	37.	-0.037941
11.215170	12.	0.	38.	-0.028437
10.951230	12.	0.	39.	-0.019464
10.256720	12.	0.	40.	-0.009613
11.666350	12.	0.	41.	-0.037958
13.147900	11.	0.	42.	-0.057947
11.086240	11.	0.	43.	-0.023086
9.272814	13.	0.	44.	-0.008620
10.525770	11.	0.	45.	-0.008162
12.193030	11.	0.	46.	-0.056947
9.589289	13.	0.	47.	-0.018207
9.139634	15.	0.	48.	-0.019536
13.302290	10.	0.	49.	-0.073874
10.806590	12.	0	50.	-0.035036

TABLE(32) AVERAGE SNR = 29.525789

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
7.315786	19.	0.	1.	-0.000018
8.495259	17.	0.	2.	-0.005919
7.760924	17.	0.	3.	-0.003345
7.446634	20.	0.	4.	-0.010529
8.085850	18.	0.	5.	-0.004816
7.734996	18.	0.	6.	-0.008698
8.104994	19.	0.	7.	-0.012748
8.532338	17.	0.	8.	-0.019246
7.681018	20.	0.	9.	-0.004030
7.895891	18.	0.	10.	0.000456
8.390689	19.	0.	11.	-0.007516
8.980170	17.	0.	12.	-0.015305
8.270487	17.	0.	13.	-0.004380
7.369601	19.	0.	14.	-0.003955
8.158388	19.	0.	15.	-0.011575
8.377299	18.	0.	16.	-0.010308
8.619022	16.	0.	17.	-0.002030
7.861460	20.	0.	18.	-0.011105
7.343160	19.	0.	19.	-0.012146
8.089566	17.	0.	20.	-0.000591
8.698585	17.	0.	21.	-0.000449
7.704100	18.	0.	22.	-0.008863
8.178650	18.	0.	23.	-0.010564
8.275409	16.	0.	24.	-0.019298
8.150025	19.	0.	25.	-0.009558
7.316804	18.	0.	26.	-0.015587
8.733450	16.	0.	27.	-0.005605
8.514361	19.	0.	28.	-0.006966
8.572556	16.	0.	29.	-0.018090
8.283847	19.	0.	30.	-0.010856
7.628445	19.	0.	31.	-0.011085
8.180305	18.	0.	32.	-0.005666
8.068481	18.	0.	33.	-0.004575
8.963150	17.	0.	34.	-0.006029
8.224533	17.	0.	35.	-0.016262
8.418651	18.	0.	36.	-0.009730
8.265250	19.	0.	37.	-0.010905
8.398780	18.	0.	38.	-0.011533
8.082070	18.	0.	39.	-0.011270
7.607956	18.	0.	40.	-0.003280
8.627525	18.	0.	41.	-0.009248
9.545705	16.	0.	42.	-0.022045
8.272751	17.	0.	43.	-0.009822
6.906265	20.	0.	44.	-0.010685
7.815366	17.	0.	45.	-0.014971
9.014911	16.	0.	46.	-0.016479
7.006933	20.	0.	47.	-0.008854
6.759719	22.	0.	48.	-0.000337
11.199050	11.	0.	49.	-0.009194
8.117874	18.	0.	50.	-0.011708

TABLE(21) AVERAGE SNR =108.261200

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.341621	197.	147.	1.	0.000995
2.821401	207.	148.	2.	0.000996
2.887903	187.	129.	3.	0.000993
2.461803	196.	140.	4.	0.000999
2.852439	181.	134.	5.	0.000990
2.641737	179.	137.	6.	0.000991
2.752923	196.	128.	7.	0.000987
3.020818	174.	119.	8.	0.000976
2.385809	214.	139.	9.	0.000998
2.636262	197.	138.	10.	0.000989
2.747622	193.	136.	11.	0.000999
2.994894	193.	126.	12.	0.000992
2.952267	187.	142.	13.	0.000997
2.484911	192.	139.	14.	0.000995
2.537713	211.	143.	15.	0.000997
2.747830	196.	129.	16.	0.000987
3.041290	186.	128.	17.	0.000999

TABLE(33) AVERAGE SNR = 39.367710

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
5.984739	27.	0.	1.	0.000591
7.060900	24.	0.	2.	-0.000358
6.408188	23.	0.	3.	0.000374
6.084318	28.	0.	4.	-0.003464
6.616811	25.	0.	5.	-0.001885
6.339706	25.	0.	6.	-0.003086
6.600825	26.	0.	7.	-0.005155
6.955102	22.	0.	8.	0.000829
6.221606	28.	0.	9.	0.000167
6.471409	26.	0.	10.	-0.001853
6.820210	26.	0.	11.	-0.001257
7.348662	23.	0.	12.	-0.002122
6.872921	24.	0.	13.	-0.001717
6.036716	27.	0.	14.	-0.003223
6.695366	26.	0.	15.	0.000865
6.816841	25.	0.	16.	-0.005259
7.114150	22.	0.	17.	0.000773
6.393424	27.	0.	18.	-0.000271
5.981826	26.	0.	19.	-0.002398
6.604228	24.	0.	20.	-0.005676
7.133105	24.	0.	21.	-0.005159
6.371039	25.	0.	22.	-0.000091
6.688293	25.	0.	23.	-0.004215
6.860400	21.	0.	24.	0.000318
6.690185	26.	0.	25.	-0.000982
5.997118	24.	0.	26.	-0.002932
7.197417	22.	0.	27.	-0.001900
6.953088	26.	0.	28.	-0.000391
7.088036	21.	0.	29.	0.000454
6.793632	26.	0.	30.	-0.003550
6.255766	26.	0.	31.	-0.003468
6.725424	25.	0.	32.	-0.000356
6.607188	26.	0.	33.	-0.003207
7.353499	24.	0.	34.	-0.004978
6.789634	23.	0.	35.	0.000282
6.899265	25.	0.	36.	-0.003083
6.761390	26.	0.	37.	-0.003440
6.936168	25.	0.	38.	-0.003584
6.646839	24.	0.	39.	-0.000342
6.269387	25.	0.	40.	-0.002825
7.045433	25.	0.	41.	-0.000056
7.792303	21.	0.	42.	-0.003432
6.820107	24.	0.	43.	-0.005584
5.695804	27.	0.	44.	-0.001607
6.472890	23.	0.	45.	-0.004905
7.429053	22.	0.	46.	-0.007015
5.688618	28.	0.	47.	-0.005079
5.498116	31.	0.	48.	-0.000697
10.372780	12.	0.	49.	-0.005815
6.711045	25.	0.	50.	-0.002443

TABLE(34) AVERAGE SNR = 49.209648

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
5.073970	37.	0.	1.	-0.001493
6.061213	33.	0.	2.	0.000594
5.522857	31.	0.	3.	-0.003089
5.160447	37.	0.	4.	-0.000976
5.647283	33.	0.	5.	-0.000926
5.409139	33.	0.	6.	-0.001065
5.612190	34.	0.	7.	-0.002187
5.945710	29.	0.	8.	-0.000541
5.238477	38.	0.	9.	-0.000977
5.507965	35.	0.	10.	-0.001421
5.789950	34.	0.	11.	0.000791
6.273374	31.	0.	12.	-0.001903
5.918736	32.	0.	13.	0.000577
5.139306	35.	0.	14.	0.000836
5.682376	36.	0.	15.	-0.000150
5.796729	32.	0.	16.	0.000956
6.121377	30.	0.	17.	-0.002197
5.417464	36.	0.	18.	-0.000210
5.076191	34.	0.	19.	0.000700
5.646608	31.	0.	20.	-0.001276
6.113153	31.	0.	21.	-0.000507
5.447526	34.	0.	22.	0.000163
5.702260	33.	0.	23.	-0.001931
5.926322	28.	0.	24.	0.000722
5.702613	35.	0.	25.	-0.000179
5.139344	31.	0.	26.	0.000603
6.193103	29.	0.	27.	-0.000469
5.911828	35.	0.	28.	-0.000817
6.113400	28.	0.	29.	0.000299
5.801927	34.	0.	30.	-0.000526
5.342439	34.	0.	31.	-0.000527
5.743841	34.	0.	32.	-0.001677
5.609242	35.	0.	33.	-0.001036
6.291258	31.	0.	34.	0.000845
5.809309	32.	0.	35.	-0.001730
5.881576	33.	0.	36.	0.000313
5.766196	34.	0.	37.	-0.000637
5.943699	33.	0.	38.	0.000587
5.701968	32.	0.	39.	-0.001201
5.385177	33.	0.	40.	-0.002371
5.978064	34.	0.	41.	-0.000276
6.674245	28.	0.	42.	-0.003555
5.848160	31.	0.	43.	0.000404
4.878965	36.	0.	44.	-0.001881
5.590102	30.	0.	45.	-0.001970
6.390261	29.	0.	46.	-0.003016
4.814046	36.	0.	47.	-0.000523
4.641615	41.	0.	48.	-0.000341
9.955810	13.	0.	49.	-0.016868
5.745857	34.	0.	50.	-0.001183

TABLE(35) AVERAGE SNR = 59.051571

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
4.377389	47.	0.	1.	-0.000349
5.271719	44.	0.	2.	0.000314
4.855147	39.	0.	3.	-0.001296
4.460999	47.	0.	4.	-0.000642
4.920574	42.	0.	5.	-0.000860
4.704947	42.	0.	6.	-0.000691
4.873123	42.	0.	7.	0.000892
5.203474	37.	0.	8.	-0.001667
4.497455	48.	0.	9.	0.000304
4.776051	44.	0.	10.	0.000585
5.019979	44.	0.	11.	-0.000680
5.465269	39.	0.	12.	0.000794
5.179381	42.	0.	13.	-0.000385
4.457927	45.	0.	14.	-0.000375
4.896879	47.	0.	15.	0.000042
5.033889	41.	0.	16.	0.000346
5.370633	38.	0.	17.	-0.000049
4.683740	46.	0.	18.	-0.000215
4.389916	44.	0.	19.	-0.000834
4.932807	39.	0.	20.	0.000075
5.347022	40.	0.	21.	-0.000911
4.729469	44.	0.	22.	0.000273
4.963380	41.	0.	23.	0.000840
5.213764	36.	0.	24.	0.000841
4.944434	45.	0.	25.	0.000666
4.492838	40.	0.	26.	-0.001326
5.438177	37.	0.	27.	0.000003
5.124867	45.	0.	28.	-0.000503
5.375052	36.	0.	29.	0.000440

TABLE(36) AVERAGE SNR = 68.893509

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.816130	57.	0.	1.	0.000808
4.615512	56.	0.	2.	0.000546
4.313514	47.	0.	3.	0.000799
3.903140	57.	0.	4.	0.000052
4.339166	51.	0.	5.	0.000199
4.138644	51.	0.	6.	0.000384
4.281169	52.	0.	7.	0.000187
4.614446	45.	0.	8.	-0.000742
3.906325	59.	0.	9.	0.000420
4.186926	54.	0.	10.	0.000932
4.406425	54.	0.	11.	-0.000161
4.814402	49.	0.	12.	-0.000046
4.573833	52.	0.	13.	0.000465
3.911957	55.	0.	14.	-0.000082
4.258156	58.	0.	15.	0.000966
4.424056	51.	0.	16.	-0.000172
4.760521	47.	0.	17.	0.000619
4.097522	56.	0.	18.	0.000653
3.840627	53.	0.	19.	0.000664
4.359587	48.	0.	20.	0.000185
4.728077	49.	0.	21.	0.000526
4.143264	55.	0.	22.	-0.000083
4.370605	51.	0.	23.	-0.000018
4.631270	45.	0.	24.	0.000441
4.326796	56.	0.	25.	0.000968
3.972850	48.	0.	26.	0.000628
4.827756	46.	0.	27.	-0.000004
4.492032	55.	0.	28.	0.000711
4.773421	45.	0.	29.	0.000263
4.449331	53.	0.	30.	0.000809
4.091274	53.	0.	31.	0.000312
4.390394	53.	0.	32.	0.000884
4.229383	55.	0.	33.	0.000773
4.844006	50.	0.	34.	0.000342
4.434827	51.	0.	35.	0.000247
4.481293	53.	0.	36.	0.000051
4.416687	53.	0.	37.	0.000509
4.550170	54.	0.	38.	0.000675
4.411036	50.	0.	39.	0.000467
4.177545	50.	0.	40.	0.000747
4.523689	54.	0.	41.	0.000467
5.188061	43.	0.	42.	0.000928
4.515630	49.	0.	43.	0.000343
3.744028	55.	0.	44.	0.000395
4.384457	46.	0.	45.	0.000231
4.977231	45.	0.	46.	0.000908
3.640261	55.	0	47.	-0.000016
3.470092	63.	0.	48.	0.000468
9.566791	14.	0.	49.	-0.022381
4.381883	55.	0	50.	0.000178

TABLE(9) AVERAGE SNR =78.735428

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
3.350488	68.	0.	1.	0.000835
4.057685	69.	0.	2.	0.000620
3.854814	57.	0.	3.	0.000366
3.444600	67.	0.	4.	0.000635
3.855899	61.	0.	5.	0.000286
3.667137	61.	0.	6.	0.000333
3.791631	62.	0.	7.	0.000378
4.126457	53.	0.	8.	0.000385
3.421156	70.	0.	9.	0.000756
3.697267	65.	0.	10.	0.000684
3.898839	64.	0.	11.	0.000591
4.273139	59.	0.	12.	0.000221
4.061809	63.	0.	13.	0.000659
3.459802	65.	0.	14.	0.000424
3.724679	71.	0.	15.	0.000379
3.918291	61.	0.	16.	0.000211
4.245831	57.	0.	17.	0.000638
3.612086	67.	0.	18.	0.000688
3.385973	63.	0.	19.	0.000658
3.881908	57.	0.	20.	0.000825
4.206107	60.	0.	21.	0.000186
3.654736	65.	0.	22.	0.000874
3.879170	61.	0.	23.	0.000171
4.139881	54.	0.	24.	0.000919
3.808663	68.	0.	25.	0.000904
3.537986	57.	0.	26.	0.000838
4.314878	55.	0.	27.	0.000835
3.964104	67.	0.	28.	0.000341
4.265975	54.	0.	29.	0.000932
3.944670	64.	0.	30.	0.000785
3.625365	63.	0.	31.	0.000751
3.882276	64.	0.	32.	0.000893
3.719155	66.	0.	33.	0.000754
4.303123	61.	0.	34.	0.000203
3.920494	61.	0.	35.	0.000622
3.962279	63.	0.	36.	0.000764
3.915021	64.	0.	37.	0.000420
4.021127	66.	0.	38.	0.000620
3.924364	60.	0.	39.	0.000878
3.722493	60.	0.	40.	0.000750
3.988779	65.	0.	41.	0.000486
4.636132	52.	0.	42.	0.000936
4.018212	59.	0.	43.	0.000259
3.317536	65.	0.	44.	0.000955
3.930714	55.	0.	45.	0.000455
4.445208	55.	0.	46.	0.000432
3.213614	64.	0.	47.	0.000997
3.038741	75.	0.	48.	0.000504
9.463104	14.	0.	49.	-0.016486
3.866133	66.	0.	50.	0.000745

TABLE(10) AVERAGE SNR =88.577362

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.958873	79.	0.	1.	0.000918
3.579777	82.	0.	2.	0.000891
3.459438	67.	0.	3.	0.000602
3.059096	78.	0.	4.	0.000519
3.445634	71.	0.	5.	0.000630
3.267578	71.	0.	6.	0.000504
3.377978	72.	0.	7.	0.000711
3.710816	62.	0.	8.	0.000412
3.014831	82.	0.	9.	0.000547
3.283566	76.	0.	10.	0.000757
3.468963	75.	0.	11.	0.000637
3.813477	69.	0.	12.	0.000669
3.621266	75.	0.	13.	0.000571
3.078060	75.	0.	14.	0.000840
3.276158	83.	0.	15.	0.000661
3.489793	71.	0.	16.	0.000671
3.802733	68.	0.	17.	0.000384
3.202773	78.	0.	18.	0.000889
3.003777	73.	0.	19.	0.000709
3.473983	67.	0.	20.	0.000672
3.757374	71.	0.	21.	0.000507
3.240461	76.	0.	22.	0.000891
3.462508	71.	0.	23.	0.000545
3.716262	64.	0.	24.	0.000692
3.367337	81.	0.	25.	0.000644
3.166491	67.	0.	26.	0.000373
3.872923	65.	0.	27.	0.000950
3.517356	78.	0.	28.	0.000937
3.828262	64.	0.	29.	0.000850
3.513269	76.	0.	30.	0.000659
3.228714	74.	0.	31.	0.000579
3.448461	76.	0.	32.	0.000630
3.290135	77.	0.	33.	0.000849
3.840518	72.	0.	34.	0.000609
3.485730	71.	0.	35.	0.000904
3.522437	74.	0.	36.	0.000719
3.487883	75.	0.	37.	0.000727
3.568776	78.	0.	38.	0.000880
3.505771	71.	0.	39.	0.000791
3.330769	71.	0.	40.	0.000487
3.538153	76.	0.	41.	0.000717
4.163326	62.	0.	42.	0.000544
3.594229	69.	0.	43.	0.000535
2.953186	76.	0.	44.	0.000825
3.540785	64.	0.	45.	0.000956
3.988721	65.	0.	46.	0.000667
2.854457	74.	0.	47.	0.000967
2.676266	87.	0.	48.	0.000639
9.390097	14.	0.	49.	-0.012362
3.426585	78.	0.	50.	0.000690

TABLE(11) AVERAGE SNR =98.419296

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.626233	90.	0.	1.	0.000933
3.167766	96.	0.	2.	0.000801
3.114451	77.	0.	3.	0.000941
2.731909	88.	0.	4.	0.000895
3.092509	81.	0.	5.	0.000957
2.924955	81.	0.	6.	0.000656
3.023781	82.	0.	7.	0.000993
3.351581	71.	0.	8.	0.000633
2.672093	93.	0.	9.	0.000793
2.929799	87.	0.	10.	0.000865
3.100621	86.	0.	11.	0.000762
3.417119	80.	0.	12.	0.000581
3.239159	87.	0.	13.	0.000705
2.750608	86.	0.	14.	0.000690
2.895644	95.	0.	15.	0.000791
3.121251	82.	0.	16.	0.000554
3.418443	78.	0.	17.	0.000924
2.852350	90.	0.	18.	0.000699
2.678834	83.	0.	19.	0.000700
3.121981	77.	0.	20.	0.000718
3.367224	82.	0.	21.	0.000887
2.886572	87.	0.	22.	0.000917
3.104513	81.	0.	23.	0.000864
3.348005	74.	0.	24.	0.000743
2.990007	93.	0.	25.	0.000900
2.847014	76.	0.	26.	0.000762
3.486693	76.	0.	27.	0.000750
3.132323	91.	0.	28.	0.000686
3.447480	74.	0.	29.	0.000985
3.140291	88.	0.	30.	0.000821
2.888945	84.	0.	31.	0.000985
3.076130	87.	0.	32.	0.000974
2.925455	88.	0.	33.	0.000918
3.438806	84.	0.	34.	0.000675
3.113513	82.	0.	35.	0.000595
3.146023	85.	0.	36.	0.000781
3.118539	87.	0.	37.	0.000690
3.177709	91.	0.	38.	0.000797
3.142760	82.	0.	39.	0.000896
2.991192	81.	0.	40.	0.000960
3.153727	87.	0.	41.	0.000923
3.753343	72.	0.	42.	0.000590
3.228240	79.	0.	43.	0.000828
2.639774	87.	0.	44.	0.000804
3.199788	74.	0.	45.	0.000877
3.590868	76.	0.	46.	0.000515
2.548767	84.	0.	47.	0.000957
2.369545	98.	0.	48.	0.000997
9.336480	14.	0.	49.	-0.009374
3.049736	90.	0.	50.	0.000709

TABLE(12) AVERAGE SNR =108.261200

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.341703	101.	0.	1.	0.000880
2.813632	109.	0.	2.	0.000936
2.810335	88.	0.	3.	0.000864
2.449771	99.	0.	4.	0.000821
2.784625	92.	0.	5.	0.000862
2.628855	91.	0.	6.	0.000735
2.716525	93.	0.	7.	0.000844
3.037878	80.	0.	8.	0.000844
2.379953	104.	0.	9.	0.000892
2.624859	98.	0.	10.	0.000927
2.782291	97.	0.	11.	0.000853
3.074002	90.	0.	12.	0.000942
2.905846	99.	0.	13.	0.000850
2.469040	96.	0.	14.	0.000913
2.571084	107.	0.	15.	0.000805
2.803299	92.	0.	16.	0.000847
3.081276	89.	0.	17.	0.000938
2.551618	101.	0.	18.	0.000859
2.400336	93.	0.	19.	0.000638
2.815687	87.	0.	20.	0.000779
3.024987	94.	0.	21.	0.000871
2.582170	98.	0.	22.	0.000904
2.793146	92.	0.	23.	0.000734
3.025605	84.	0.	24.	0.000834
2.664057	106.	0.	25.	0.000801
2.569459	85.	0.	26.	0.000981
3.147472	87.	0.	27.	0.000765
2.800477	103.	0.	28.	0.000844
3.112847	85.	0.	29.	0.000734
2.814332	101.	0.	30.	0.000772
2.593903	95.	0.	31.	0.000895
2.752816	99.	0.	32.	0.000900
2.612993	99.	0.	33.	0.000923
3.087935	96.	0.	34.	0.000829
2.794135	92.	0.	35.	0.000759
2.821226	96.	0.	36.	0.000832
2.798357	98.	0.	37.	0.000999
2.838773	104.	0.	38.	0.000793
2.826103	93.	0.	39.	0.000985
2.693155	92.	0.	40.	0.000942
2.821915	99.	0.	41.	0.000769
3.394582	82.	0.	42.	0.000728
2.908714	90.	0.	43.	0.000689
2.368442	98.	0.	44.	0.000772
2.899905	84.	0.	45.	0.000945
3.242995	86.	0.	46.	0.000923
2.286093	94.	0.	47.	0.000909
2.106506	110.	0.	48.	0.000934
9.295791	14.	0.	49.	-0.007121
2.725851	101.	0.	50.	0.000962

TABLE(13) AVERAGE SNR =118.103104

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
2.097982	111.	0.	1.	0.000994
2.508007	122.	0.	2.	0.000965
2.542099	99.	0.	3.	0.000842
2.206349	109.	0.	4.	0.000973
2.515352	103.	0.	5.	0.000821
2.371480	101.	0.	6.	0.000743
2.449123	104.	0.	7.	0.000764
2.762050	89.	0.	8.	0.000988
2.129250	115.	0.	9.	0.000896
2.360443	109.	0.	10.	0.000934
2.505529	108.	0.	11.	0.000892
2.773528	101.	0.	12.	0.000889
2.614076	111.	0.	13.	0.000940
2.223690	107.	0.	14.	0.000772
2.293918	118.	0.	15.	0.000927
2.526886	102.	0.	16.	0.000985
2.785006	100.	0.	17.	0.000956
2.291329	112.	0.	18.	0.000921
2.160933	102.	0.	19.	0.000814
2.547692	97.	0.	20.	0.000805
2.724588	106.	0.	21.	0.000876
2.318899	109.	0.	22.	0.000854
2.522392	102.	0.	23.	0.000910
2.742043	94.	0.	24.	0.000894
2.383109	118.	0.	25.	0.000882
2.325840	95.	0.	26.	0.000742
2.848201	98.	0.	27.	0.000818
2.512362	115.	0.	28.	0.000922
2.819367	95.	0.	29.	0.000907
2.529835	113.	0.	30.	0.000954
2.337166	106.	0.	31.	0.000817
2.471716	111.	0.	32.	0.000834
2.343591	110.	0.	33.	0.000875
2.780166	108.	0.	34.	0.000954
2.517677	102.	0.	35.	0.000819
2.539248	107.	0.	36.	0.000848
2.517691	110.	0.	37.	0.000979
2.544987	116.	0.	38.	0.000943
2.547848	105.	0.	39.	0.000791
2.431410	103.	0.	40.	0.000925
2.535444	110.	0.	41.	0.000878
3.078894	92.	0.	42.	0.000844
2.629865	100.	0.	43.	0.000885
2.133412	108.	0.	44.	0.000938
2.633682	95.	0.	45.	0.000740
2.935690	97.	0.	46.	0.000917
2.058795	104.	0.	47.	0.000831
1.881503	121.	0.	48.	0.001000
9.264070	14.	0.	49.	-0.005380
2.444566	113.	0.	50.	0.000863

TABLE(14) AVERAGE SNR =127.945099

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
1.887331	121.	0.	1.	0.000989
2.243664	135.	0.	2.	0.000915
2.304965	110.	0.	3.	0.000820
1.993297	120.	0.	4.	0.000860
2.279736	113.	0.	5.	0.000976
2.147656	110.	0.	6.	0.000919
2.216105	114.	0.	7.	0.000883
2.517252	99.	0.	8.	0.000781
1.913868	125.	0.	9.	0.000993
2.130076	120.	0.	10.	0.000901
2.263780	119.	0.	11.	0.000882
2.510013	112.	0.	12.	0.000837
2.358006	123.	0.	13.	0.000974
2.010548	117.	0.	14.	0.000826
2.055396	129.	0.	15.	0.000923
2.284445	113.	0.	16.	0.000817
2.523896	111.	0.	17.	0.000945
2.064949	123.	0.	18.	0.000911
1.953299	111.	0.	19.	0.000858
2.312209	107.	0.	20.	0.000789
2.460414	118.	0.	21.	0.000853
2.091081	119.	0.	22.	0.000947
2.285162	112.	0.	23.	0.000987
2.491811	104.	0.	24.	0.000903
2.139414	130.	0.	25.	0.000881
2.112908	104.	0.	26.	0.000805
2.583515	109.	0.	27.	0.000843
2.261248	127.	0.	28.	0.000941
2.560396	105.	0.	29.	0.000990
2.279140	126.	0.	30.	0.000922
2.113713	116.	0.	31.	0.000912
2.227447	122.	0.	32.	0.000909
2.111085	120.	0.	33.	0.000967
2.508468	121.	0.	34.	0.000875
2.277049	112.	0.	35.	0.000806
2.293249	118.	0.	36.	0.000828
2.271637	122.	0.	37.	0.000948
2.288945	128.	0.	38.	0.000993
2.305472	115.	0.	39.	0.000996
2.200961	114.	0.	40.	0.000880
2.286188	121.	0.	41.	0.000912
2.800023	102.	0.	42.	0.000910
2.384818	110.	0.	43.	0.000983
1.928265	118.	0.	44.	0.000987
2.398267	105.	0.	45.	0.000849
2.664092	108.	0.	46.	0.000911
1.861957	113.	0.	47.	0.000937
1.687315	132.	0.	48.	0.000976
9.238772	14.	0.	49.	-0.004007
2.201061	124.	0.	50.	0.000909

TABLE(15) AVERAGE SNR =137.787003

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
1.704366	131.	0.	1.	0.000917
2.015373	147.	0.	2.	0.000920
2.095892	120.	0.	3.	0.000928
1.807654	130.	0.	4.	0.000885
2.071035	124.	0.	5.	0.000895
1.951486	119.	0.	6.	0.000978
2.011517	124.	0.	7.	0.000925
2.301026	108.	0.	8.	0.000849
1.727072	135.	0.	9.	0.000999
1.929509	130.	0.	10.	0.000966
2.052762	129.	0.	11.	0.000971
2.279044	122.	0.	12.	0.000928
2.132771	135.	0.	13.	0.000961
1.824811	126.	0.	14.	0.000961
1.850145	139.	0.	15.	0.000979
2.073756	122.	0.	16.	0.000984
2.293240	122.	0.	17.	0.000902
1.868229	133.	0.	18.	0.000986
1.772235	120.	0.	19.	0.000821
2.105498	116.	0.	20.	0.000921
2.228675	129.	0.	21.	0.000935
1.892300	129.	0.	22.	0.000955
2.076458	122.	0.	23.	0.000992
2.270367	114.	0.	24.	0.000874
1.928246	141.	0.	25.	0.000935
1.925304	113.	0.	26.	0.000792
2.349963	119.	0.	27.	0.000994
2.041641	139.	0.	28.	0.000918
2.330240	116.	0.	29.	0.000826
2.059529	138.	0.	30.	0.000979
1.917727	126.	0.	31.	0.000929
2.013772	133.	0.	32.	0.000912
1.908670	130.	0.	33.	0.000971
2.269894	133.	0.	34.	0.000921
2.067521	121.	0.	35.	0.000924
2.078674	128.	0.	36.	0.000918
2.055332	134.	0.	37.	0.000897
2.065138	140.	0.	38.	0.000980
2.091265	126.	0.	39.	0.000936
1.998621	124.	0.	40.	0.000955
2.068344	132.	0.	41.	0.000888
2.552916	112.	0.	42.	0.000923
2.167701	121.	0.	43.	0.000841
1.748501	128.	0.	44.	0.000964
2.188822	115.	0.	45.	0.000901
2.423471	119.	0.	46.	0.000887
1.689867	122.	0.	47.	0.000944
1.518957	143.	0.	48.	0.000900
9.218218	14.	0.	49.	-0.002904
1.988698	135.	0.	50.	0.000887

TABLE(16) AVERAGE SNR =147.628906

MEAN SQURED ERROR	UNFOLDING ITERATIONS	SMOOTHING ITERATIONS	CASE NUMBER	DIFFERENCE ERROR
1.545688	140.	0.	1.	0.000931
1.817761	158.	0.	2.	0.000947
1.910510	130.	0.	3.	0.000959
1.645413	139.	0.	4.	0.000971
1.887395	134.	0.	5.	0.000928
1.778827	128.	0.	6.	0.000966
1.831177	134.	0.	7.	0.000913
2.108637	117.	0.	8.	0.000859
1.564238	145.	0.	9.	0.000949
1.753422	140.	0.	10.	0.000963
1.867105	139.	0.	11.	0.000988
2.075200	132.	0.	12.	0.000949
1.934235	147.	0.	13.	0.000917
1.660562	136.	0.	14.	0.000882
1.671890	149.	0.	15.	0.000953
1.887457	132.	0.	16.	0.000912
2.090003	132.	0.	17.	0.000960
1.695810	143.	0.	18.	0.000985
1.614488	128.	0.	19.	0.000894
1.922720	125.	0.	20.	0.000965
2.024246	140.	0.	21.	0.000941
1.718124	139.	0.	22.	0.000908
1.892210	132.	0.	23.	0.000955
2.074876	123.	0.	24.	0.000967
1.743867	152.	0.	25.	0.000921
1.760355	121.	0.	26.	0.000906
2.141718	130.	0.	27.	0.000924
1.849927	150.	0.	28.	0.000948
2.127962	125.	0.	29.	0.000975
1.865989	150.	0.	30.	0.000980
1.745181	136.	0.	31.	0.000893
1.827227	143.	0.	32.	0.000966
1.731631	140.	0.	33.	0.000920
2.059274	145.	0.	34.	0.000919
1.883523	130.	0.	35.	0.000955
1.890053	138.	0.	36.	0.000934
1.865647	145.	0.	37.	0.000921
1.868959	152.	0.	38.	0.000927
1.903255	136.	0.	39.	0.000969
1.819784	134.	0.	40.	0.000959
1.878180	142.	0.	41.	0.000937
2.333383	122.	0.	42.	0.000901
1.977498	130.	0.	43.	0.000980
1.590406	138.	0.	44.	0.000901
2.002089	125.	0.	45.	0.000905
2.210823	129.	0.	46.	0.000970
1.538717	131.	0.	47.	0.000900
1.374266	152.	0.	48.	0.000972
9.201257	14.	0.	49.	-0.001993
1.803720	145.	0.	50.	0.000925

APPENDIX B

Always-Convergent for Positive Data (Narrow Guassian)

See E.J. Murphy, 1986 M.S. Thesis U.N.O. For Documentation.

```
C        FORTRAN PROGRAM FOR DECONVOLUTION - DCONP.FORXX
C        GM TRANSFORM HAS LARGEST ACTUAL MAGNITUDE OF 1.
C        USES ITERATIVE TECHNIQUE.  HANDLES POSITIVE GOING DATA
C        AUGUST 1984
C        READS DATA FILE FOR20.DAT AND FOR21.DAT
C        WRITES FOR22.DAT TO FOR37.DAT AS STANDARD OUTPUT
C        WRITES FOR38.DAT TO FOR55.DAT AS NON-STANDARD OUTPUT
C        WRITES FOR59.DAT = FOURIER DECON, X AND Y
C        FOR PLOTTER, ORIGINAL WINDOW
C        WRITES FOR60.DAT = LAST SMOOTHING, XY FOR PLOTTER,
C        ORIGINAL WINDOW
C        WRITES FOR61.DAT = FOURIER DECON, 5 NUMBERS/LIN
C        FOR LPT, 2048 PTS
C        WRITES FOR62.DAT = FOURIER DECON, XY FOR
C        PLOTTER, 2048 PTS
C        WRITES FOR63.DAT = IERRH, IERRF
C        G(I) = RESPONSE (APPARATUS) FUNCTION
C        H(I)=BROADENED FUNCTION
```

```
      DIMENSION XX(2048),H(2081,3),GS(256),HO(1000)
      DIMENSION G(2048),GNEW(257),I1OUT(23),QAZ(10000)
      COMPLEX X(2048),GM(257),CAPG(2048),Z(2048)
      COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY
      EXTERNAL FFT
C     RESPONSE AND BROADENED FUNCTIONS ARE READ FROM DATA FILE

      I=1
105   READ(81,7,END=110) G(I)
7     FORMAT (2G)
777   FORMAT(4G)
      I = I + 1
      GOTO 105
110   NG = I - 1
200   FORMAT (1PE16.6)
      I = 1
120   READ(82,7,END=125) HO(I)
      I = I+1
      GOTO 120
125   NHORIG=I-1
      NH =NHORIG
      NHSV = NH
      DO 45 I = 1,NH
45    XX(I) = I-1

C     FIRST MOMENT CALCULATION
      SUM = 0.
      DO 20 I = 1,NG
      GS(I)=G(I)
C     SUM = SUM OF G
C     SUM2 = FIRST MOMENT OF G
20    SUM = SUM+G(I)
C     TYPE 122, SUM
122   FORMAT (' SUM = ',1PE16.6)
C     FIND FIRST MOMENT - FIND ORIGIN
      SUM2 = 0.
      DO 30 I = 1,NG
41    SUM2=SUM2 + I*G(I)
30    CONTINUE
C     TYPE 201,SUM2
201   FORMAT (' SUM2 = ',1PE16.6)
42    SUM2=SUM2/SUM
C40   ISUM2 = SUM2 +0.5
C     TYPE 43
C43   FORMAT (' USE SUM2 OR USER INPUT, 1 OR 2? '$)
C     ACCEPT 71,JSUI
C     GOTO (46,44),JSUI
C44   TYPE 50
C50   FORMAT (' ENTER INDEX OF ORIGIN '$)
C     ACCEPT 7, SUM2
C     NORMALIZE G
48    DO 21 I=1,NG
```

```
C       GS(I)=GS(I)/SUM
21      G(I)=G(I)/SUM
C       PROGRAM SPECIFICATIONS
C49     TYPE 1
C1      FORMAT(' NUMBER OF SMOOTHINGS AND UNFOLDINGS (2I3) ')
C       ACCEPT*, NS, NU
        NU=10
11      FORMAT(2I3)
C       NFT=NUM OF POINTS IN FOURIER DOMAIN FOR INVERSE
C       FILTER = 2048
C       NIT=NO. OF PTS. IN FOUR. DOM. FOR CALC. OF GM, MAX = 256
C       CHOOSE 16,32,64,128,256 - SHOULD BE > 2 * NG IF POSSIBLE
71      FORMAT(I)
        NFT = 2048
C       TYPE 72
C72     FORMAT(' NO. OF PTS. IN TRANSFORM FOR MODIFIED G= '$)
C       ACCEPT 71,NIT
        NIT=32
        DO 80 I=NH+1,NFT
80      XX(I)=I-1
C       TYPE 60
C60     FORMAT(' ONLY SMOOTHINGS 0,S AND U 1 '$)
C       ACCEPT 71,ISU
        ISU=1
        IF (ISU .EQ. 0) GOTO 68
        IF (NU .EQ. 0) GO TO 68
C       TYPE 61
C61     FORMAT(' STANDARD OUTPUT? NO=0 '$)
C       ACCEPT 71,IST
        IST=1
        NNS=0
C       TYPE 62
C62     FORMAT(' HOW MANY NON-STANDARD OUTPUTS? '$)
C       ACCEPT 71,NNS
        IF(NNS.EQ.0) GO TO 68
C       TYPE 63
C63     FORMAT(' TYPE NON-STANDARD ITERATIONS, ONE PER LINE ')
C       ACCEPT 71,(I1OUT(I),I=1,NNS)
68      CONTINUE
C       TAKE FFT OF G
        DO 22 I=1,NG
22      X(I)=CMPLX(G(I),0.)
        ND=NG+1
        DO 54 I=ND,NFT
54      X(I)=CMPLX(0.,0.)
        CALL FFT(NFT,X,CAPG,-1.)
C       TYPE 55,(CAPG(I),I=1,2)
55      FORMAT (1PE16.6,E16.6)
C       PHASE MULT TO GET CAPG CORRESPONDING TO SMALL G
     1  IN RIGHT ORDER
C       USE SHIFT THEOREM TO PUT ORIGIN AT FIRST MOMENT
        Y=2*3.1415926*(SUM2-1)/NFT
```

```
      N21=(NFT/2)+1
      DO 140 I=1,NFT
      IF (I.LT.N21) Z(I)=CMPLX(COS((I-1)*Y),SIN((I-1)*Y))
      IF (I.EQ.N21) Z(I)=CMPLX(COS((NFT/2)*Y),0.)
      IF (I.GT.N21) Z(I)=CMPLX(COS((I-NFT-1)*Y),
     1 SIN((I-NFT-1)*Y))
140   CAPG(I)=CAPG(I)*Z(I)
C     TYPE 7,(CAPG(I),I=1,2)
C     FIND FFT OF GS
      DO 37 I=1,NG
37    X(I)=(CMPLX(GS(I),0.))
      DO 655 I=ND,NIT
655   X(I)=CMPLX(0.,0.)
      CALL FFT(NIT,X,GM,-1.)
C     TYPE 7,CAPG(1)
C     TYPE 71, NIT
      TEMP = CABS(GM(1))
      DO 23 I = 2,(NIT/2) + 1
   23 IF (CABS(GM(I)).GT.TEMP) TEMP = CABS(GM(I))
C     TYPE 79
C79   FORMAT (' DO YOU WANT MAG GM? Y=1,N=2 '$)
C     ACCEPT 71,MGM
      MGM=1
      DO 24 I=1,NIT
      XMAG=CABS(GM(I))/TEMP
      GOTO (81,24),MGM
81    IF (I.GT.((NIT/2)+1)) GOTO 24
C     TYPE 200,XMAG
C     SET IMAGINARY GM TO ZERO
24    GM(I)=CMPLX(XMAG,0.)*(-1)**(I-1)
C     TAKE INVERSE FFT OF GM
      CALL FFT(NIT,GM,X,+1.)
      DO 25 I = 1,NIT
25    GNEW(I) = REAL(X(I))
      NG = NIT + 1
      M = (NIT/2) + 1
      GNEW(1) = GNEW(1)/2.
      GNEW(NG)=GNEW(1)
      NS=1
C     DECONVOLUTION CALCULATION PERFORMED IN SUBROUTINE
31    CALL DCON(NG,NH,NS,M,H,GNEW,CAPG,QAZ,NHORIG,HO)
C     CALL EXIT
      END
C
      SUBROUTINE DCON(NG,NH,NS,M,H,G,CAPG,QAZ,NHORIG,HO)
C     SMOOTHING AND UNFOLDING SUBROUTINE
C     ALWAYS-CONVERGENT ITERATIVE NOISE REMOVAL AND
C     DECONVOLUTION
C     NS = NUMBER OF SMOOTHINGS, >=0
C     NU = NUMBER OF UNFOLDINGS, >=0
C     M = I OF THE PEAK OF G(I)
C     NH = NUMBER OF POINTS OF H
```

```
C         NG = NUMBER OF POINTS OF G
          DIMENSION H(2081,3),G(257),F(2081),HI(2081),
        1 M2(2081),XX(2048),GUS(1000)
          DIMENSION FS(2048),M3(2081),K(2081),
        1 I1OUT(23),GO(2048),ITERAVE(1000)
          DIMENSION XSME(1000),QAZ(10000),HP(1000),
        1 VAR(1000),Q(200),XMSEAVE(1000)
          DIMENSION LOP(1000),SH(1200,1),AN(200)
          COMPLEX CAPG(2048),CAPHF(2048),X(2048)
          COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY
          I=1
776       READ(80,281,END=775)GUS(I)
          I=I+1
          GO TO 776
775       LGUS=I-1
8         NHN=NH
9         XNH = FLOAT(NH)
13        NHEAD = NG - M
14        NTAIL = M - 1
15        NHH1 = NHEAD + NH + 1

          TYPE*,'TYPE IN THE FOLLOWING INFORMATION IN ONE LINE'
          TYPE*,'   0)  IS THE DATA NOISY ? Y=1 , N=0'
          ACCEPT*,IYN
          IF(IYN.EQ.0) NS=0

          TYPE*,'   1)  HOW MANY SNR CASES DO YOU WISH ?
        1 TYPE BEGIN,END,STEP'
          TYPE*,'   2)  HOW MANY CASES FOR EACH SNR ?'
          TYPE*,'   3)  NUMBER OF SMOOTHING ITERATIONS ?
        1 BEGIN,END'
          TYPE*,'   4)  RESULT OF EACH SNR CASE TO BE
        1 STARTED AT ? I4OUT'
          TYPE*,'   5)  MAX UNFOLDING ITERATION ? NU'
          type*,'   6)  snr  sd desired ?  '
          TYPE*,'   7)  WHAT CASE DO YOU WHISH? IBN,INN'
          ACCEPT*,ITRB,ITREN,ITRST,N,ILB,ILE,I4OUT,NU,ds,IBN,INN

          DO 660 ITRUESNR=ITRB,ITREN,ITRST
          NH=NHORIG
C         TYPE*,'N=?'
C         ACCEPT*,N
          JRAN=777
          I=1
          IY=0
          CALL AMINI(IY,HO,NH,1.,0,1,JRAN,SNR,QAZ,itruesnr,I,ds)
          I=0.
          OLDSNR=SNR
          SF=(OLDSNR/ITRUESNR)**2
          SF=SF-0.1
          JRAN=777
          DO 661 JN=1,N
```

```
921     CALL AMINI(IY,HO,NH,SF,IOUT,JN,JRAN,SNR,QAZ,
      1 itruesnr,I,ds)

        BAD=',SNR
        IF(IY.EQ.0)go to 921
661     AN(JN)=SNR
        P=0.
        DO 333 IA=1,N
333     P=AN(IA)+P
        AVRSNR=P/N
        TYPE*,AVRSNR
        JIJI=1
        DO 665 INC=IBN,INN
        NH=NHORIG
        IQA=(INC*NH)-(NH-1)
        IWS=INC*NH
        L=1
        DO 664 IED=IQA,IWS
        H(L,1)=QAZ(IED)
664     L=L+1
        WRITE(7,1001)(I,H(I,1),I=1,NHN)
16      DO 19 IH = 1,NH
17      IH1 = NHH1 - IH
18      IH2 = NH + 1 - IH
19      H(IH1,1) = H(IH2,1)
20      NH = NH + NHEAD + NTAIL
21      DO 22 IH3 = 1,NHEAD
22      H(IH3,1) = 0.0
23      DO 24 IH4 = NHH1,NH
24      H(IH4,1) = 0.
55      XNHI = 1./XNH
60      ERRH = 0.
C       HI = RECIPROCAL ARRAY OF H
65      DO 69 I3 = 1,NH
        IF (H(I3,1)) 68,67,68
67      HI(I3) = 0.
        GOTO 69
68      HI(I3) = 1./H(I3,1)
69      CONTINUE

        DO 654 IK=1,NH
654     SH(IK,1)=H(IK,1)

        DO 666 IL=ILB,ILE
        NS=IL

        DO 653 IK=1,NH
653     H(IK,1)=SH(IK,1)

C       PERFORM THE SMOOTHINGS
70      DO 130 I3=1,NH
```

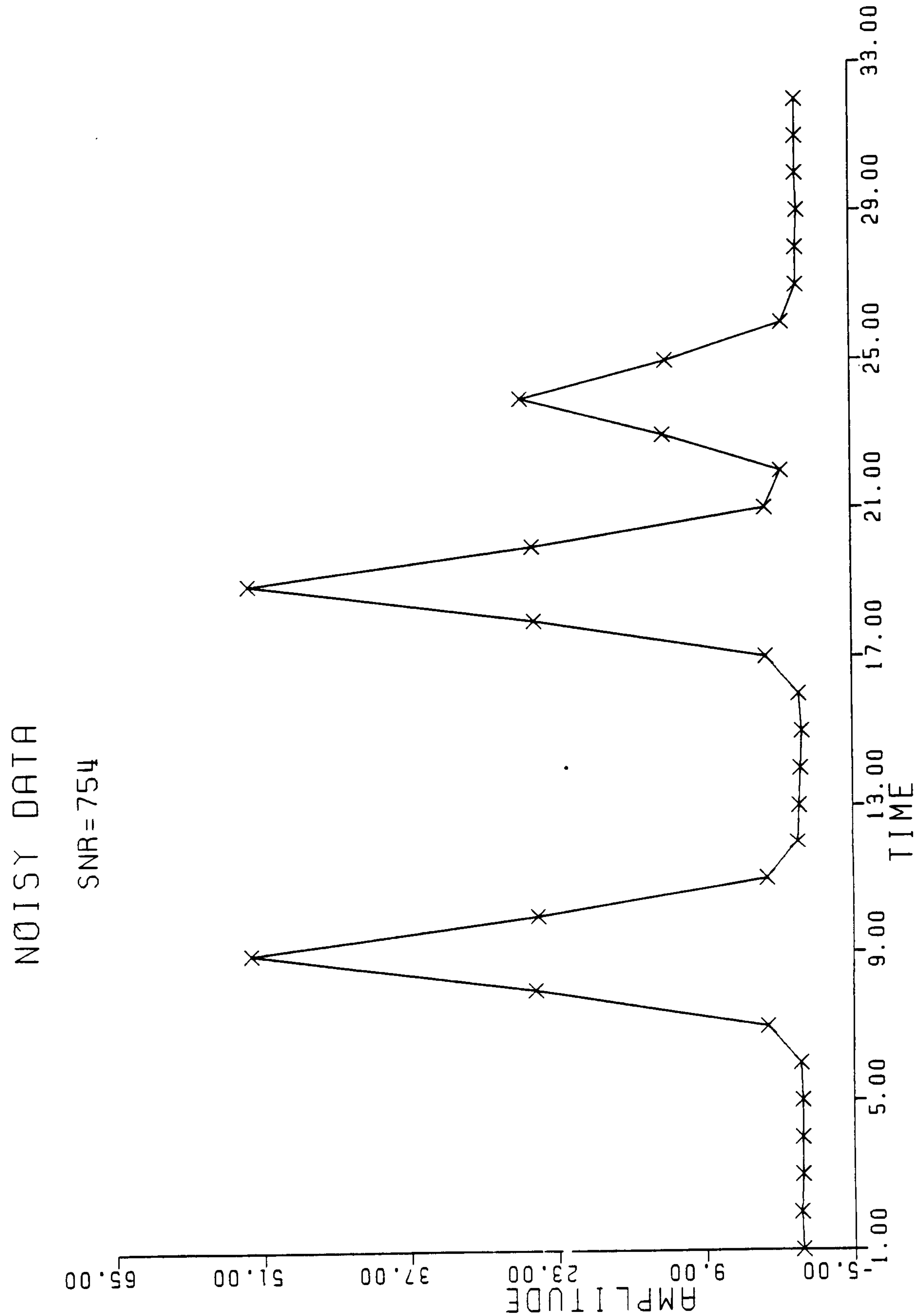
```
        H(I3,2) = 0.
 75     M1 = I3 - M + 1
 80     M2(I3) = MAX0(M1,1)
 85     M3(I3) = MIN0((I3 + NG - M),NH)
 90     K(I3) = MAX0(1,(2-M1))
 95     M4 = M2(I3)
 100    M5 = M3(I3)
 105    K1 = K(I3)
 110    DO 120 I4 = M4,M5
 115    H(I3,2) = H(I4,1) * G(K1) + H(I3,2)
 120    K1 = K1 + 1
 130    ERRH = ABS((H(I3,2) - H(I3,1))*HI(I3)) + ERRH
 135    ERRH = ERRH * XNHI
 C      SKIP SMOOTINGS AND PUT H BACK IF REQUESTED
        IF (NS.NE.0) GOTO 500
        DO 310 I = 1,NH
        H(I,3) = H(I,1)
 310    H(I,2) = H(I,1)
        GOTO 320
 500    I=1
 C      TYPE 136, I, ERRH
 C      WRITE(63,136) I,ERRH
 136    FORMAT(' ITERATION     ERRH/F'/I5,6X,1PE16.6)
        IF(NS.NE.1) GO TO 140
        DO 330 I=1,NH
 330    H(I,3)=H(I,2)
        GO TO 320
 140    DO 200 I5 = 2,NS
 145    ERRH = 0.
 150    DO 195 I6 = 1,NH
 155    H(I6,3) = H(I6,2)
 160    M4 = M2(I6)
 165    M5 = M3(I6)
 170    K1 = K(I6)
 175    DO 185 I7 = M4,M5
 180    H(I6,3) = (H(I7,1) - H(I7,2))*G(K1) + H(I6,3)
 185    K1 = K1 + 1
        ERRH = ABS((H(I6,3) - H(I6,2))*HI(I6)) + ERRH
        H(I6,2) = H(I6,3)
 195    CONTINUE
        ERRH = ERRH * XNHI
 C      DO 196 I = 1,NH
 C196   H(I,2) = H(I,3)
        I=I5
 C      TYPE 405, I, ERRH
 C      WRITE(63,405) I,ERRH
 200    CONTINUE
 405    FORMAT(I5,6X,1PE16.6)
 320    CONTINUE
        IF(ISU.EQ.0) GO TO 290
 C      CALCULATE INVERSE FILTERED F
        DO 201 K2=1,NH
```

```
201     X(K2)=CMPLX(H(K2,3),0.)
        K3=NH+1
        DO 202 K4=K3,NFT
202     X(K4)=CMPLX(0.,0.)
        CALL FFT(NFT,X,CAPHF,-1.)
        DO 204 K5 = 1,NFT
        IF (CAPG(K5).EQ.CMPLX(0.0,0.0)) GOTO 203
        CAPHF(K5) = CAPHF(K5)/CAPG(K5)
C       CAPG(0) = 1 SO AREAS ARE PRESERVED
        GOTO 204
203     CAPHF(K5) = CMPLX(0.0,0.0)
204     CONTINUE
        CALL FFT(NFT,CAPHF,X,+1.)
        NFT2=NFT/2
        NIT2=NIT/2
        SUMF=0
C       FIND WHAT PERCENTAGES OF F ARE IN VARIOUS WINDOWS
        DO 340 I=1,NFT
        FS(I)=REAL(X(I))
340     CONTINUE
C       CLOSE(UNIT=59)
C       CLOSE(UNIT=61)
C       CLOSE(UNIT=62)
        IF(NU.EQ.0) GOTO 290
C       PERFORM THE UNFOLDINGS
C       IOUT AND I2OUT ARE OUTPUT DATA FILE NUMBERS
211     IOUT=22
        I2OUT=38
        IJ=1
        II=1
        WRITE(2,1001)(I,H(I+NHEAD,3),I=1,NHN)
        XTEMP=(10.01)**25
        XSME(ILB)=(10.01)**25
215     DO 285 I9 = 1,NU
220     ERRF = 0.
225     DO 280 I10 = 1,NH
240     F(I10)=H(I10,2)
245     M4 = M2(I10)
250     M5 = M3(I10)
255     K1 = K(I10)
260     DO 270 I11 = M4,M5
265     F(I10) = (FS(I11)-H(I11,2))*G(K1) + F(I10)
270     K1 = K1 + 1
275     F(I10) = AMAX1(F(I10),0.)
        ERRF = (ABS(F(I10)-H(I10,2))*HI(I10))+ERRF
C       POINT SUCCESSIVE
        H(I10,2)=F(I10)
280     CONTINUE
        ERRF = ERRF * XNHI
        I=I9
        IF(IST.EQ.0) GO TO 282
c       WRITE(2,281)(F(I+NIT2),I=1,NHN)
```

```
281     FORMAT(G)

        DO 999 J=LGUS+1,NHN
999     GUS(J)=0.
        XMSE=0.
        DO 998 J=1,NHN
C       TYPE*,F(J+NIT2+4),GUS(J)
998     XMSE=XMSE+(F(J+NIT2+4)-GUS(J))**2
C       TYPE*,'    ',XMSE,I9
        DIF=XTEMP-XMSE
        IF(DIF.LE.0.05)GO TO 990
        IF(XTEMP.LE.XMSE)GO TO 990
555     XTEMP=XMSE

        II=II+1
282     IF(NNS.EQ.0) GO TO 285
        IF(I.NE.I1OUT(IJ))GO TO 285
        IJ=IJ+1
285     CONTINUE
990     CONTINUE
c        TYPE*,XTEMP,I9-1,NS
        XSME(IL+1)=XTEMP
        LOP(IL+1)=I9-1
        IF(XSME(IL+1).GT.XSME(IL)) GO TO 291
1001    FORMAT(2X,I3,10X,G)
C       WRITE(I3OUT,*)XTEMP,I9-1,NS
        WRITE(3,1001)(I,F(I+NIT2+4),I=1,NHN)
C290    WRITE(60,281)(XX(I),H(I+NHEAD,3),I=1,NHN)
290     GO TO 666
666     CONTINUE
291     TYPE*,XSME(IL),LOP(IL),IL-1,INC,AVRSNR,DIF
C       WRITE(I4OUT,*)XSME(IL),LOP(IL),IL-1,INC,AVRSNR,DIF
        ITERAVE(JIJI)=I9-1
        XMSEAVE(JIJI)=XSME(IL)
665     JIJI=JIJI+1
        CLOSE(UNIT=I4OUT)
        I4OUT=I4OUT+1
        SNRAVRG=ALOG(AVRSNR)
        PLO=0
        OLP=0
        DO 659 IAVER=1,N
        PLO=PLO+ITERAVE(IAVER)
659     OLP=OLP+XMSEAVE(IAVER)
        AVRGITER=PLO/N
        AVRGMSE=OLP/N
C       WRITE(83,658)SNRAVRG,AVRGITER
C       WRITE(84,658)SNRAVRG,AVRGMSE
658     FORMAT(2G)
660     CONTINUE
C       write(2,281)(f(i+nit2),i=1,nhn)
300     RETURN
        END
```

```
C
      SUBROUTINE FFT(N,X,Y,SIGN)
C     COMPUTES FORWARD OR INVERSE FOURIER TRANSFORM
C     FOR ANY SET
C     OF DISCRETE DATA POINTS.
C     N = NUMBER OF DATA POINTS = POWER OF TWO
C     SIGN: -1 FOR A FORWARD TRANSFORM AND +1 FOR
C     AN INVERSE TRANSFORM
C     X = ORIGINAL DATA
C     Y = FOURIER TRANSFORM OF DATA
C     BOTH X AND Y ARE COMPLEX NUMBERS
      COMPLEX W,X(256),Y(256)
      INTEGER R
C     CALCULATIONS
      N2 = N/2
      FLTN = N
      NSTAGE = IFIX(ALOG(FLTN)/ALOG(2.))
      PHI2N = 6.283185307179586/FLTN
      DO 3 J = 1,NSTAGE
      N2J = N/(2**J)
      NR = N2J
      NI = (2**J)/2
      DO 2 I = 1,NI
      IN2J = (I-1)*N2J
      FLIN2J = IN2J
      TEMP = FLIN2J*PHI2N*SIGN
      W = CMPLX(COS(TEMP),SIN(TEMP))
      DO 2 R = 1,NR
      ISUB = R + IN2J
      ISUB1 = R + IN2J*2
      ISUB2 = ISUB1 + N2J
      ISUB3 = ISUB + N2
      Y(ISUB) = X(ISUB1) + W*X(ISUB2)
      Y(ISUB3) = X(ISUB1) - W*X(ISUB2)
 2    CONTINUE
      DO 3 R = 1,N
 3    X(R) = Y(R)
C     FACTOR OF (1/N) IN INVERSE TRANSFORM
      IF (SIGN.LT.0.) GOTO 5
      DO 4 R = 1,N
 4    Y(R) = Y(R)/FLTN
 5    RETURN
      END

      SUBROUTINE AMINI(k,H,NH,SF,IOUT,JN,JRAN,SNR,QAZ,itruesnr,I
      DIMENSION H(1000),HP(1000),VAR(1000),Q(1000),QAZ(10000)
 15   FORMAT (G)
      RMS = 0.
      AMAX = ABS(H(1))
      SD = SQRT(SF)
      DO 230  I = 1, NH
      k=0
```

```
        IF (ABS(H(I)).GT.AMAX) AMAX = ABS(H(I))

        CALL GAUSS(SD,H(I),HP(I),JRAN)
        RMS = (HP(I) - H(I))**2 + RMS
230     CONTINUE
        RMS = SQRT(RMS/(NH+1))
        SNR = AM[AAX/RMS
c       type*,snr
c       write(1,15)snr

c       IF(ITRUESNR.GT.70) DS=20
        IF(L.EQ.1) go to 432
        IF(snr.GT.(itruesnr+DS))go to 999
        IF(snr.LT.(itruesnr-DS))go to 999
c       WRITE (IOUT,15) (HP(I),I=1,NH)
432     IBG=(NH*JN)-(NH-1)
        IED=NH*JN
        L=1
        DO 888 ICA=IBG,IED
        QAZ(ICA)=HP(L)
888     L=L+1
C       type*,snr
        k=1
999     RETURN
        END

        SUBROUTINE GAUSS(S,AM,V,JRAN)

        A=0.0
        DO 1 I=1,12
1       A=A+RAN(JRAN)
        V=(A-6.0)*S+AM
        RETURN
        END
```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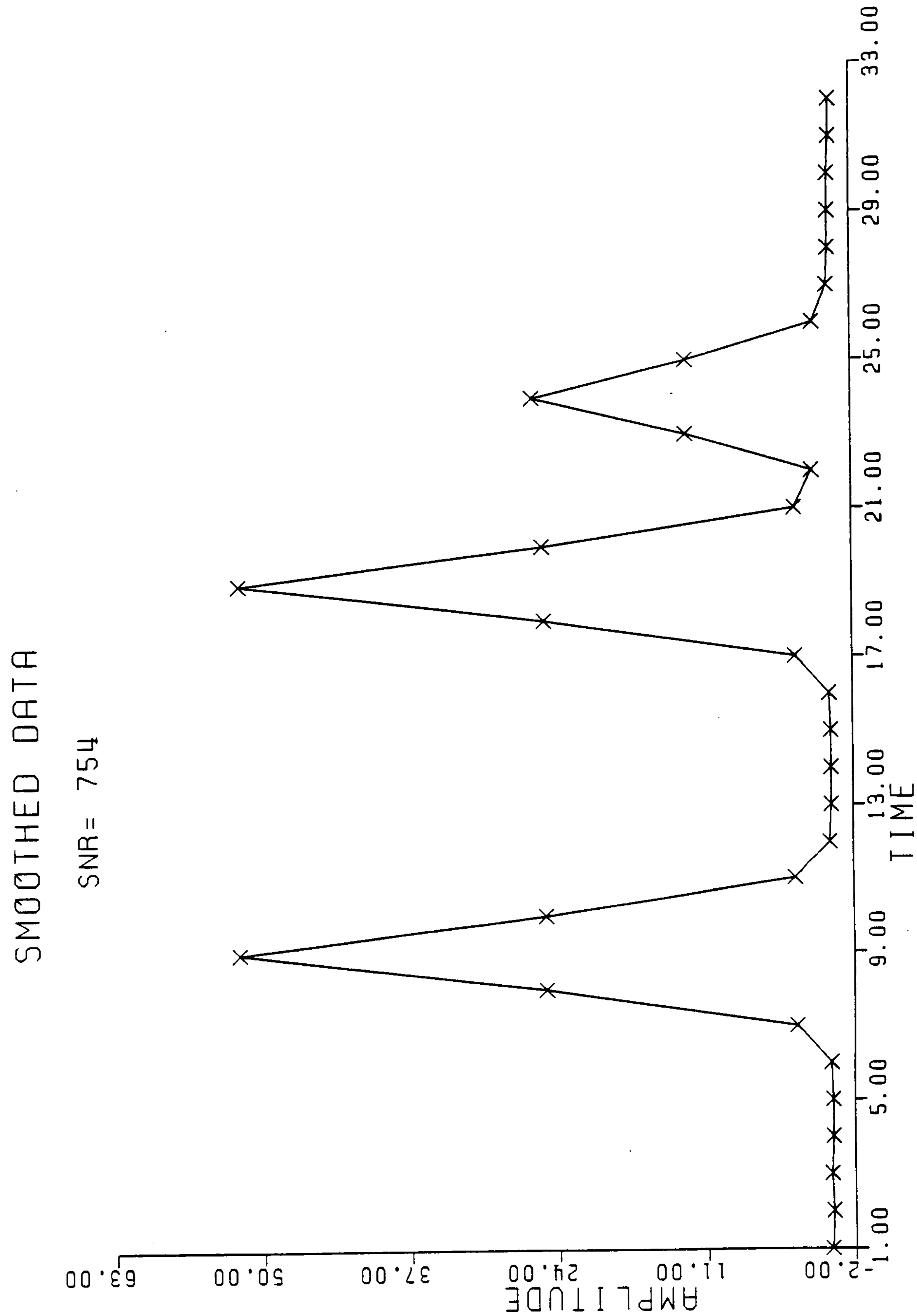
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AMPLITUDE
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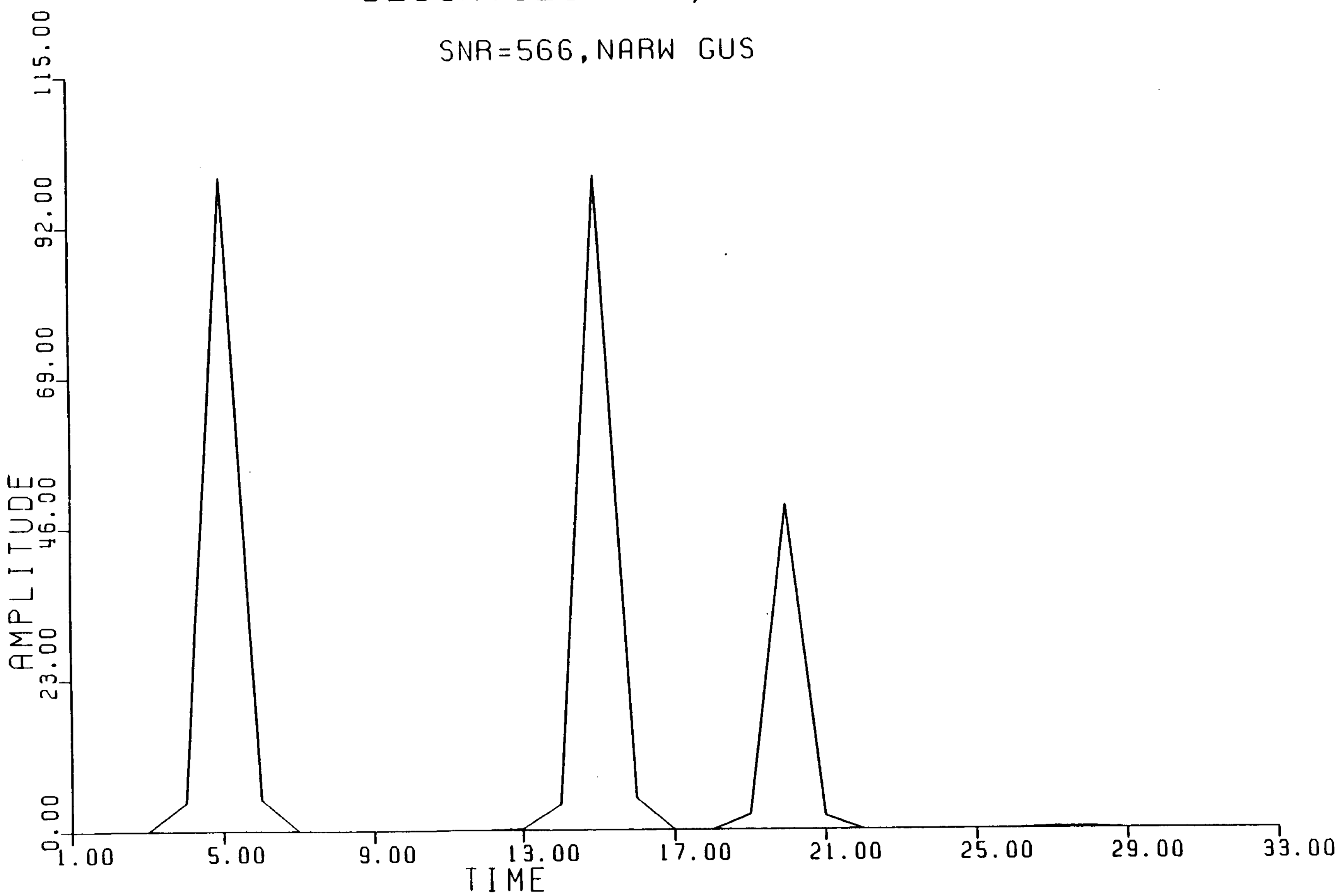
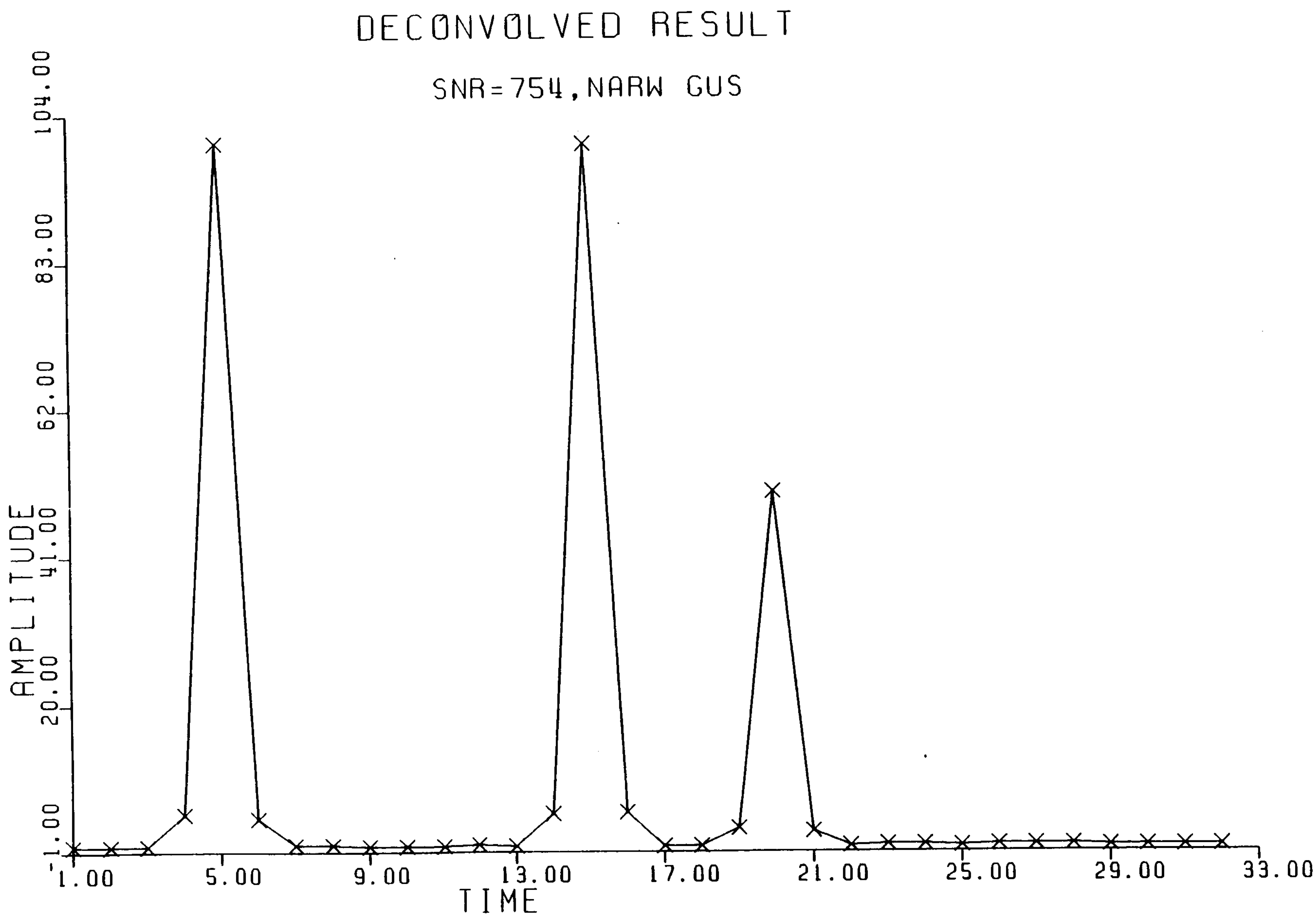
SNR=566,NARW GUS

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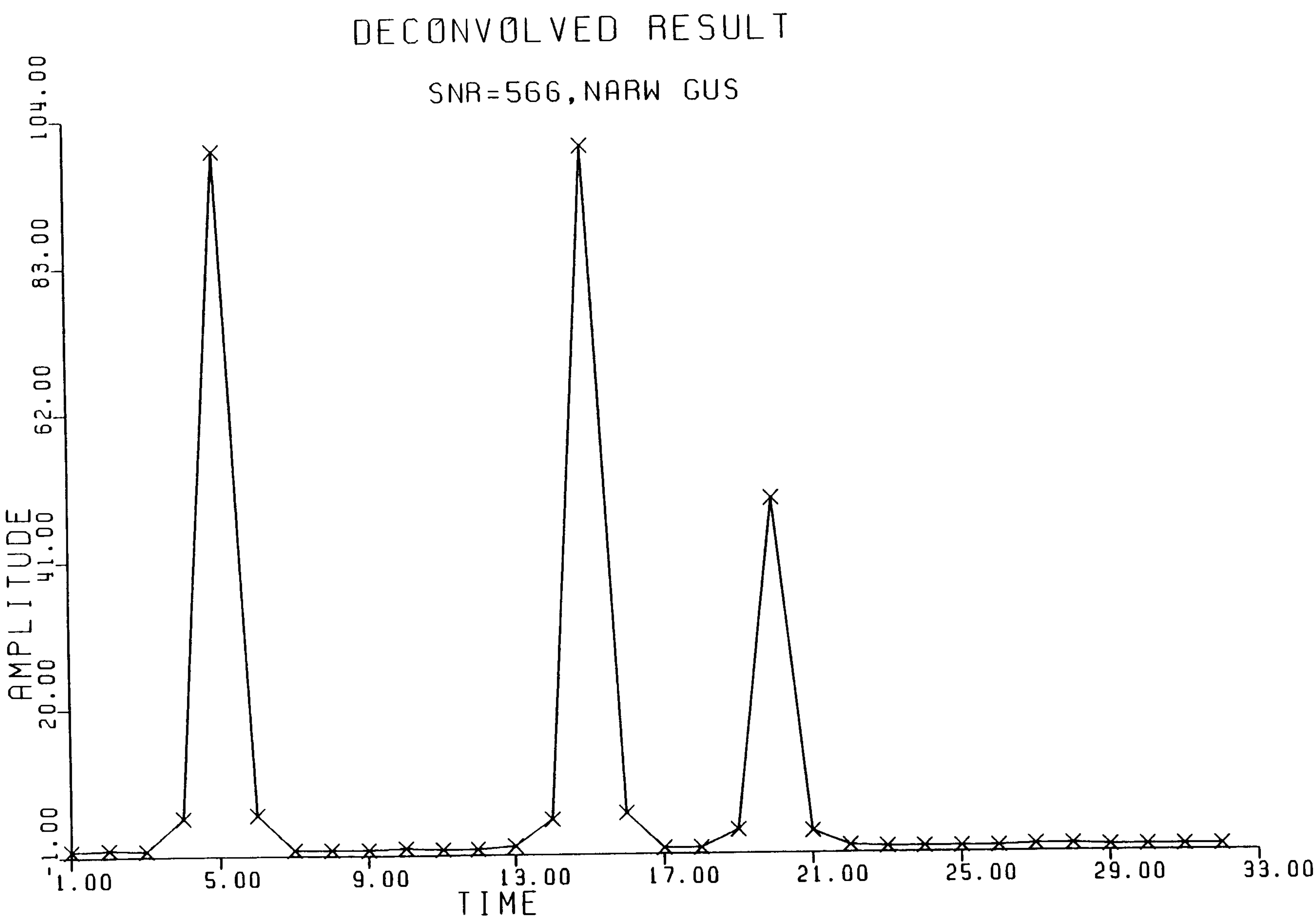
41.00
20.00
-1.00
1.00
5.00
9.00
13.00
17.00
21.00
25.00
29.00
33.00
TIME


DECONVOLVED RESULT
SNR=566,NARW GUS
AMPLITUDE
104.00
83.00
62.00
41.00
20.00
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TIME
1.00
5.00
9.00
13.00
17.00
21.00
25.00
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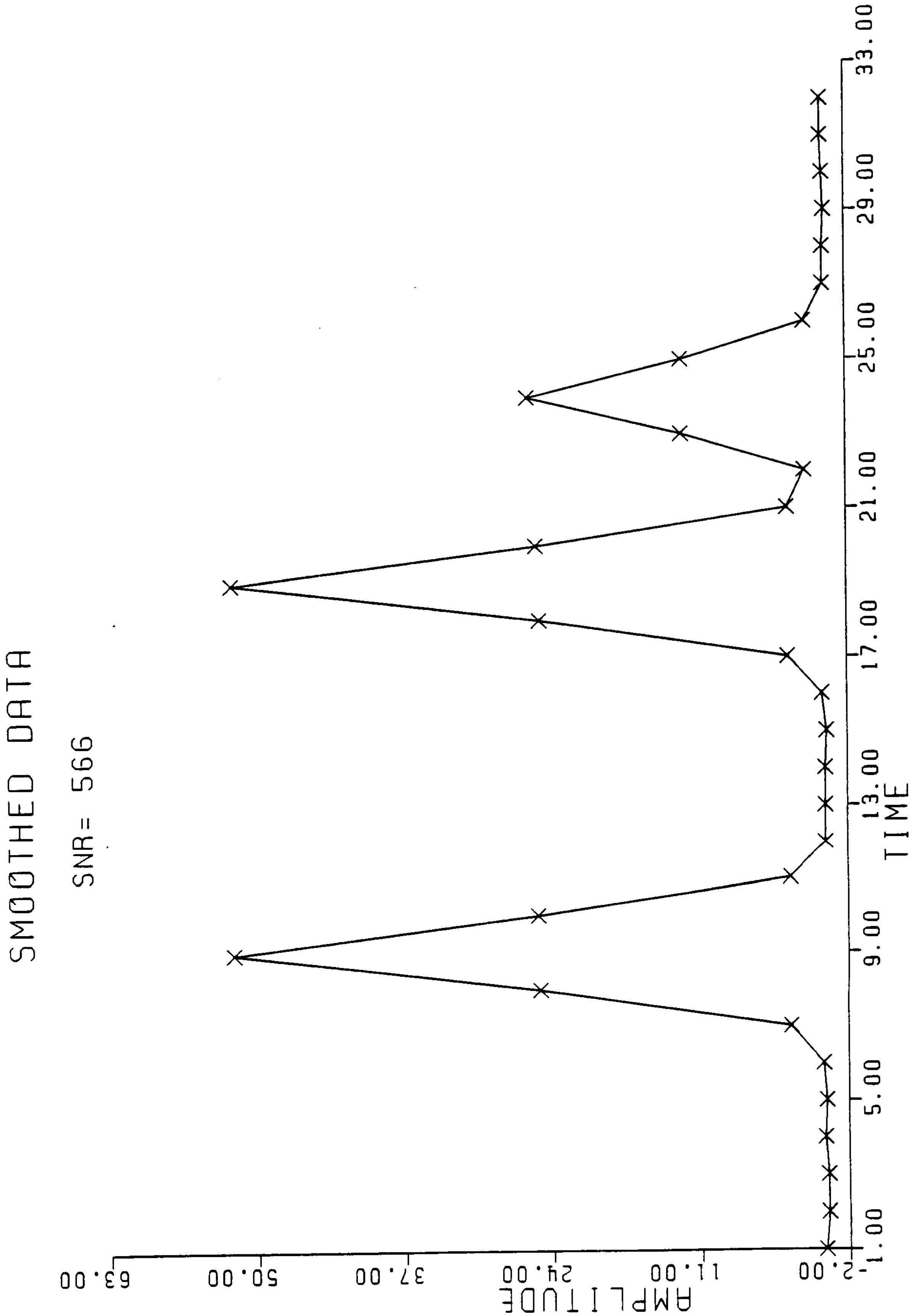
33.00



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33.00
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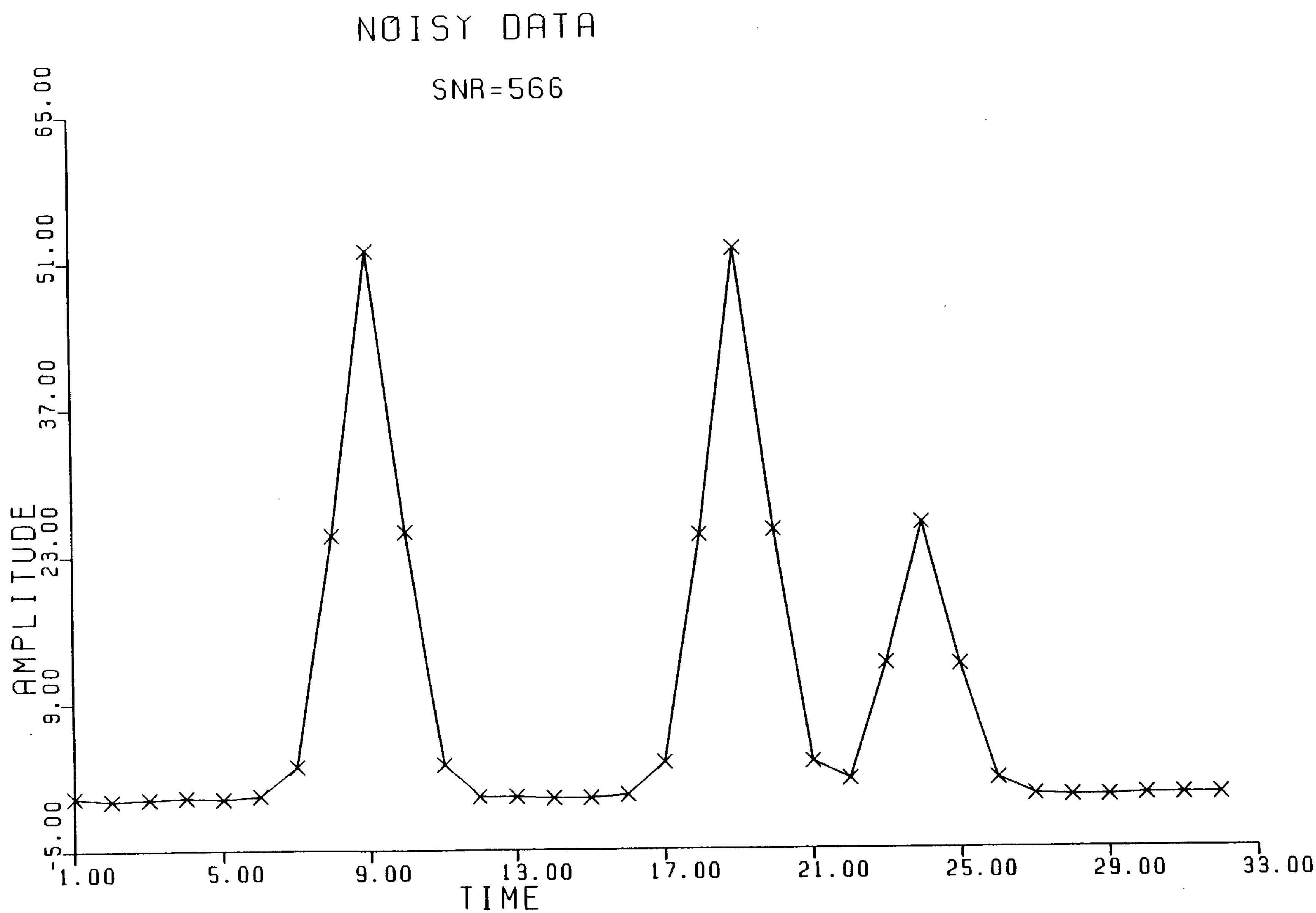
24.00
37.00
50.00
63.00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9.00
13.00
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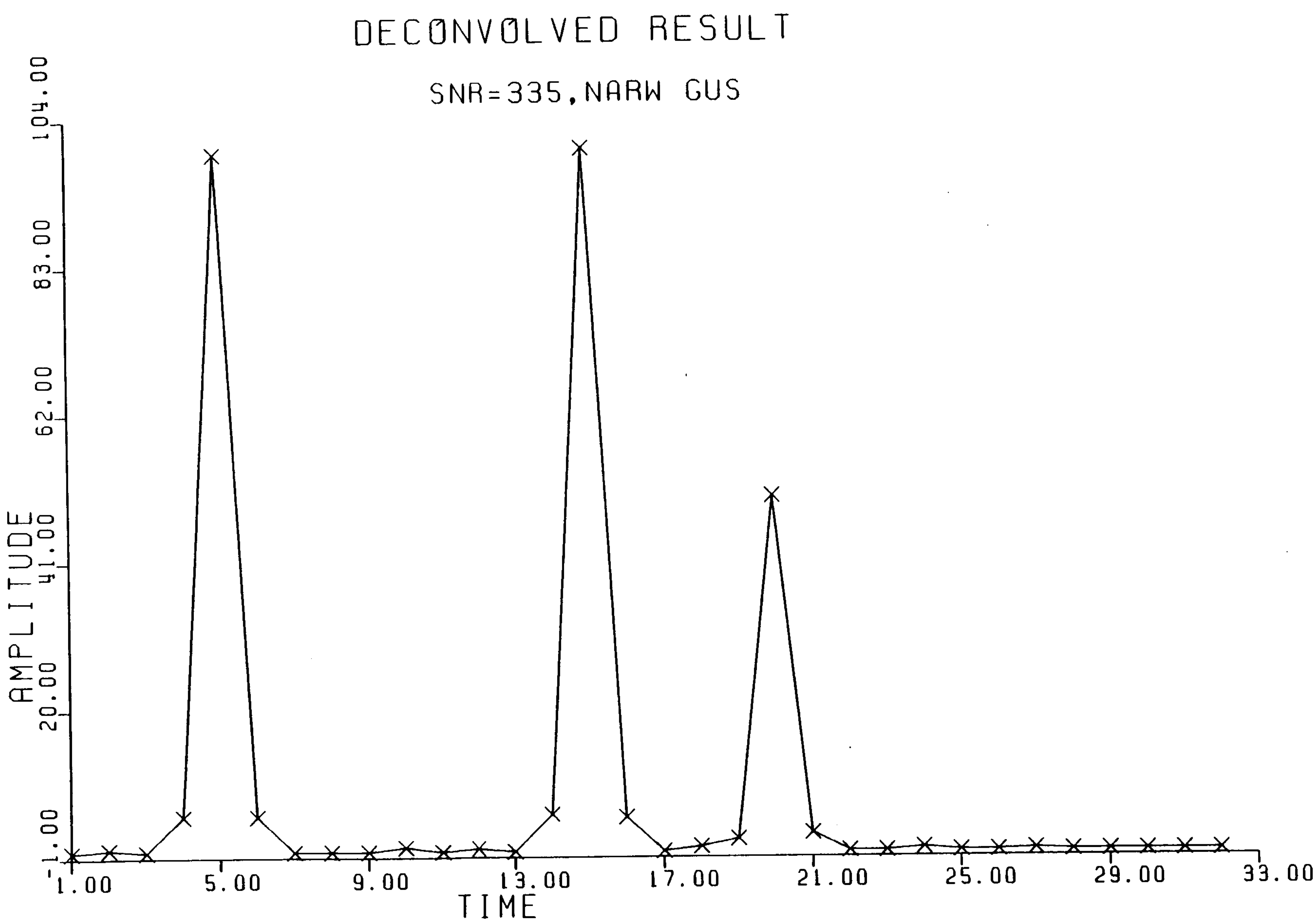
21.00
25.00
29.00
33.00
TIME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41.00
62.00
83.00
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TIME
1.00
5.00
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25.00
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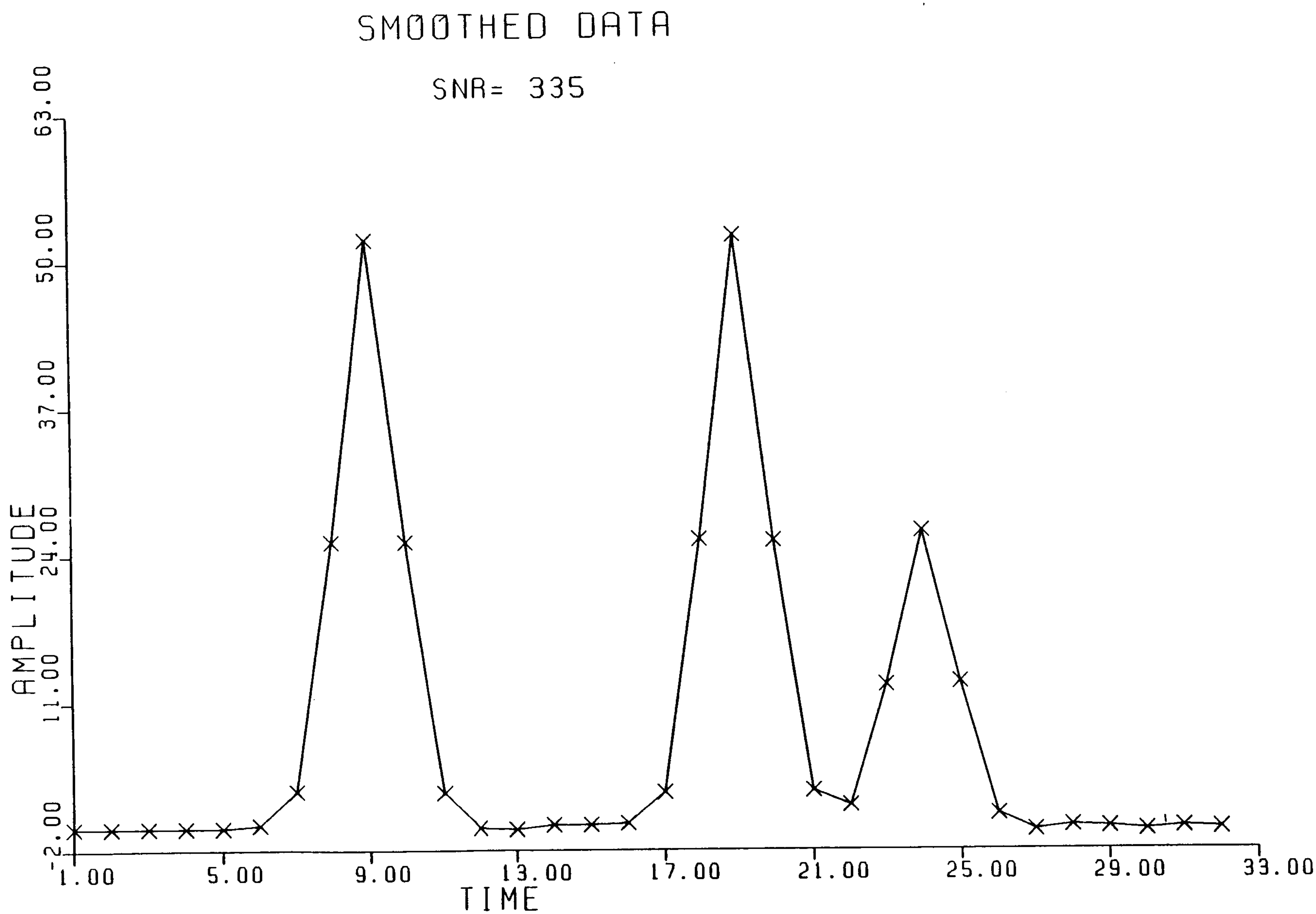
33.00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1.00
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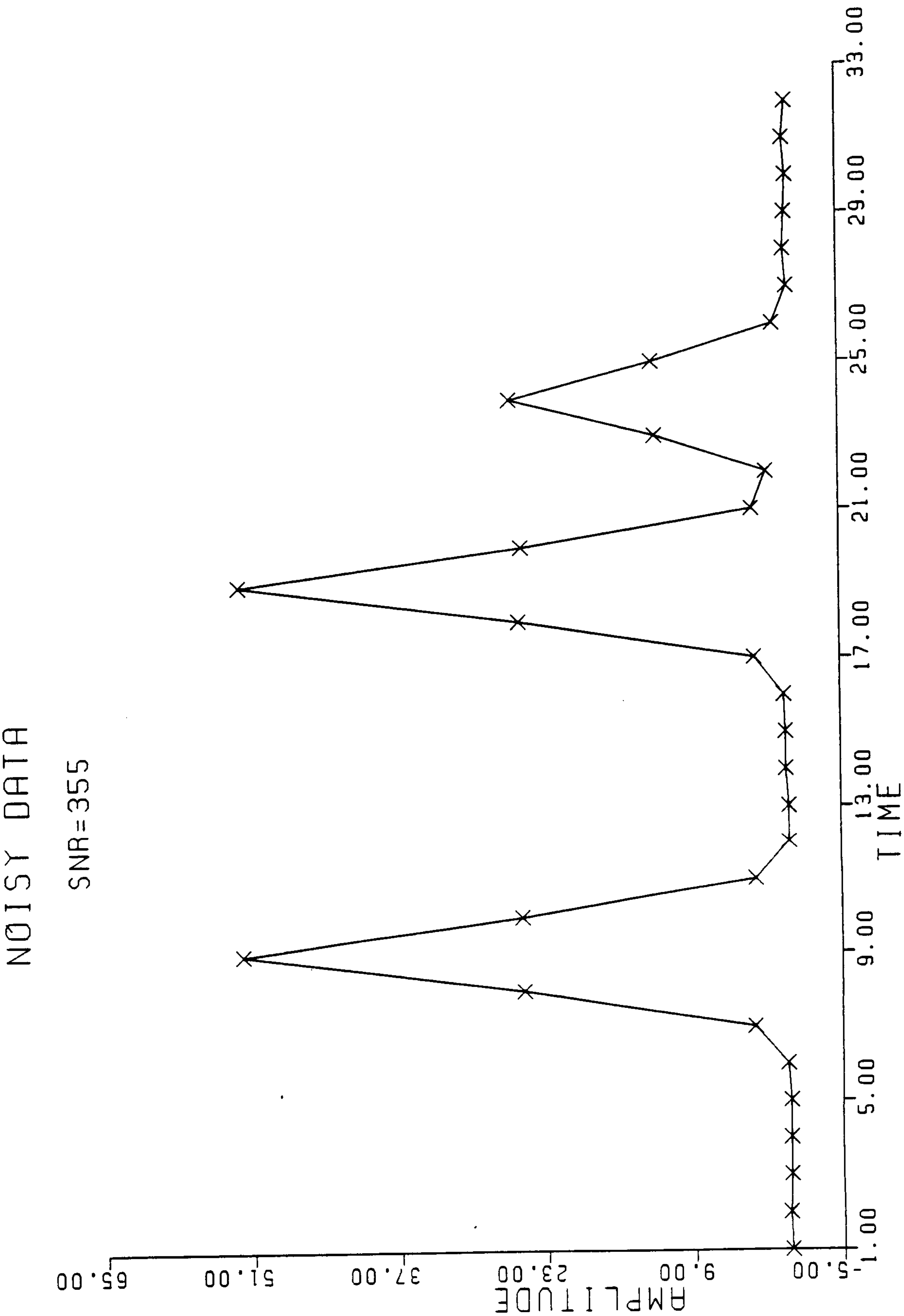
21.00
25.00
29.00
33.00
TIME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AMPLITUDE
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1.00
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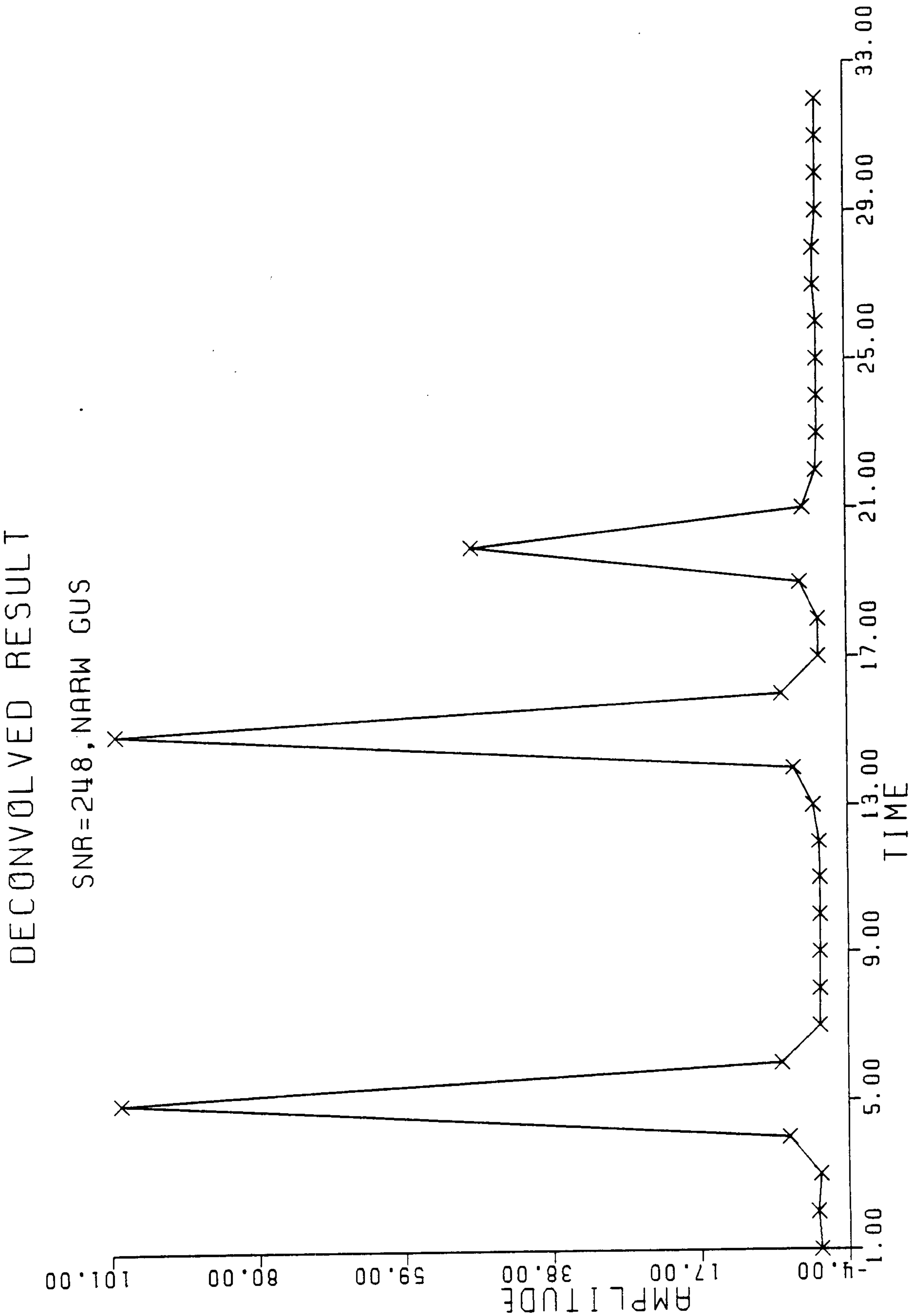
25.00
29.00
33.00



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33.00
AMPLITUDE
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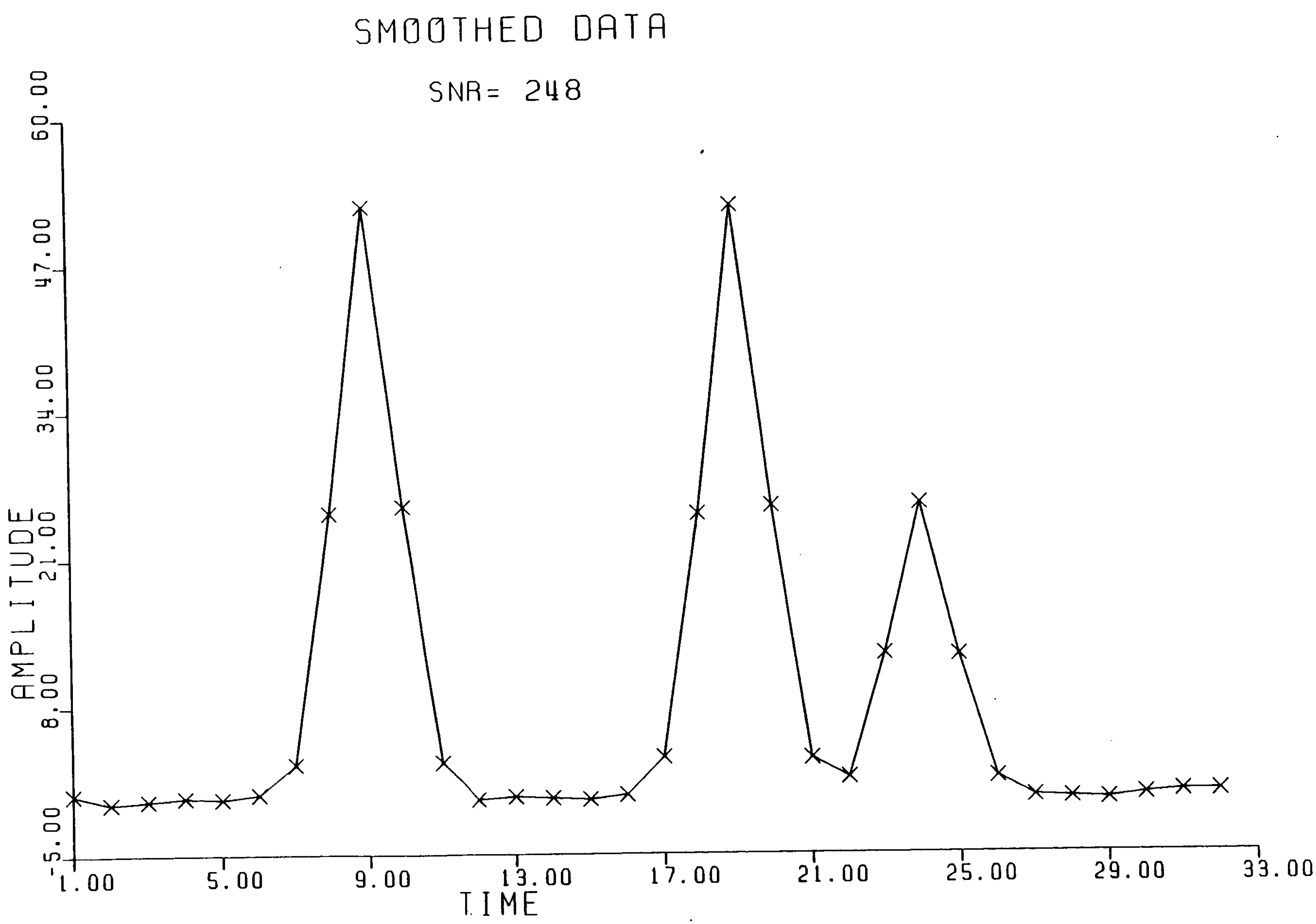
59.00
80.00
101.00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SNR= 248
AMPLITUDE
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TIME
1.00
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25.00
29.00
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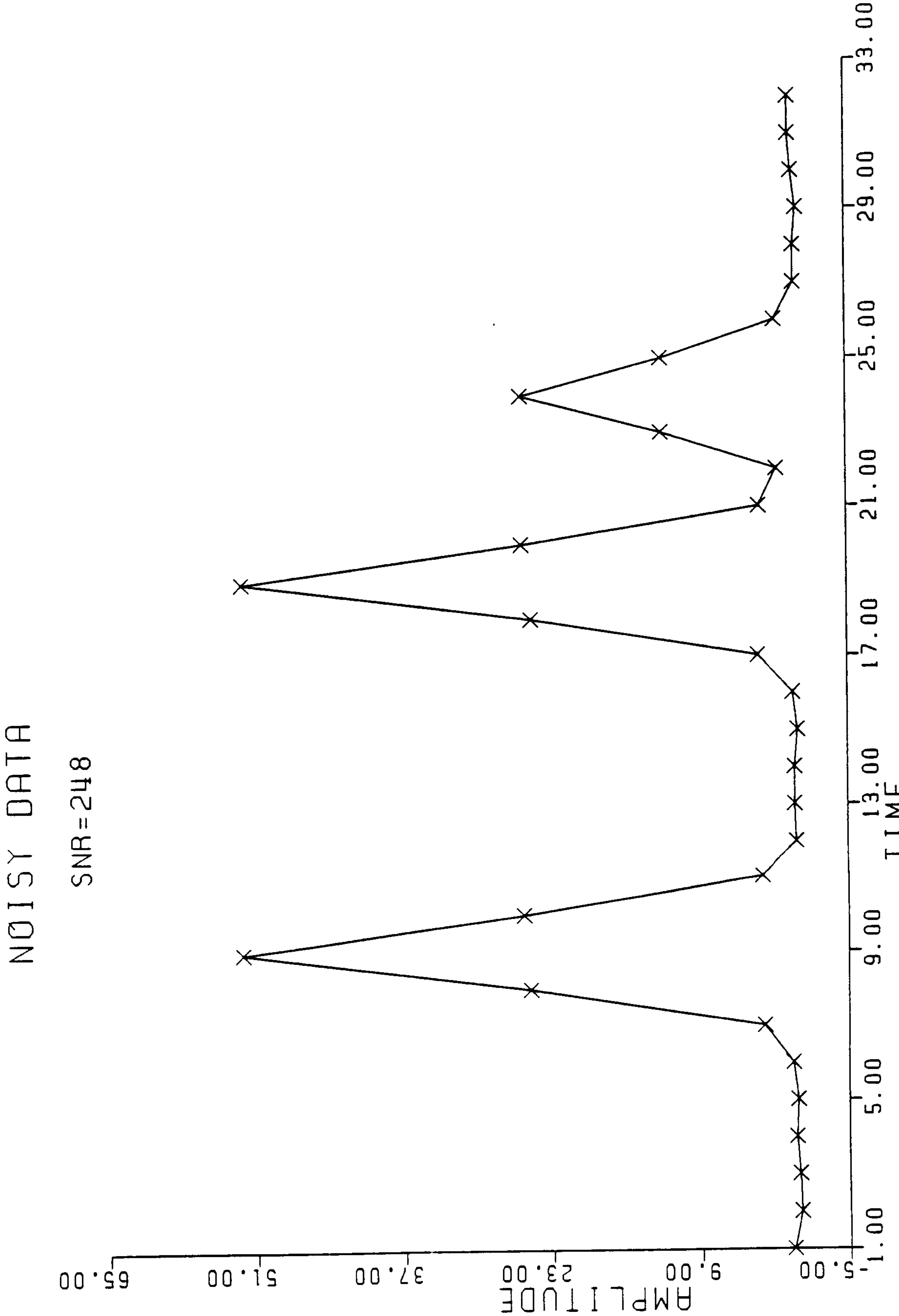
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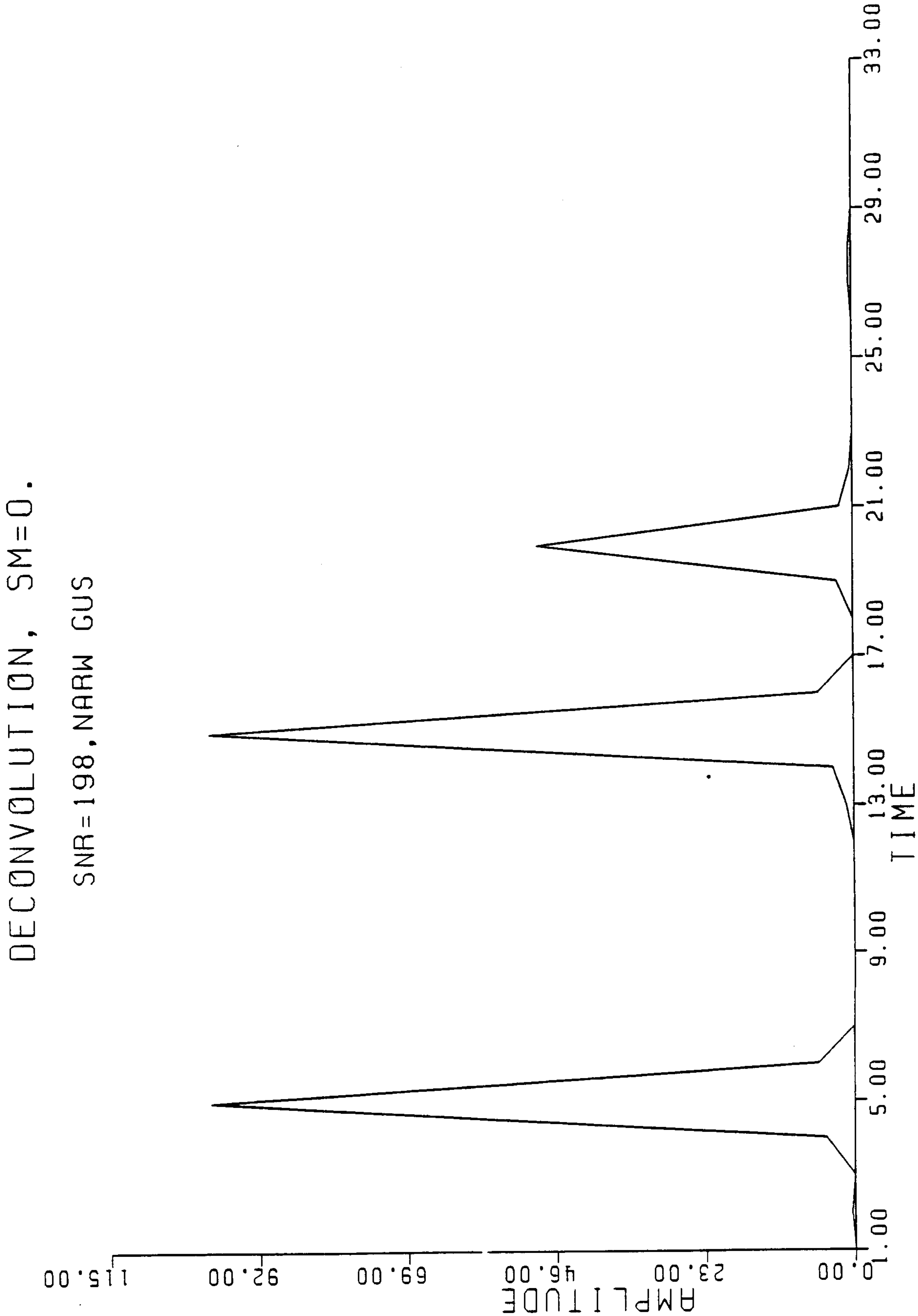
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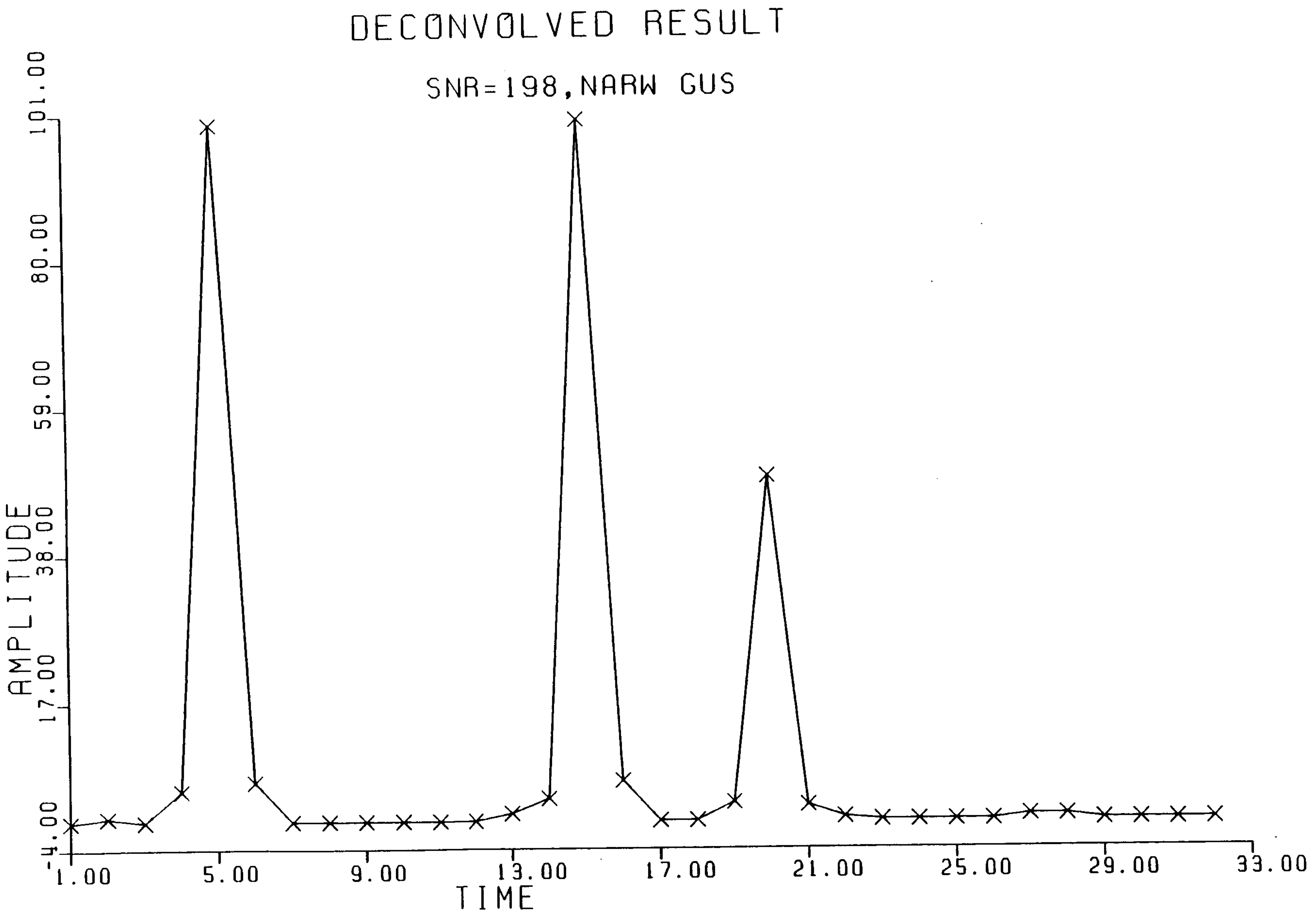
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AMPLITUDE
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TIME
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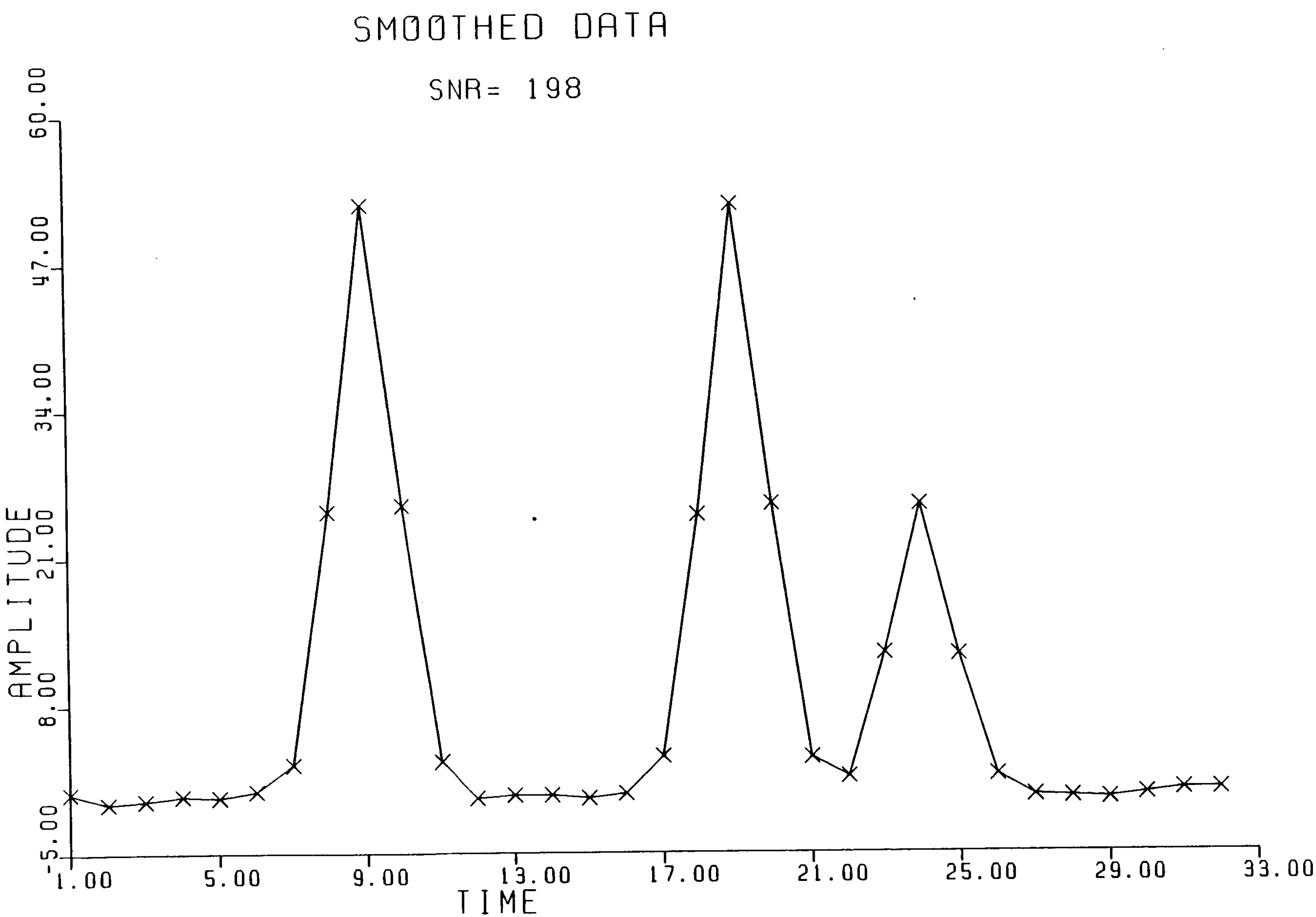
29.00
33.00


SMOOTHED DATA
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AMPLITUDE
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TIME
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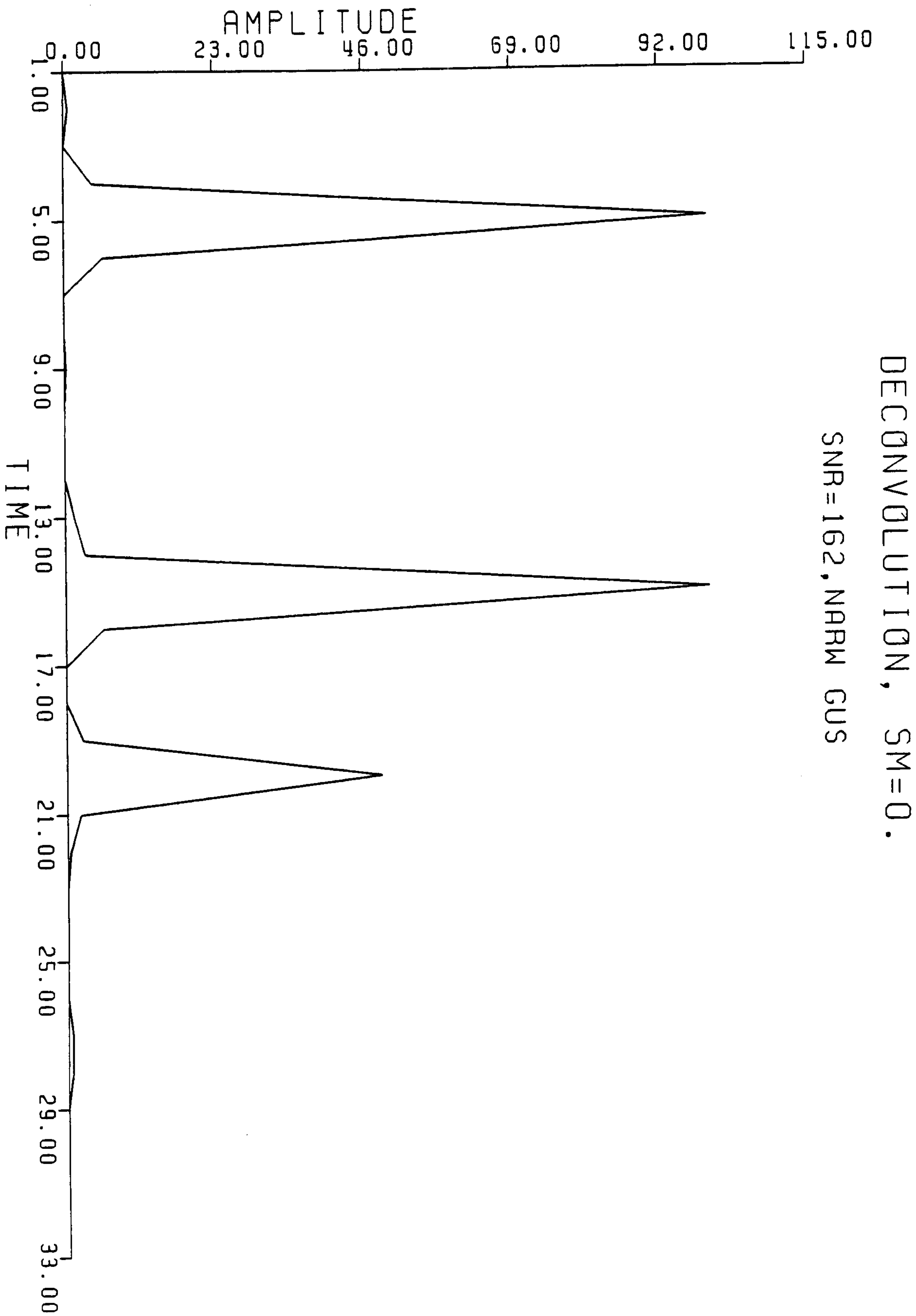
25.00
29.00
33.00



AMPLITUDE
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92.00
115.00
TIME
1.00
5.00
9.00
13.00
17.00
21.00
25.00
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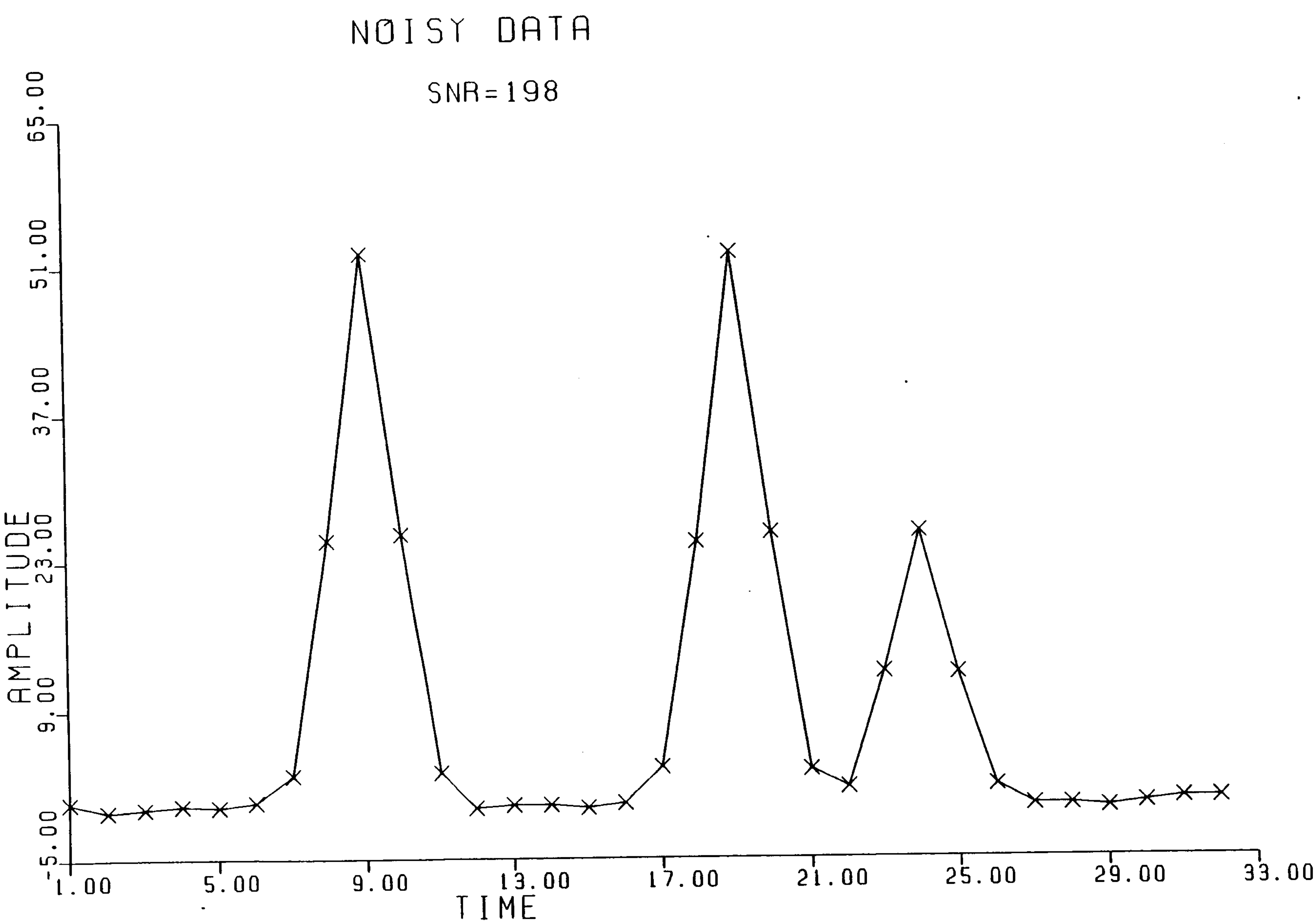
SNR=162,NARW GUS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AMPLITUDE
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9.00
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21.00
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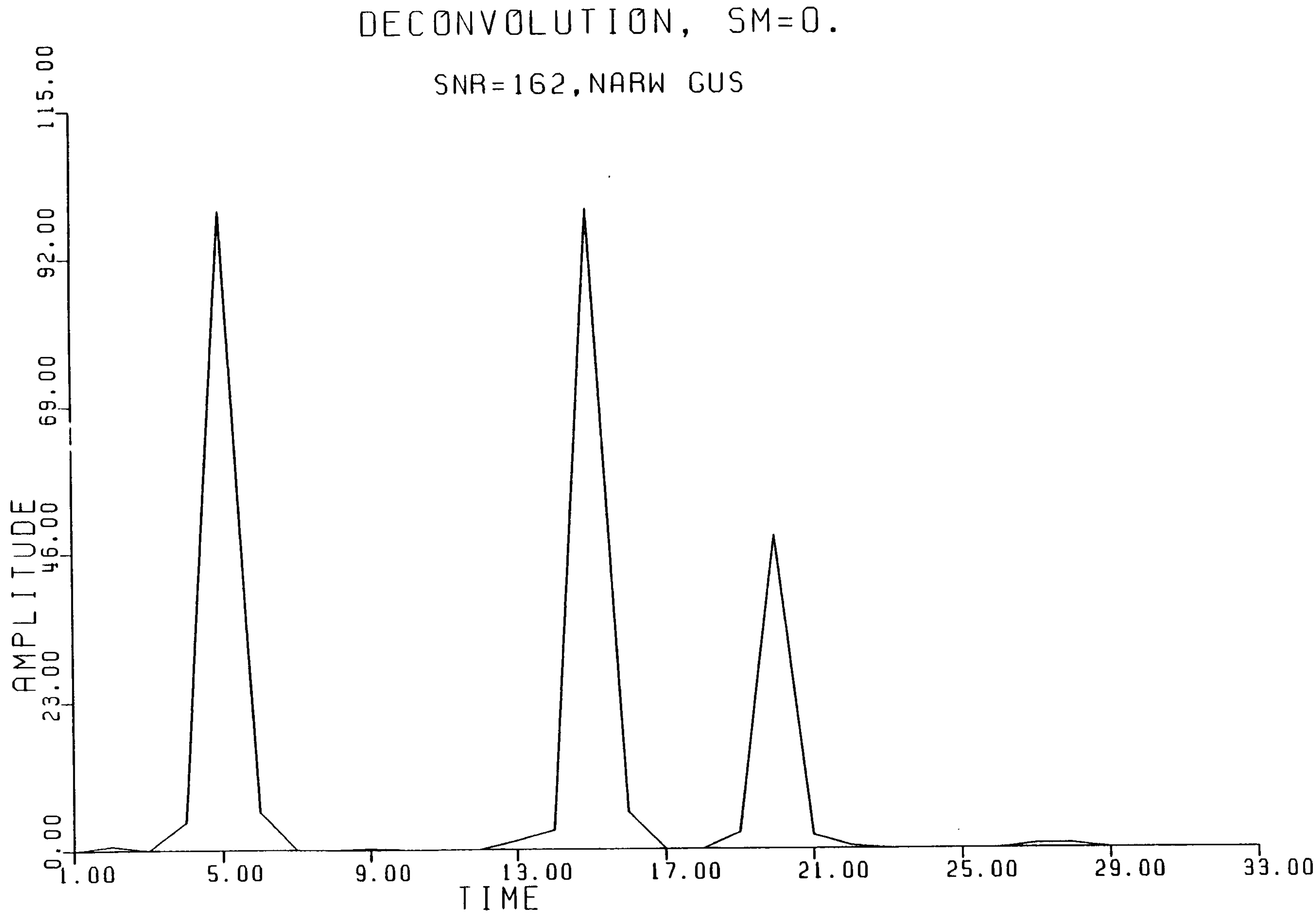
TIME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SNR=162,NARW GUS
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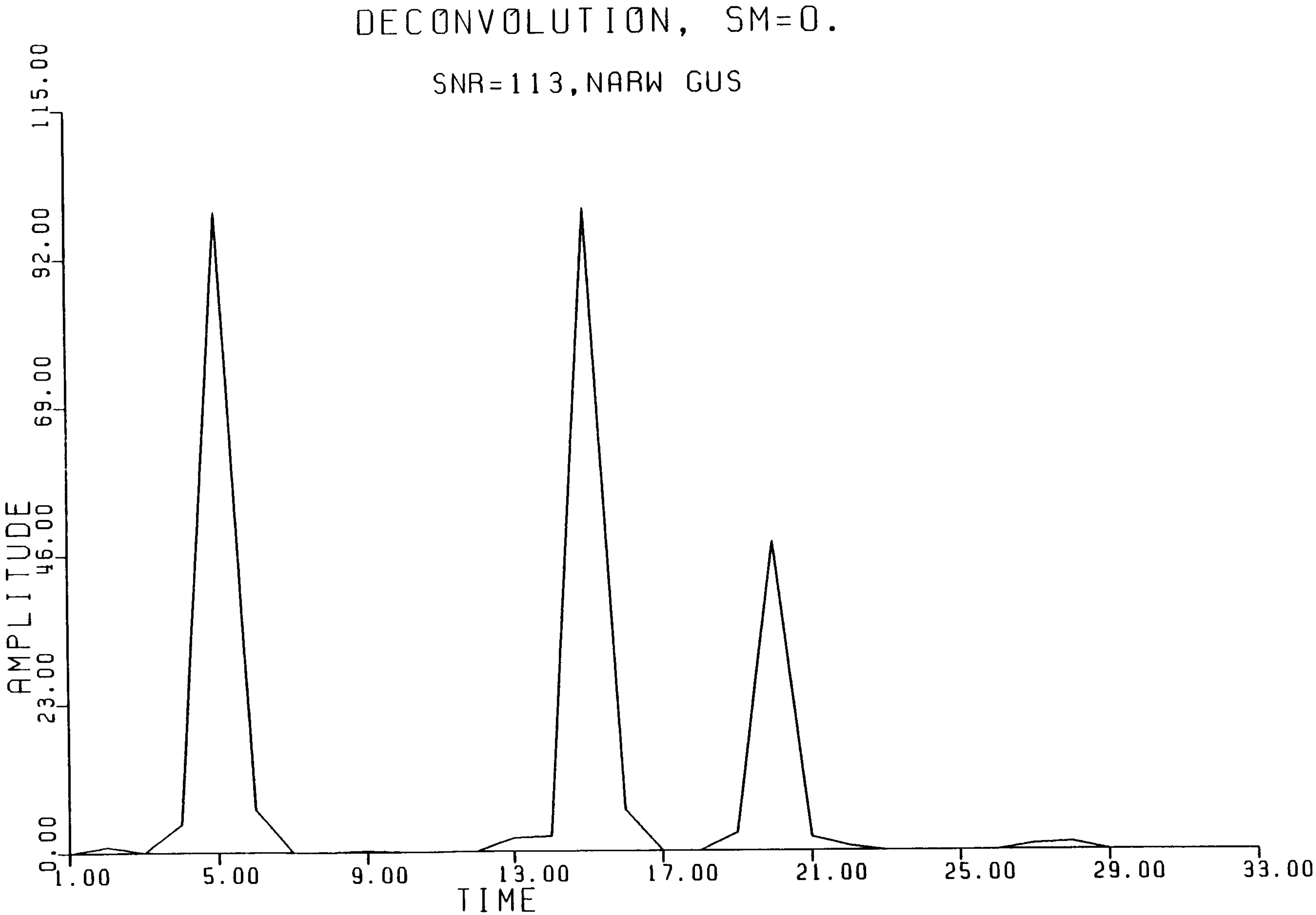
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TIME
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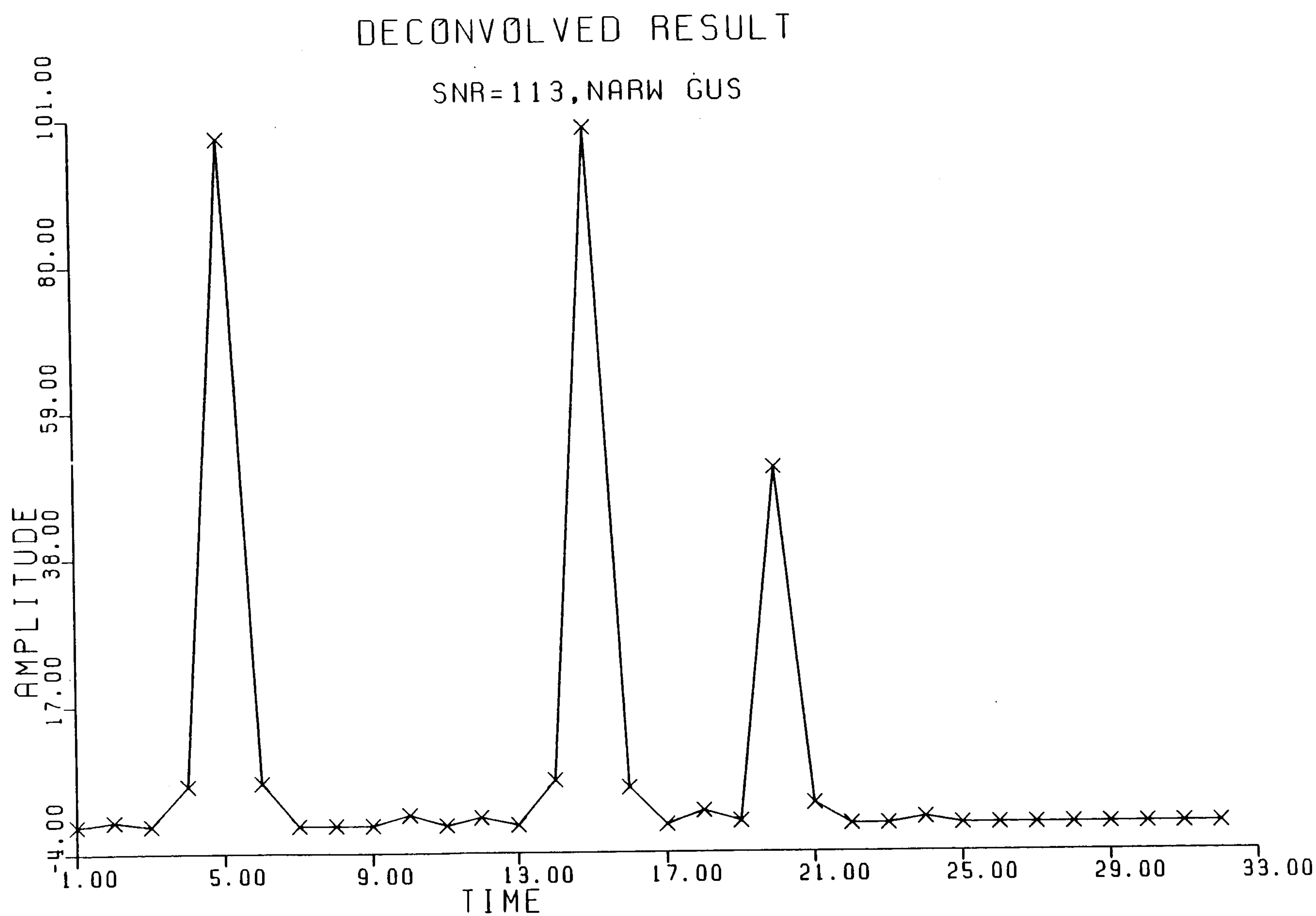
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AMPLITUDE
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38.00
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TIME
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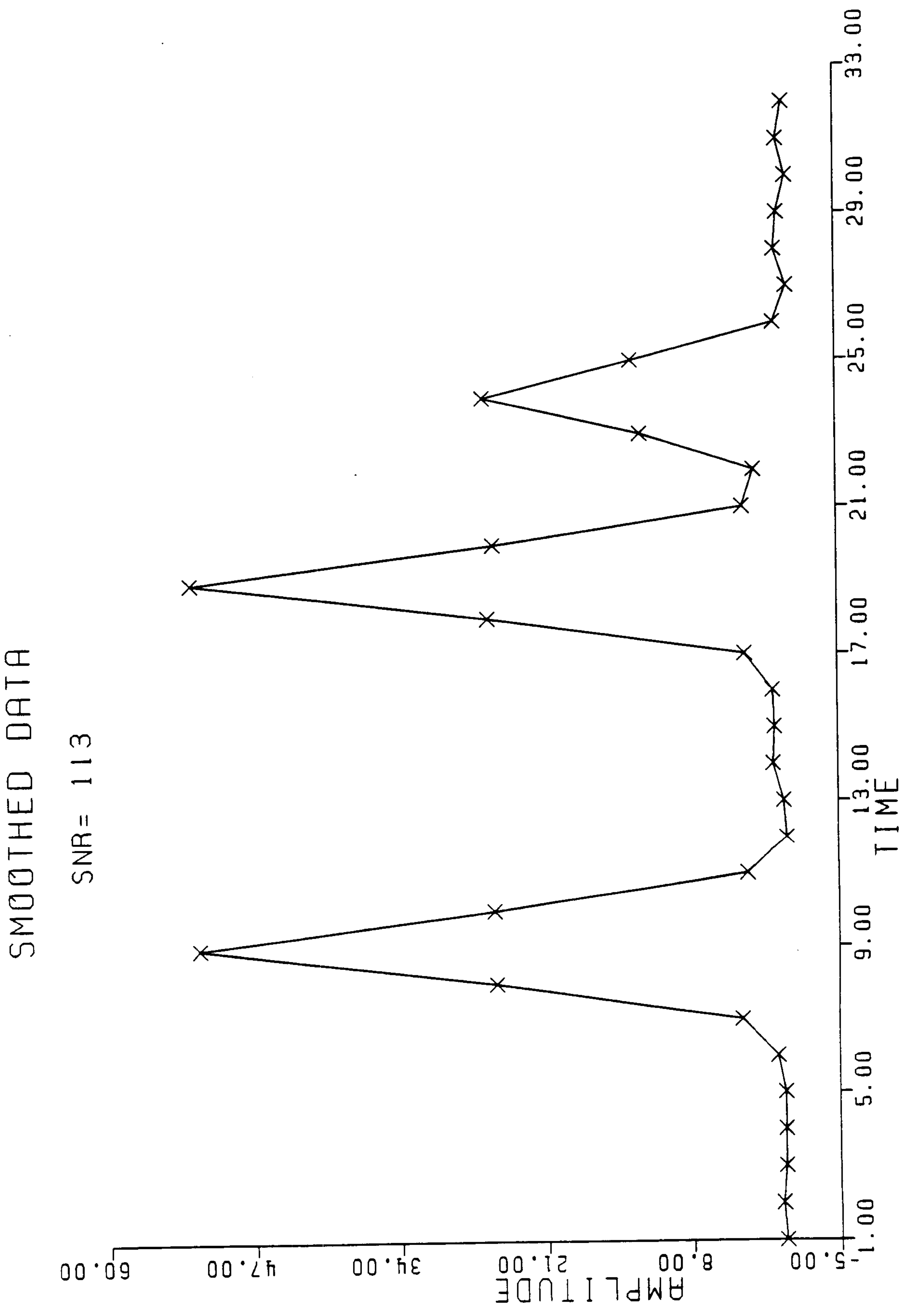
33.00


SMOOTHED DATA
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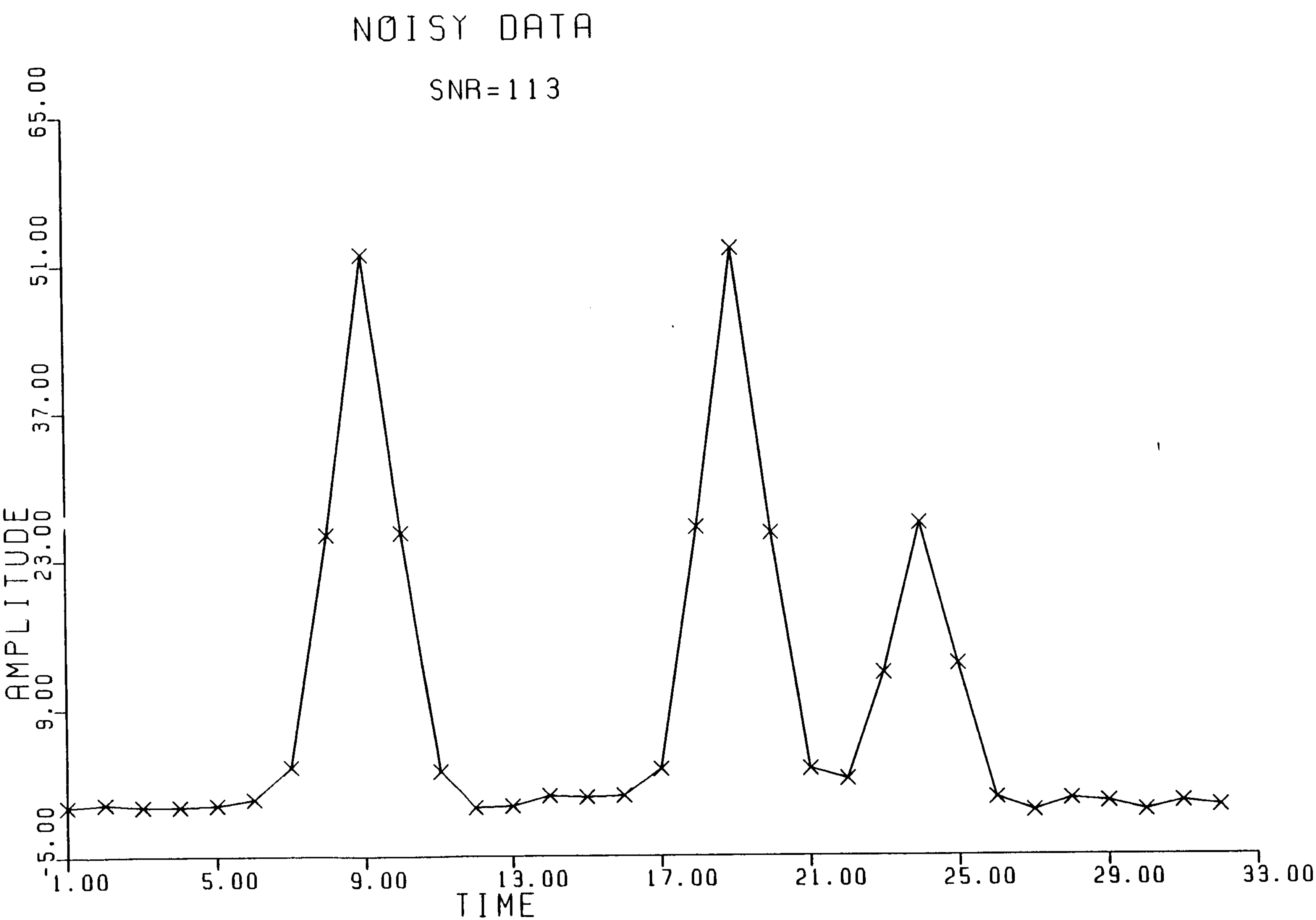
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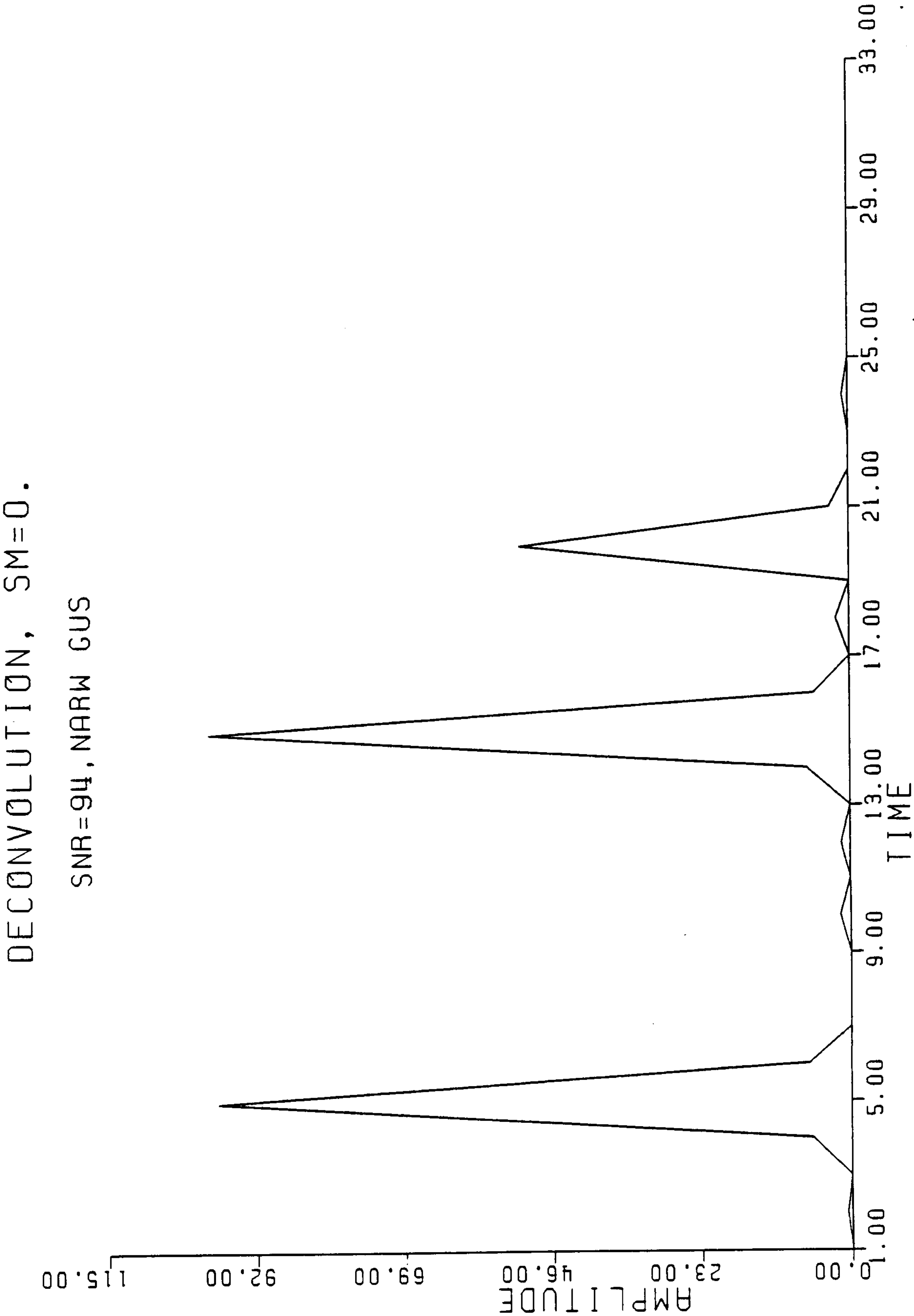

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TIME
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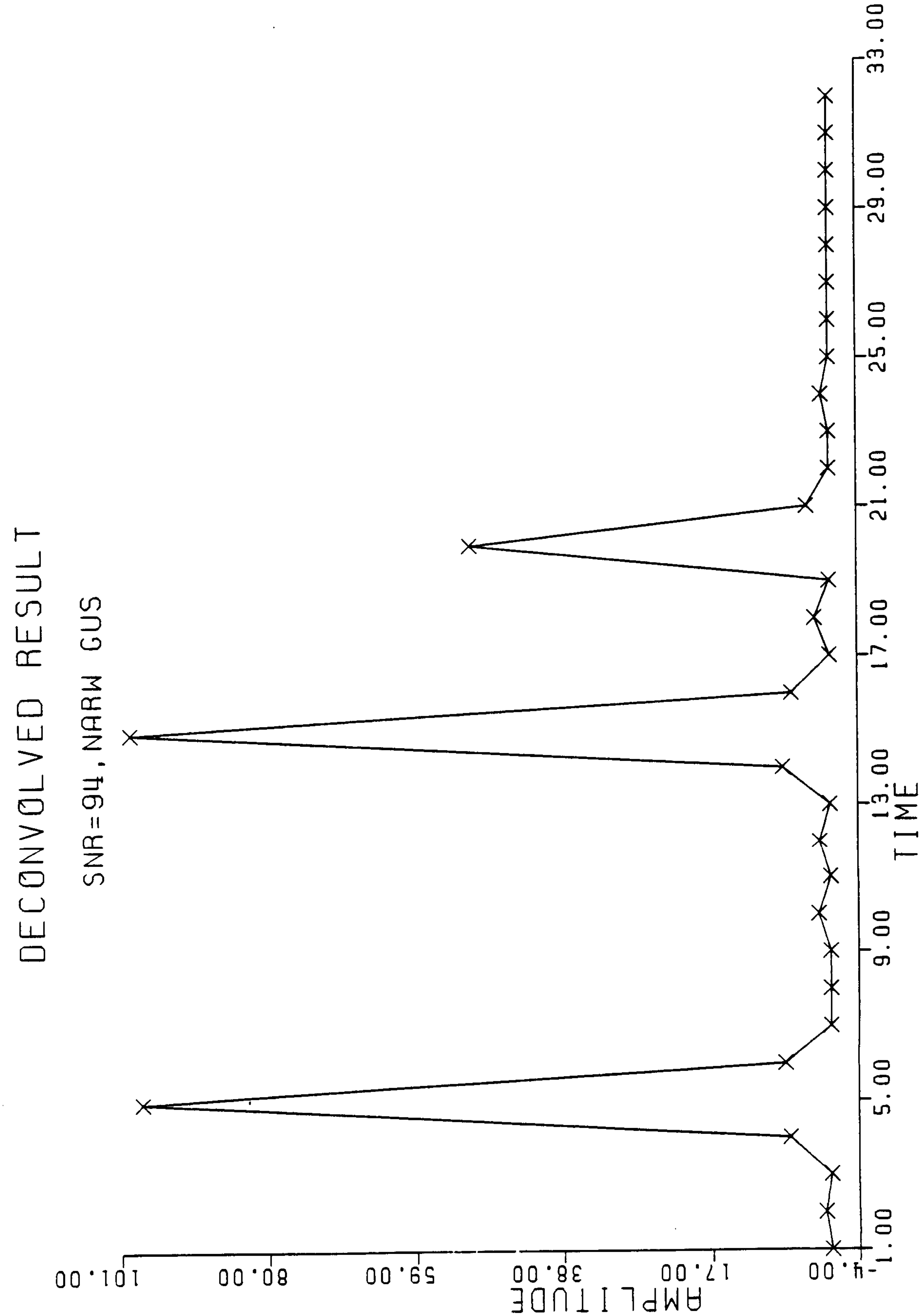
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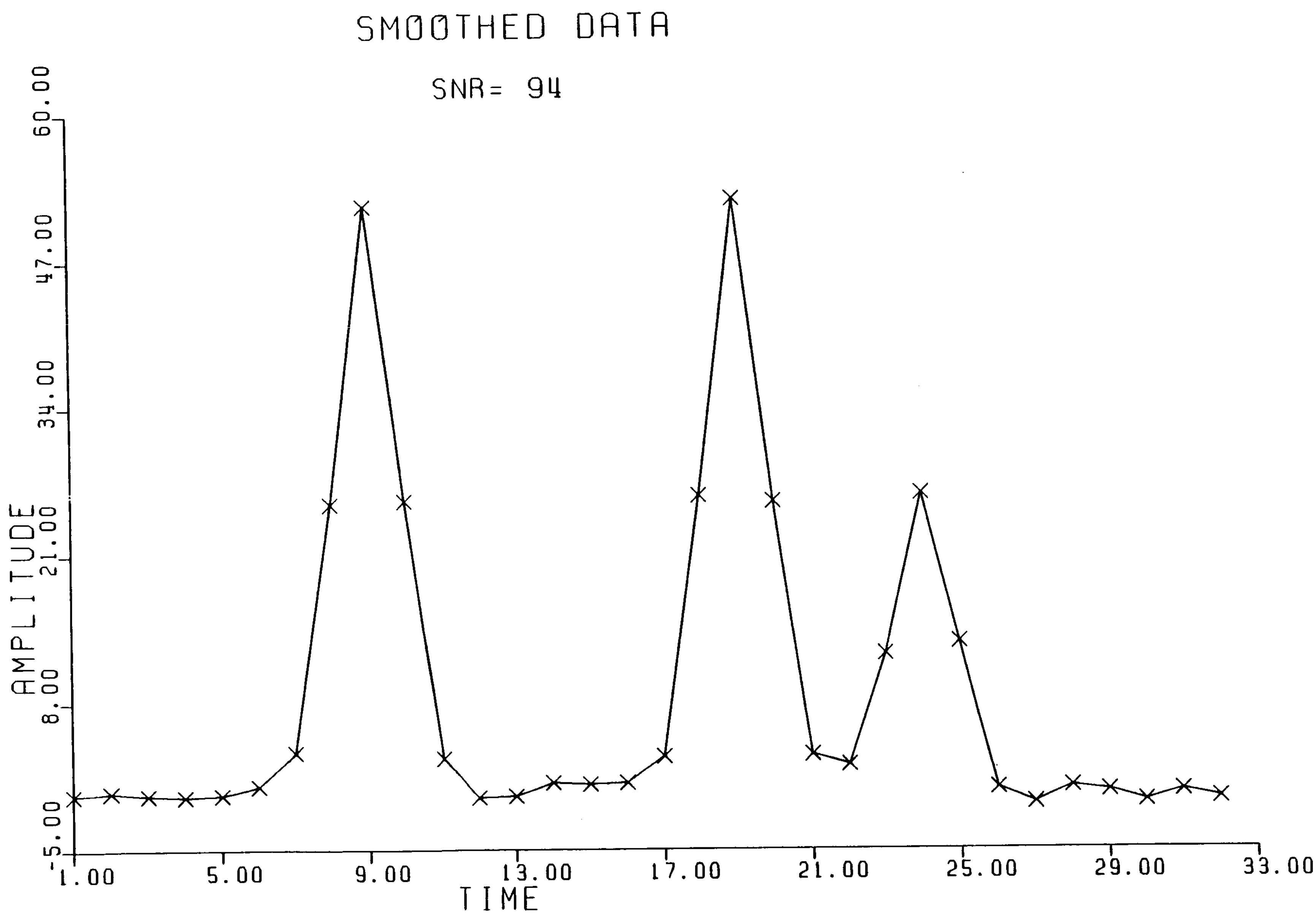
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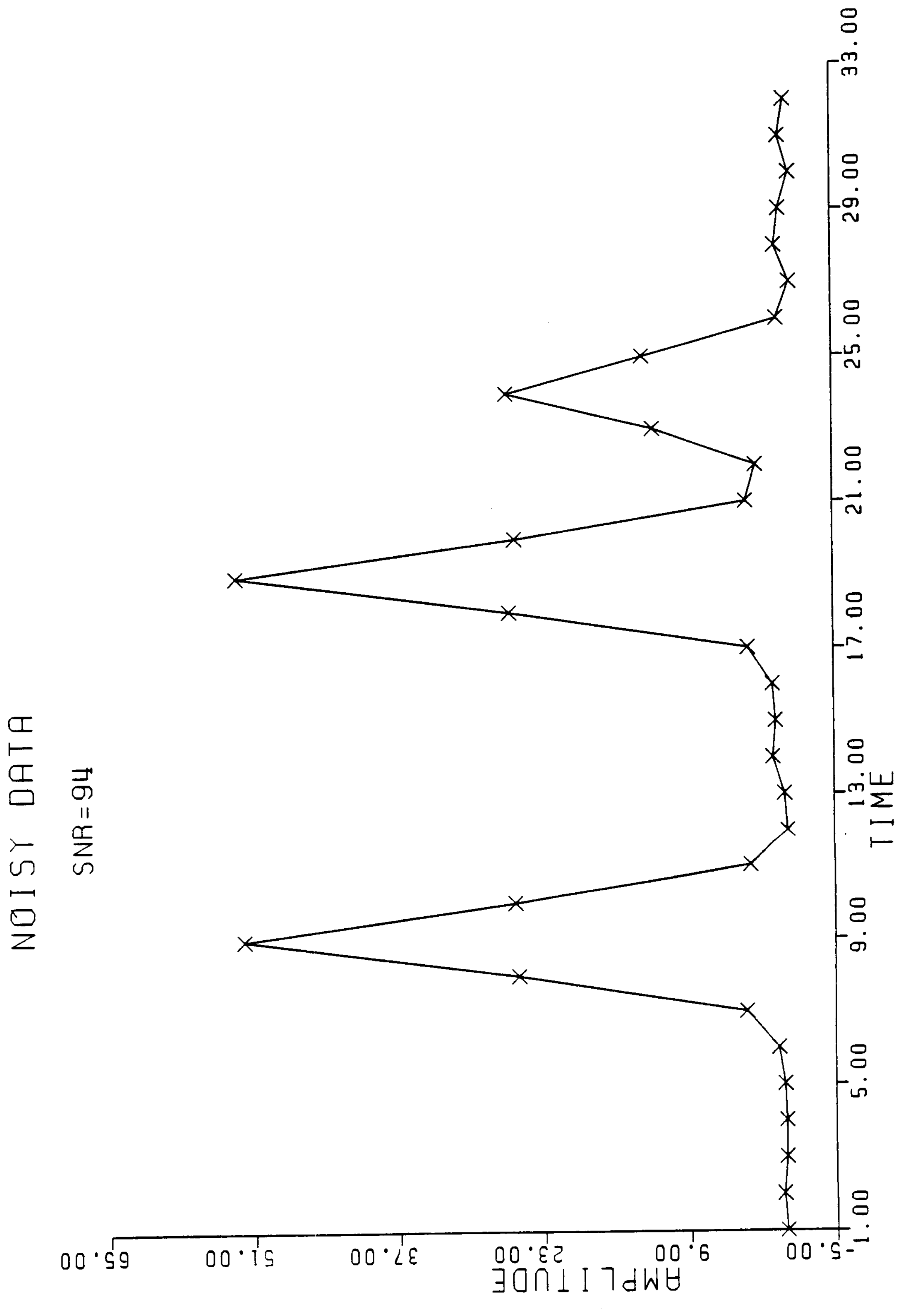
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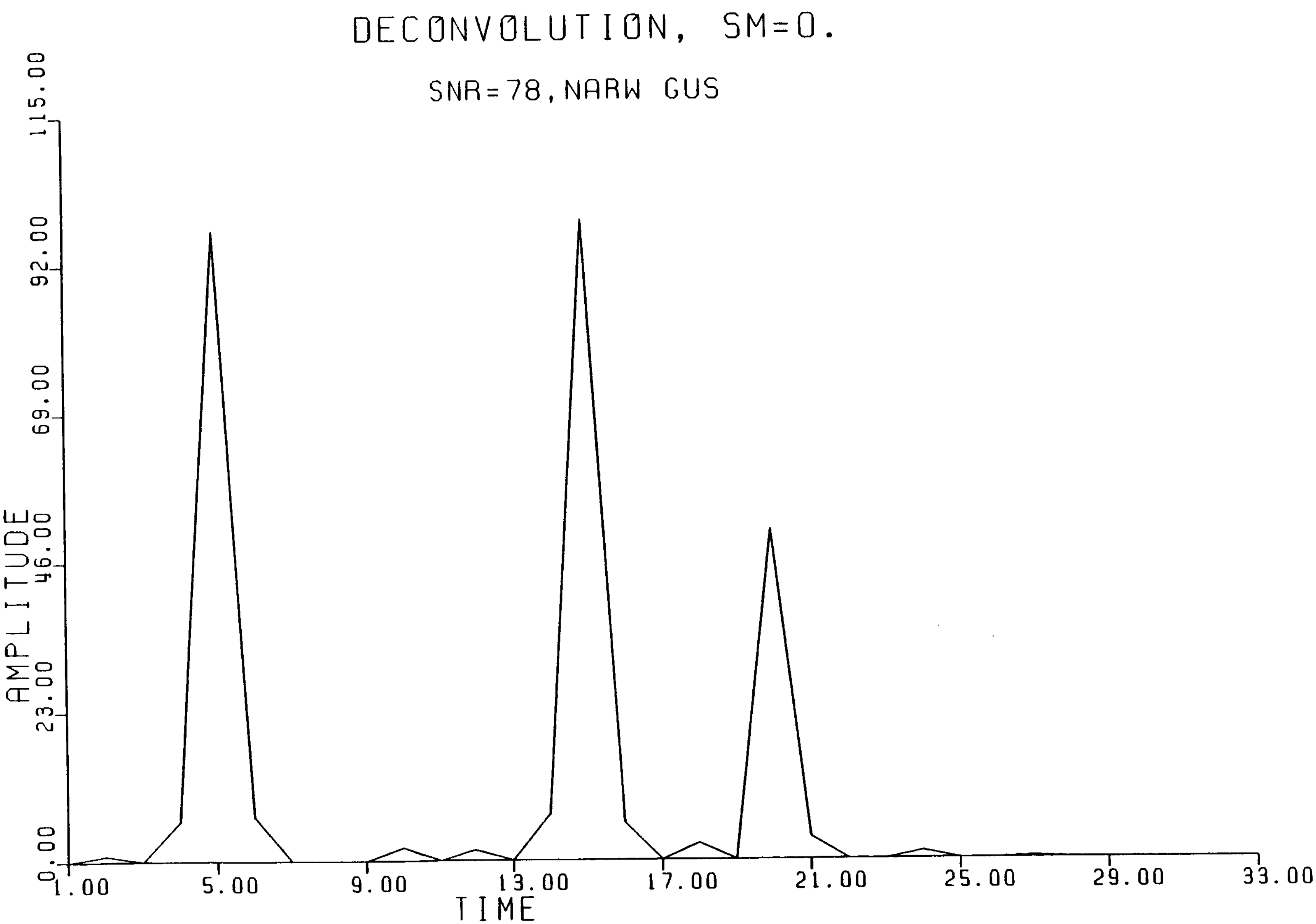
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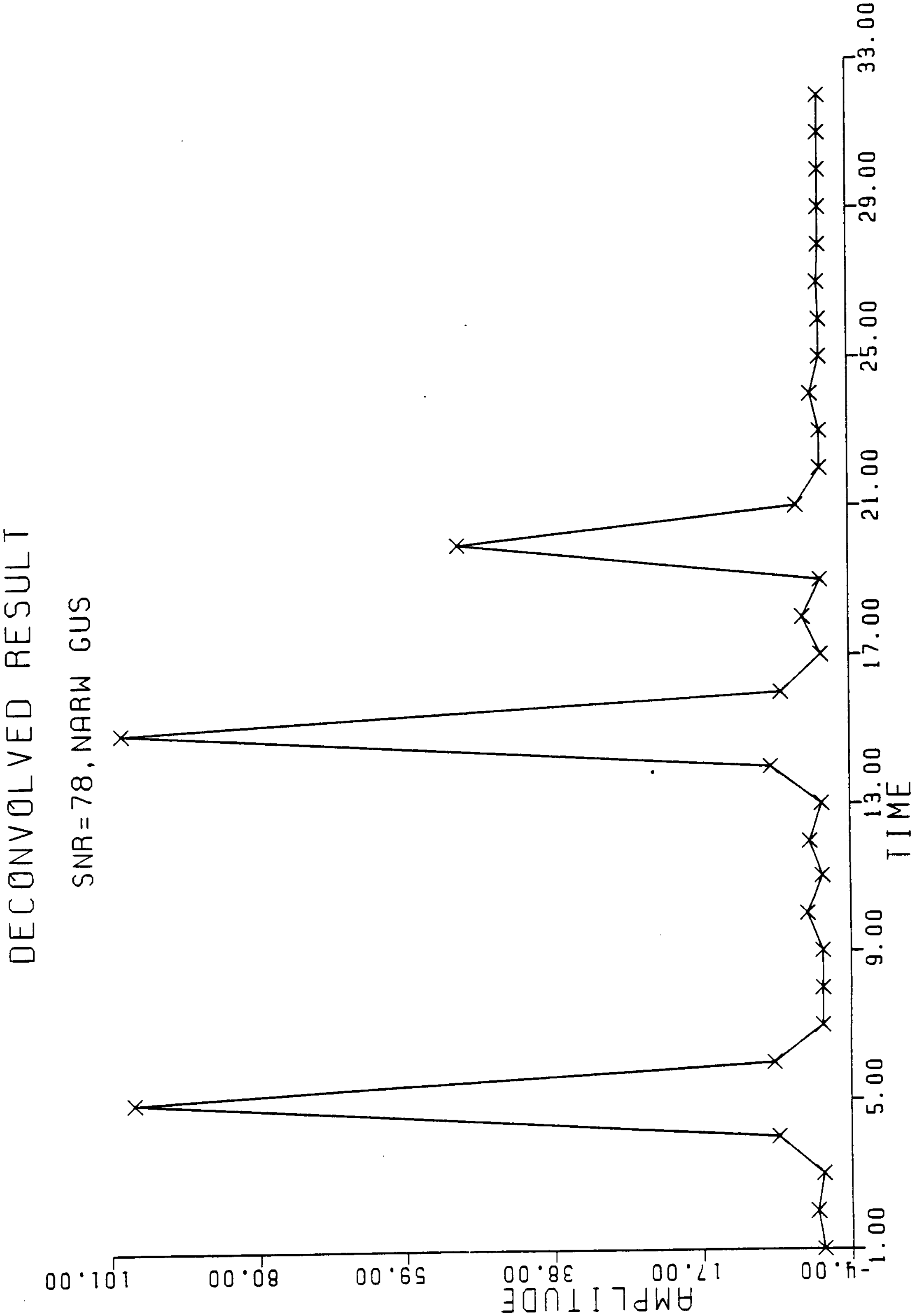

DECONVOLVED RESULT
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AMPLITUDE
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TIME
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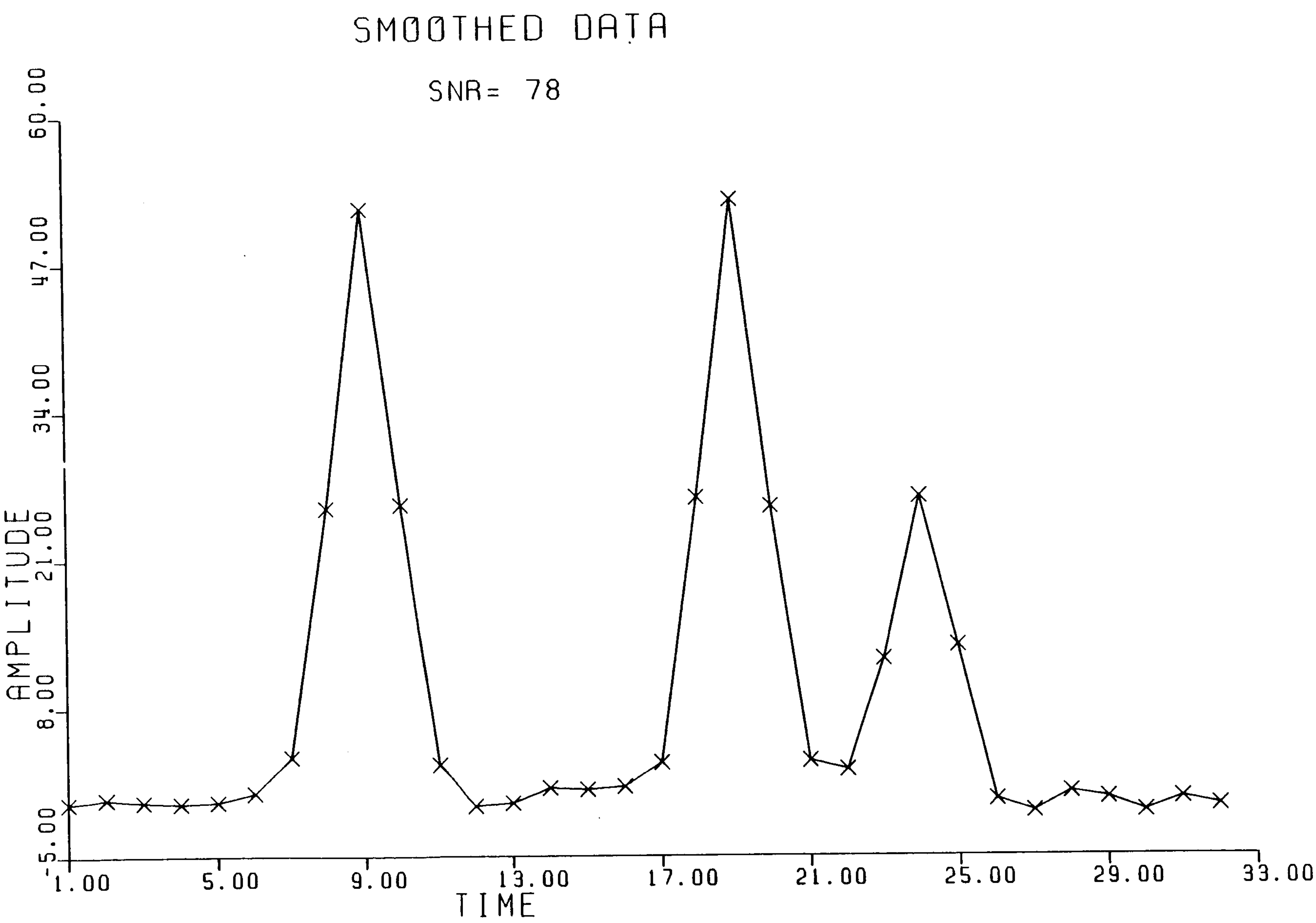
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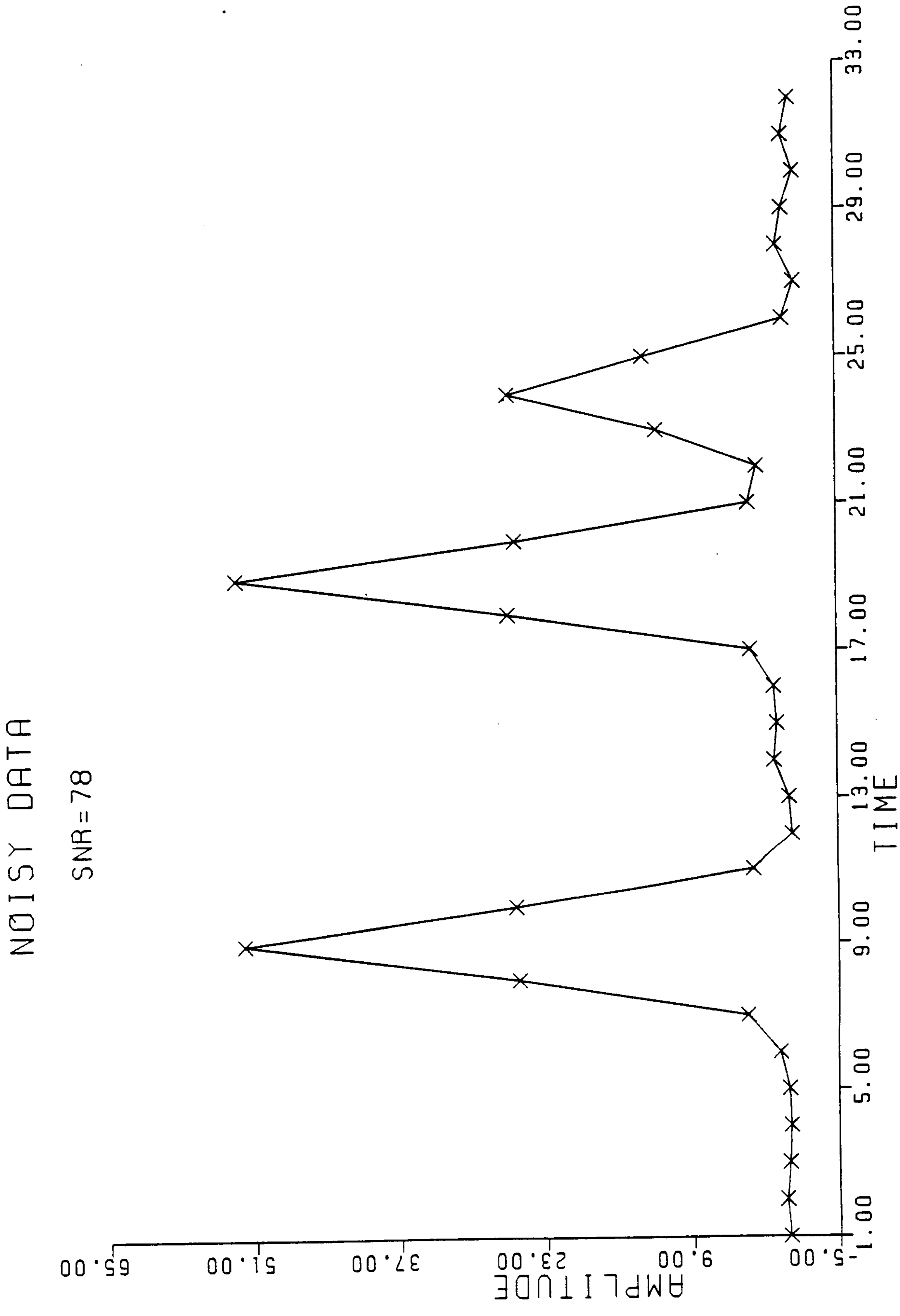
TIME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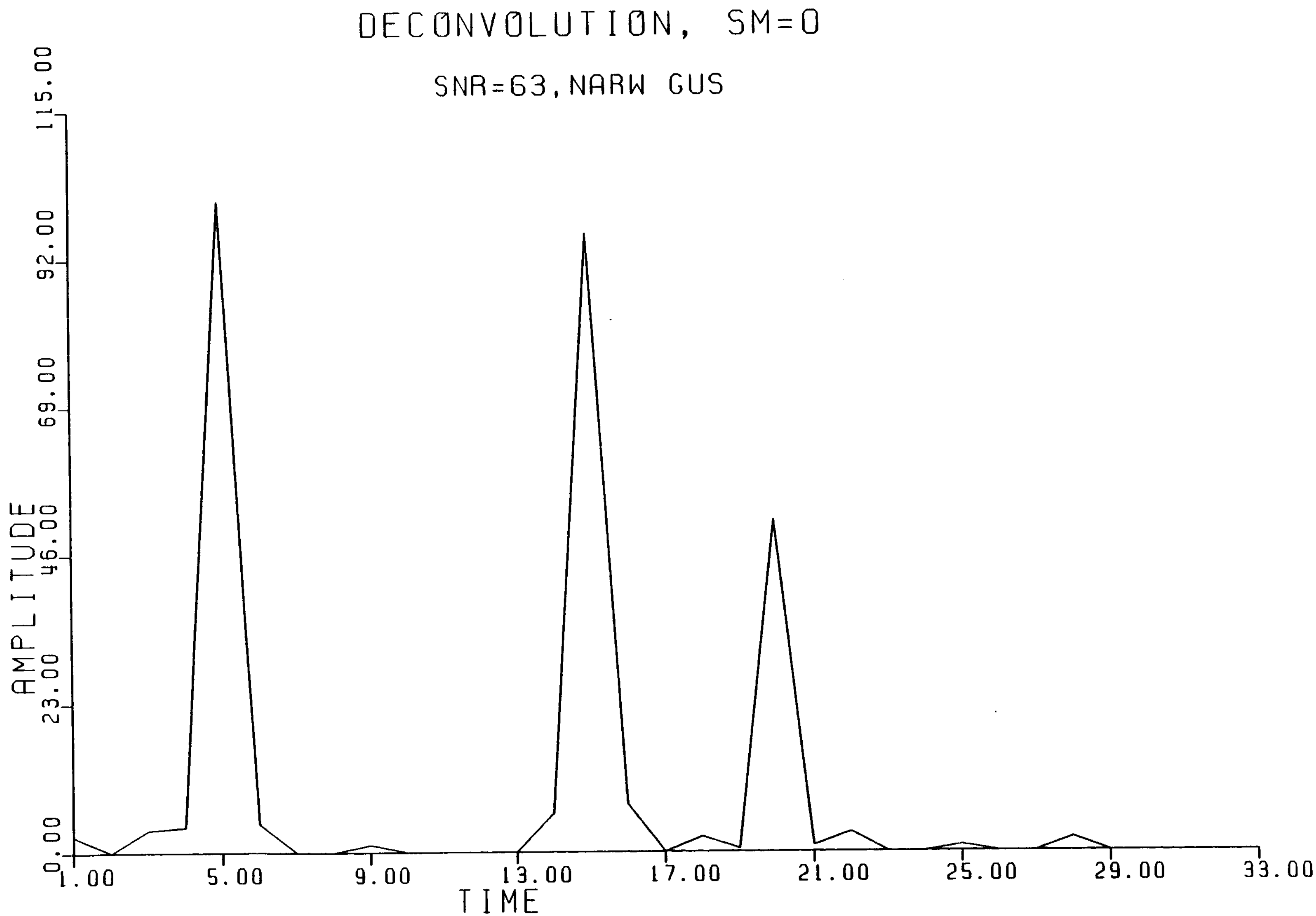
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17.00
21.00
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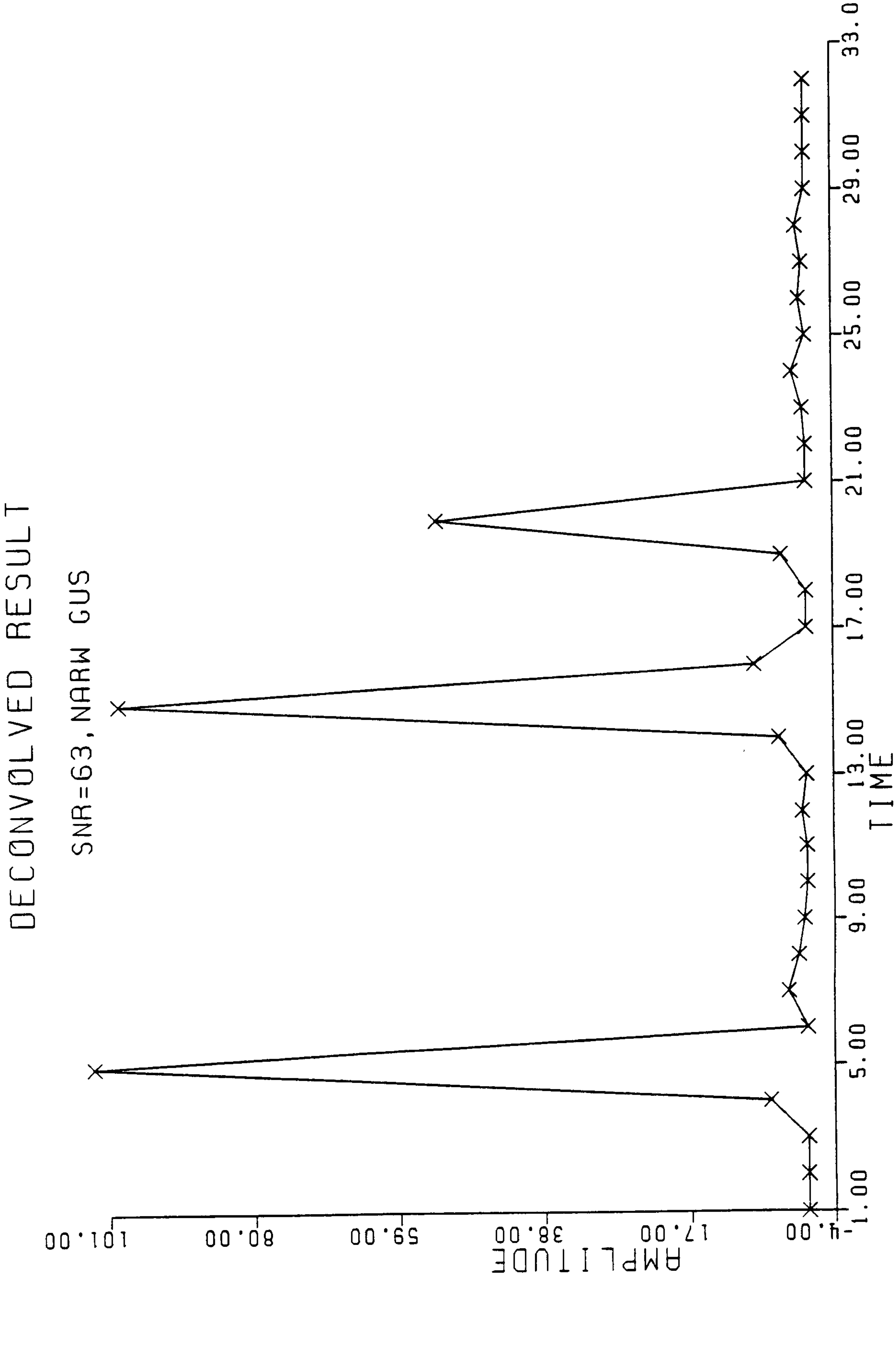
33.00


DECONVOLVED RESULT
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TIME
AMPLITUDE
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17.00
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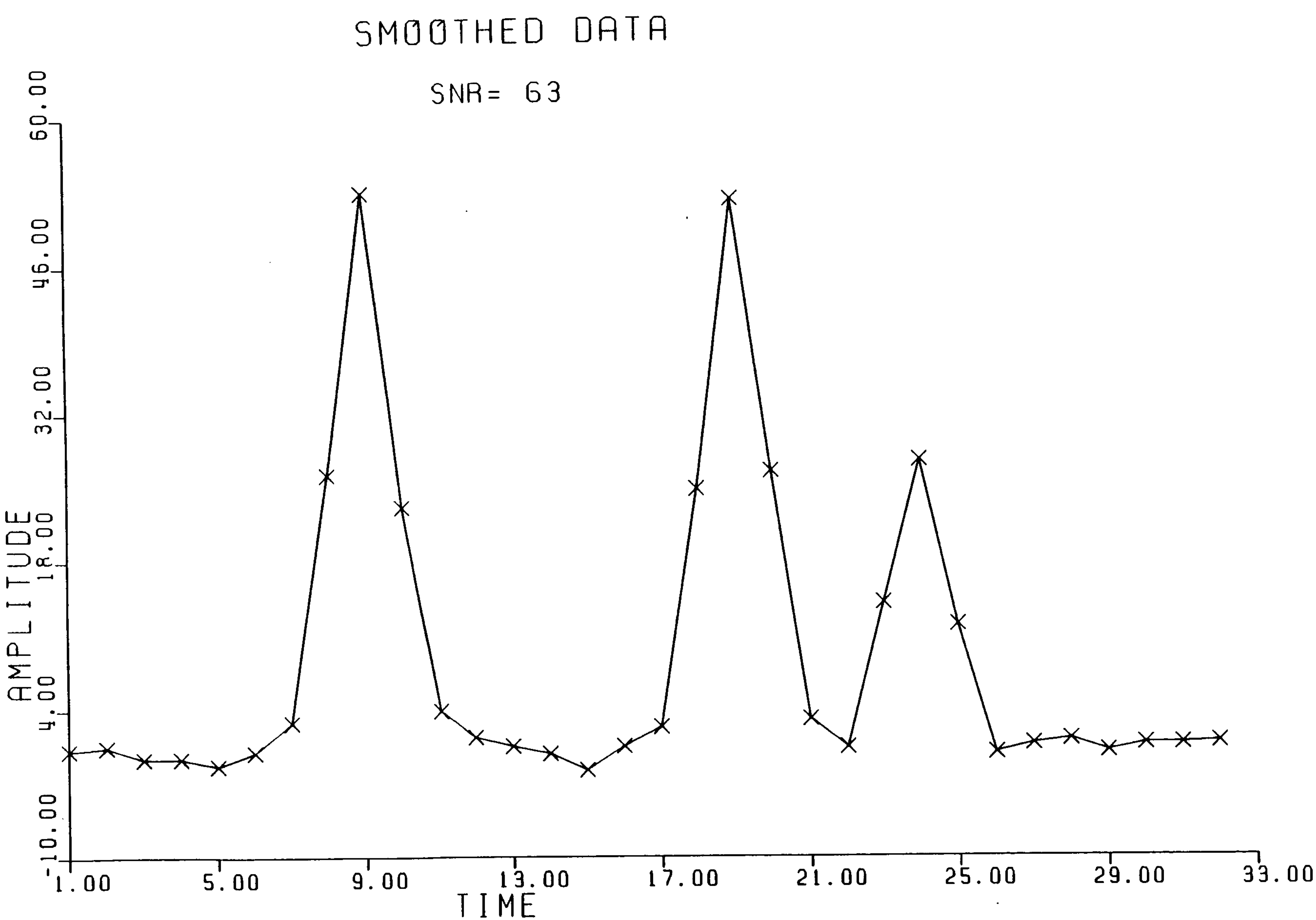
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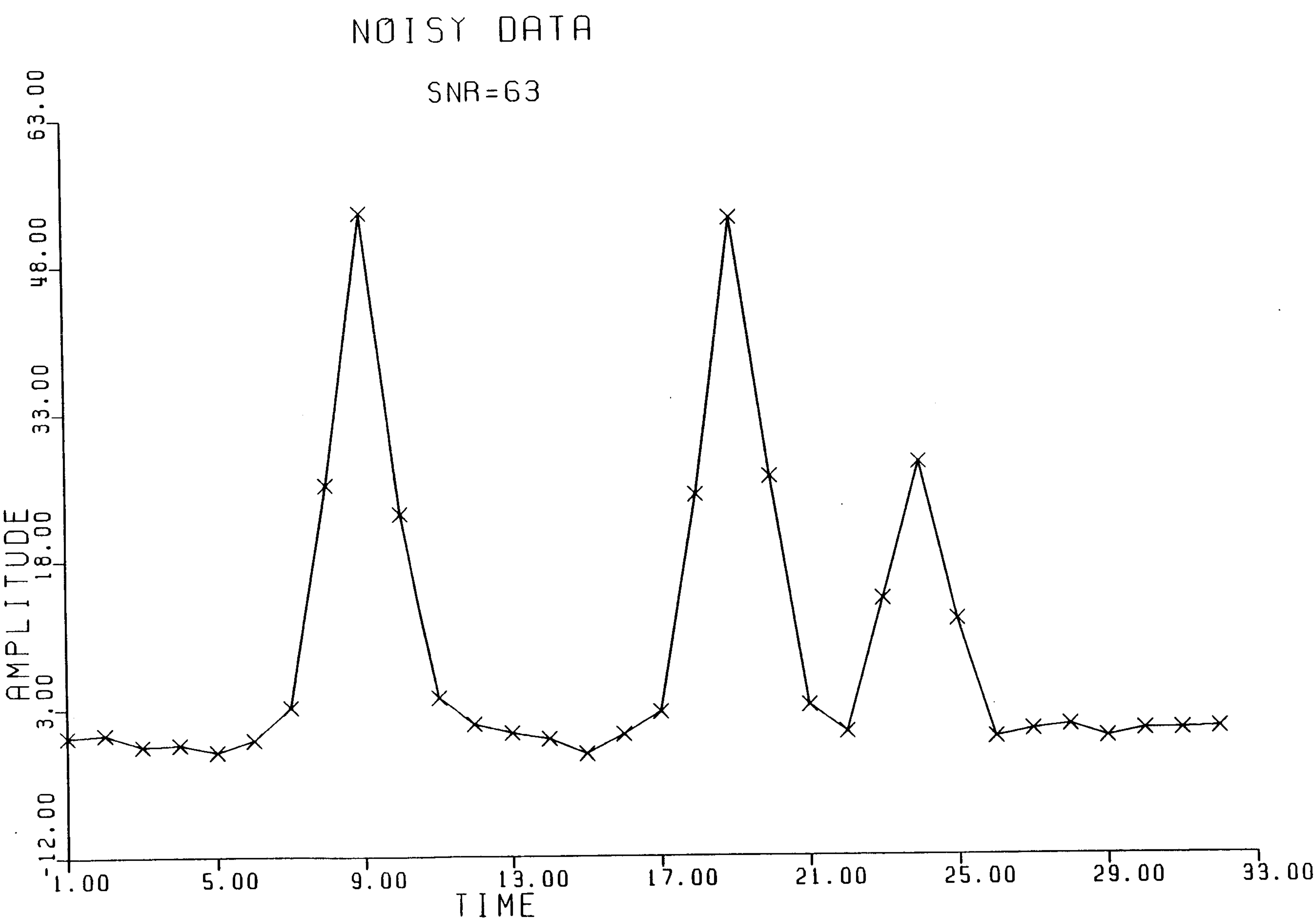
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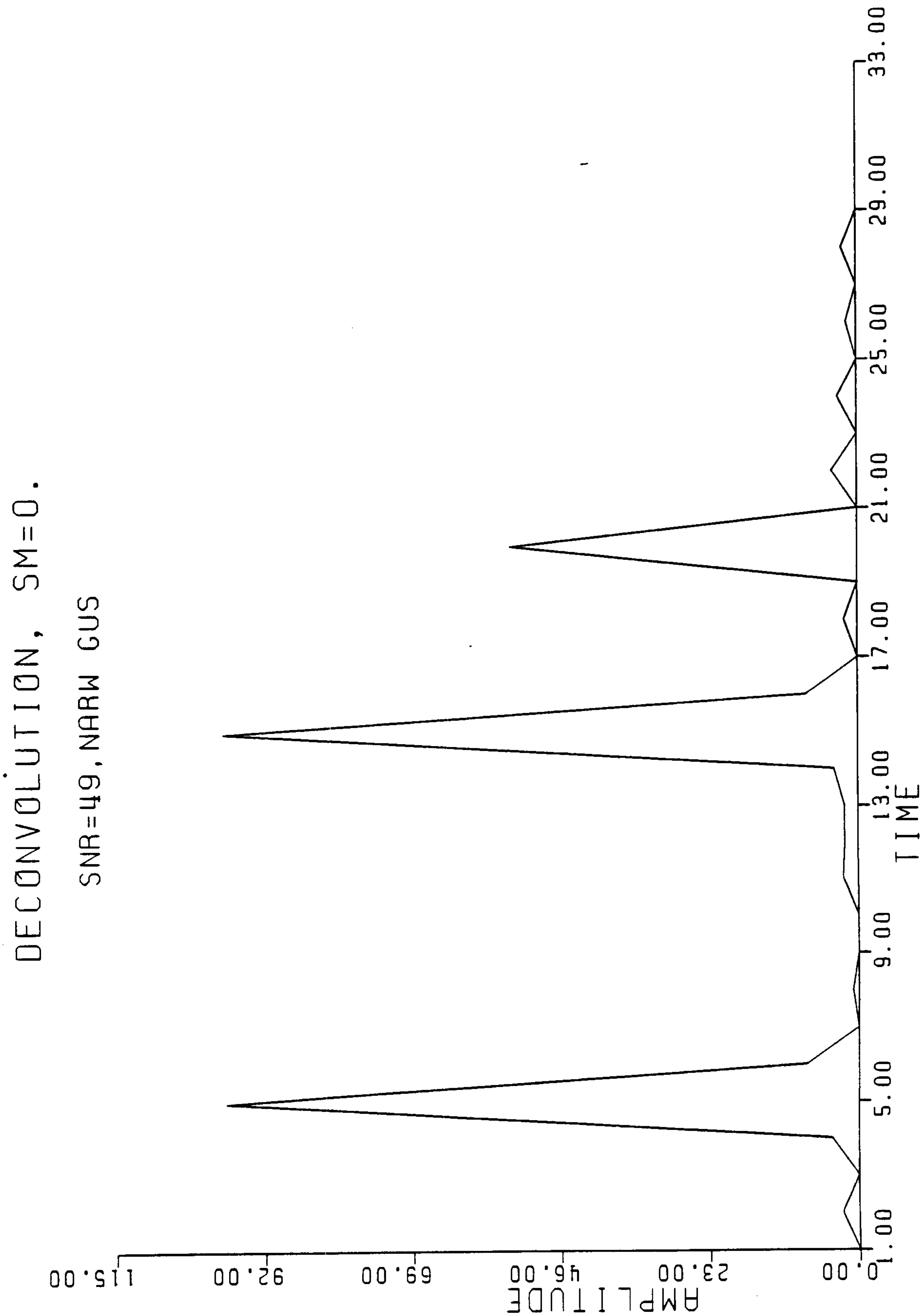
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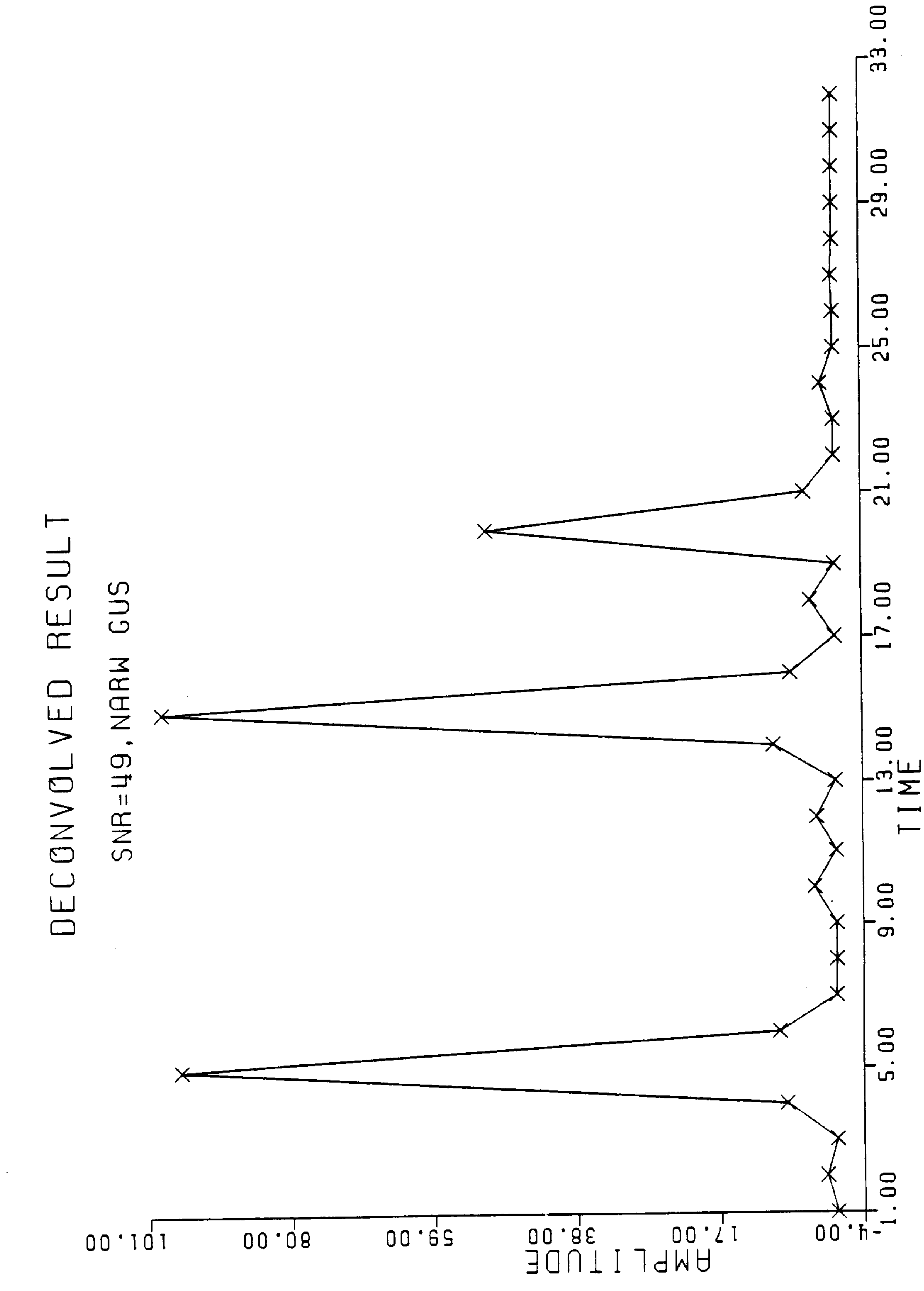
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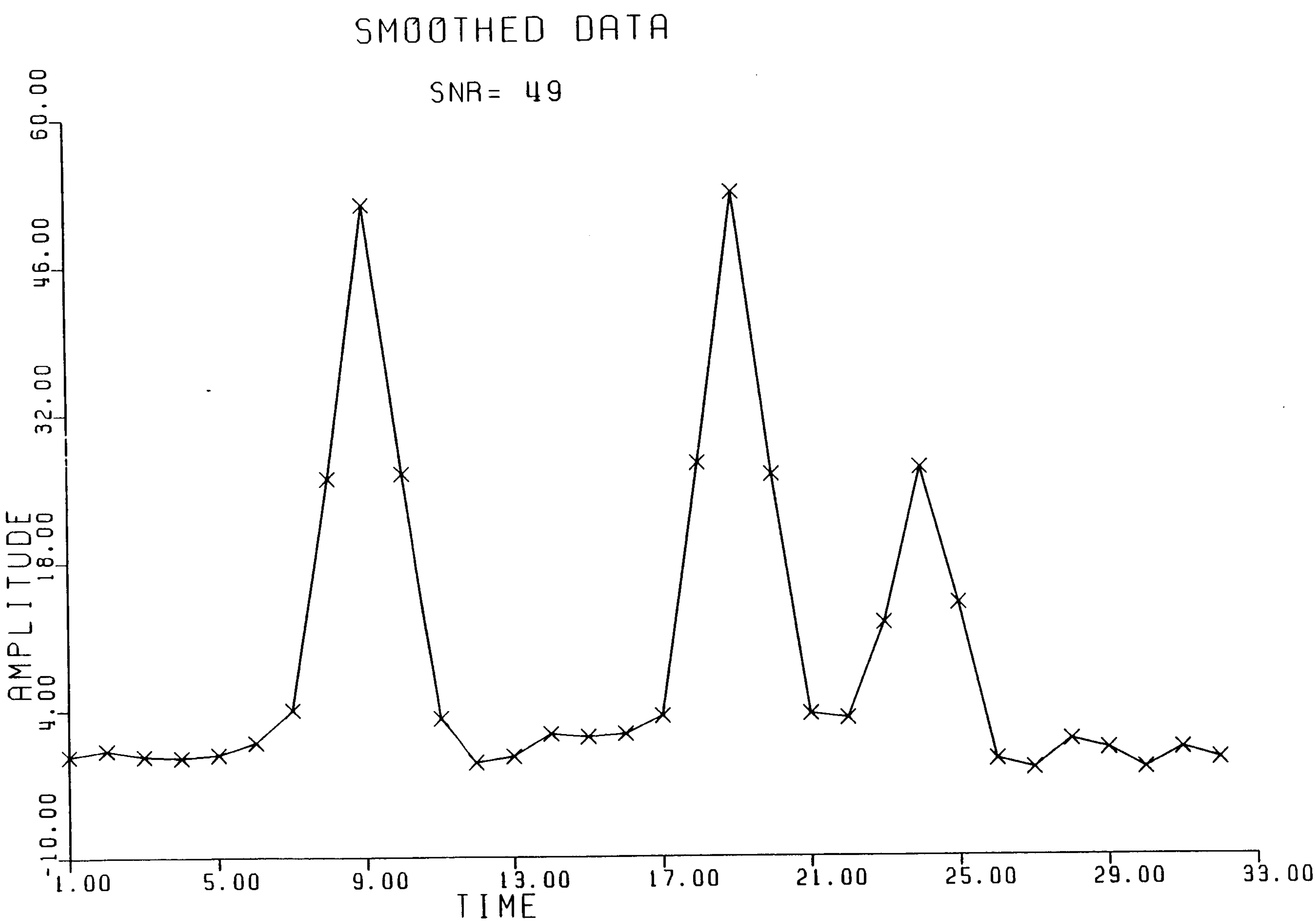
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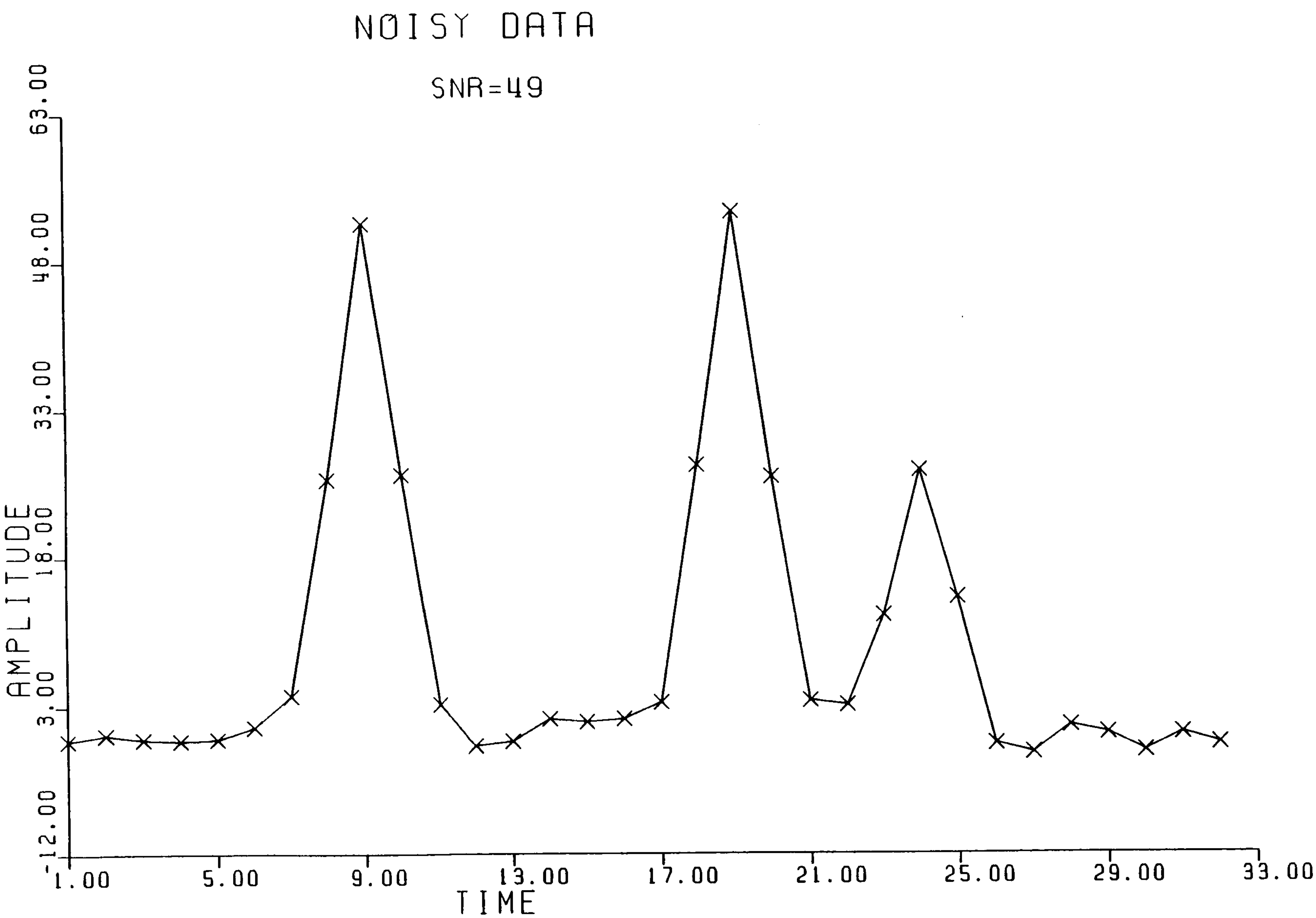
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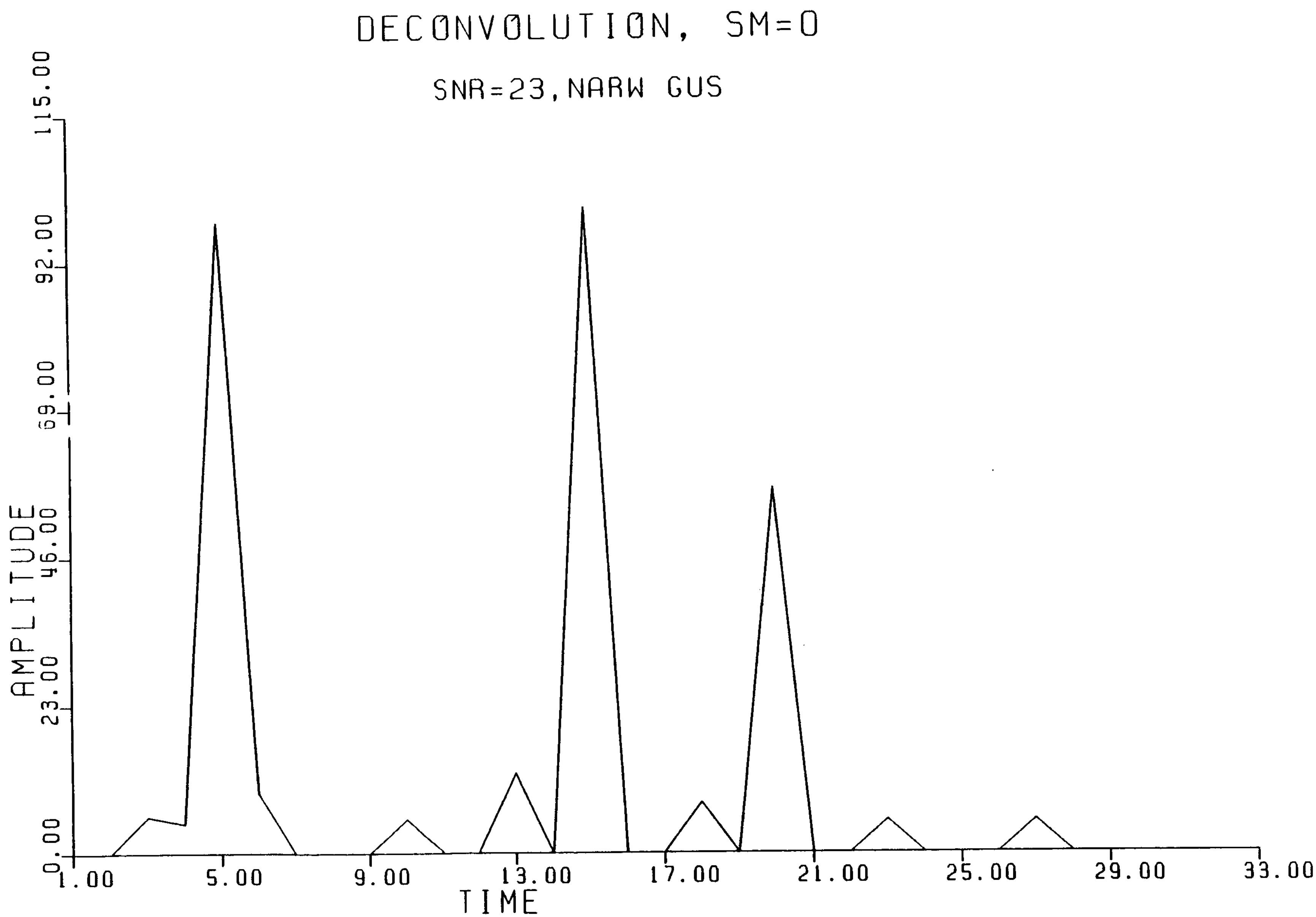
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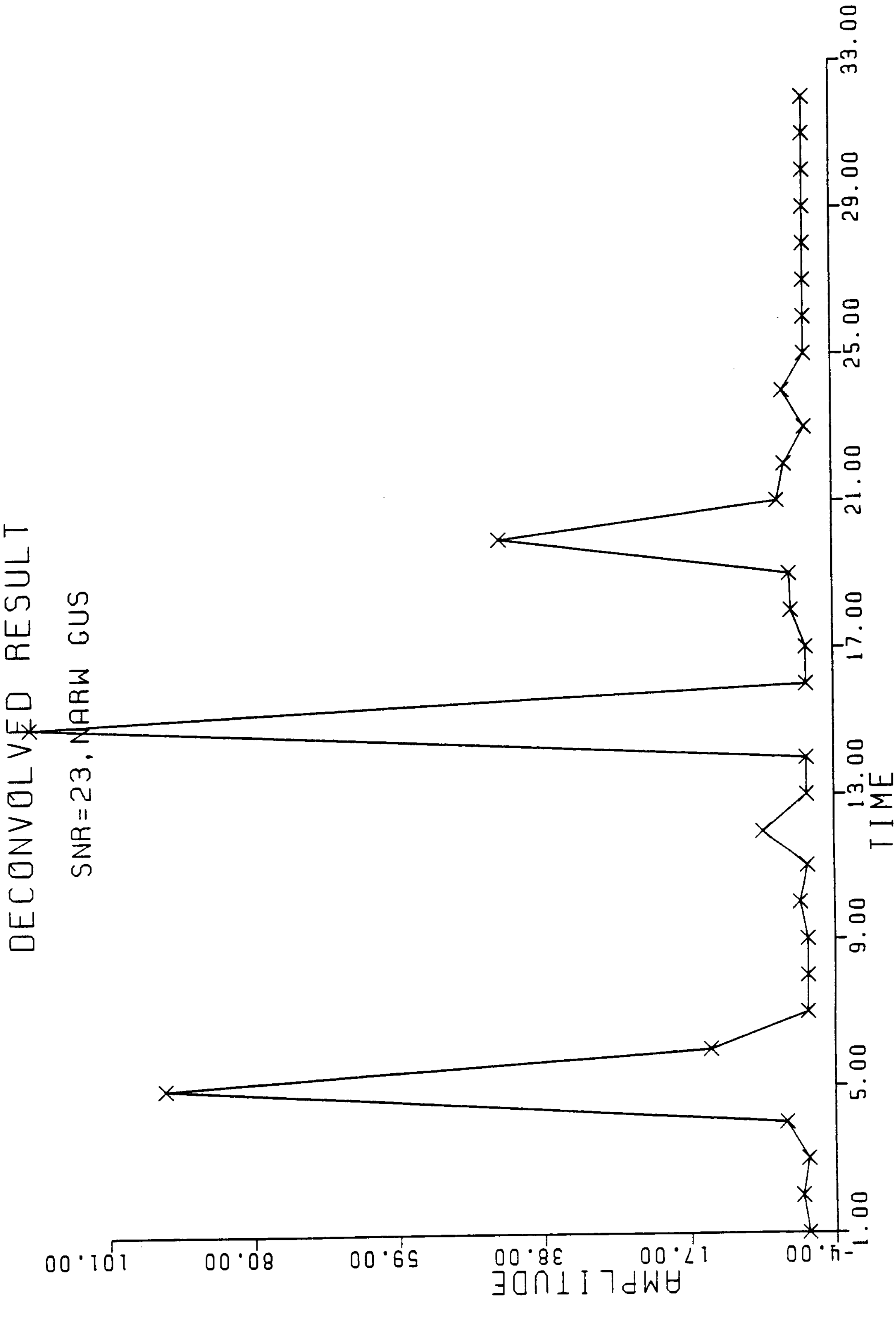
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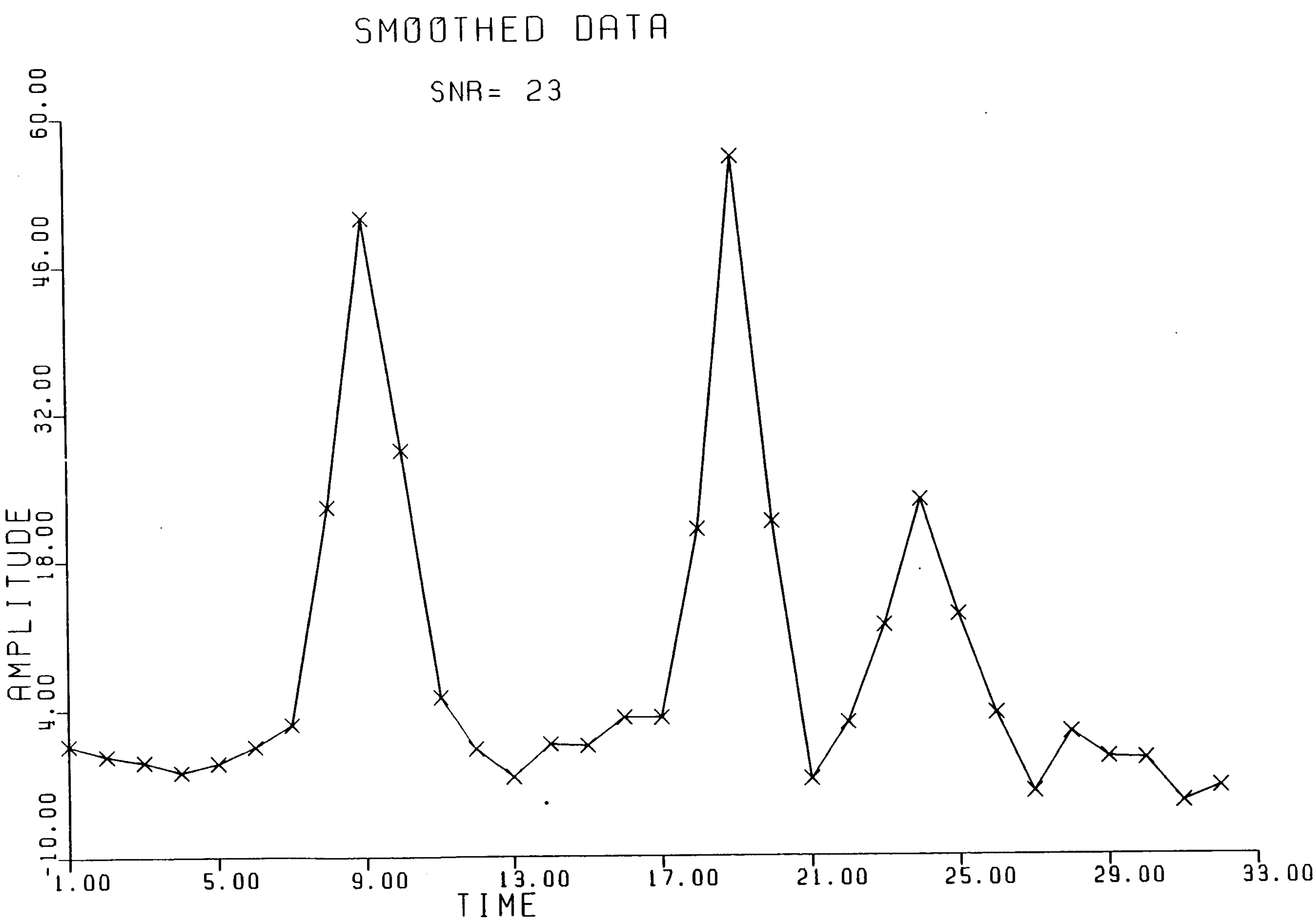
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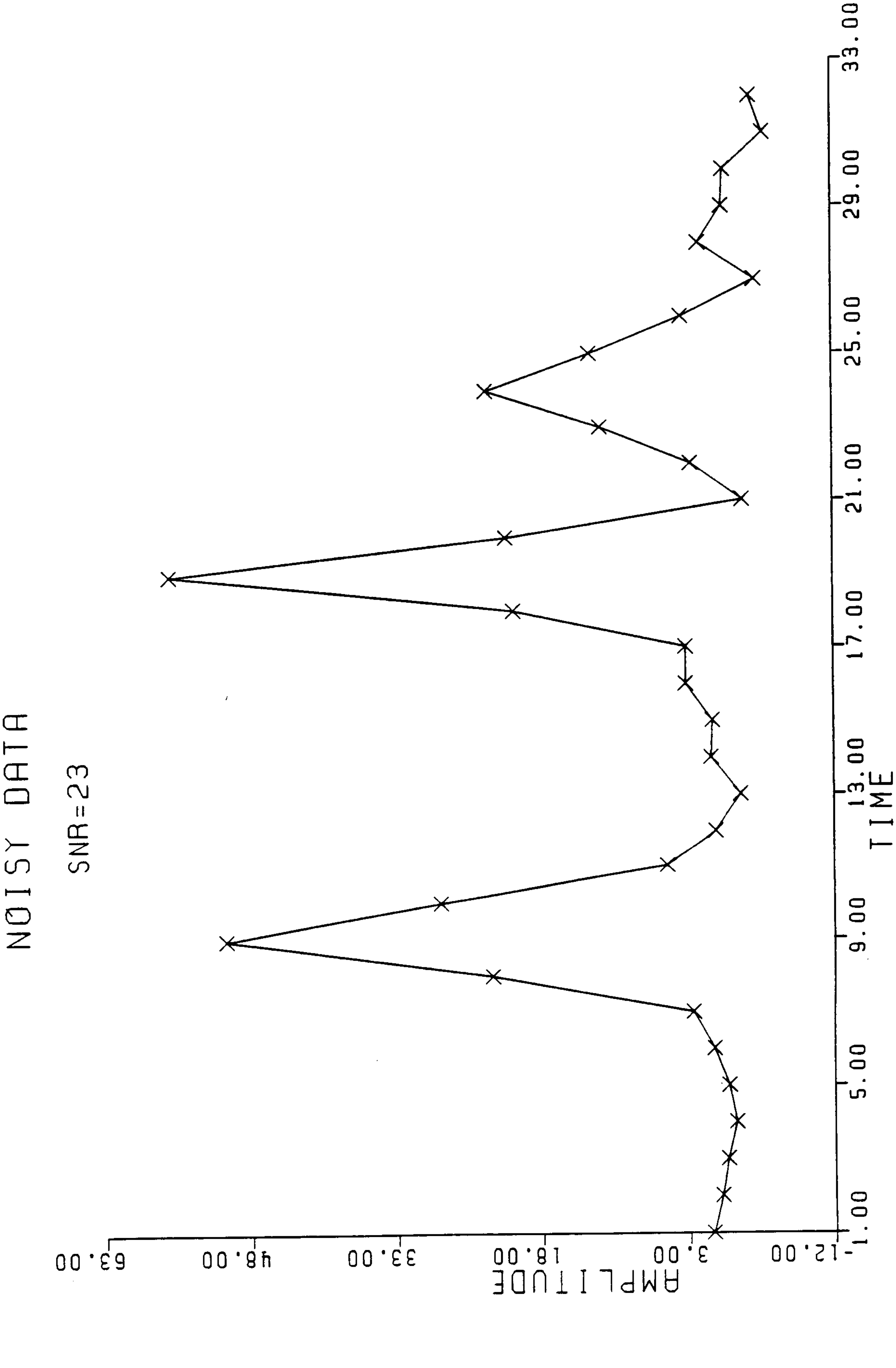
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63.00

SNR≈11.91

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1663.089	5	0	4	-8.147339
2074.931	34	0	5	0.4028320E-01
1631.157	34	0	6	0.4309082E-01
388.2651	4	0	7	-4.330139
505.9643	5	0	8	-19.52893
848.4391	5	0	9	-33.99176
1460.881	40	0	10	0.4211426E-01
2201.013	43	0	11	0.4858398E-01
5420.866	36	0	12	0.4931641E-01
2820.533	39	0	13	0.3930664E-01
1661.254	27	0	14	0.4748535E-01
3374.110	38	0	15	0.4370117E-01
463.3286	37	0	16	0.4675293E-01
1230.634	30	0	17	0.4455566E-01
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1129.831	7	0	27	-0.9364014
2007.414	33	0	28	0.4455566E-01
1478.216	6	0	29	-15.03345
3719.944	41	0	30	0.4223633E-01
1677.385	33	0	31	0.4052734E-01
1901.887	38	0	32	0.4565430E-01
1400.088	36	0	33	0.4895020E-01
2584.942	44	0	34	0.4418945E-01
1038.447	7	0	35	-1.979370
2494.361	36	0	36	0.4199219E-01
3990.945	43	0	37	0.4443359E-01
1006.840	6	0	38	-1.347351
1797.740	36	0	39	0.4040527E-01
1250.331	38	0	40	0.4504395E-01
2032.130	44	0	41	0.4394531E-01
680.8724	8	0	42	-6.726135
1623.591	41	0	43	0.4223633E-01
961.4064	5	0	44	-17.39581
676.3027	9	0	45	-0.4522705E-01
1770.024	10	0	46	-0.6577148
364.7570	43	0	47	0.4360962E-01
2196.617	40	0	48	0.4028320E-01
1115.013	38	0	49	0.4711914E-01
1221.831	24	0	50	0.4736328E-01

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710.7184	41	0	2	0.4217529E-01
456.3814	20	0	3	-0.1037598E-02
483.2046	8	0	4	-6.782623
512.6810	35	0	5	0.4235840E-01
422.3404	38	0	6	0.4528809E-01
115.3312	7	0	7	-22.56680
155.1053	6	0	8	-6.858078
231.7157	7	0	9	-3.224350
432.8432	37	0	10	0.4455566E-01
616.3801	42	0	11	0.4534912E-01
1336.339	37	0	12	0.4980469E-01
719.6361	37	0	13	0.4754639E-01
439.8676	13	0	14	-3.041199
829.3293	39	0	15	0.4229736E-01
129.1675	31	0	16	0.4022217E-01
344.1685	28	0	17	0.4391479E-01
368.6711	37	0	18	0.4421997E-01
424.9180	10	0	19	-1.250977
467.2797	12	0	20	-0.5935059
311.2302	32	0	21	0.4974365E-01
746.4229	34	0	22	0.4315186E-01
365.5122	17	0	23	-0.4406738E-01
345.0691	6	0	24	-1.871857
244.0995	15	0	25	-0.2154846
270.0763	30	0	26	0.4690552E-01
331.4392	7	0	27	-4.213501
506.6742	34	0	28	0.4916382E-01
408.1384	8	0	29	-4.799957
916.9733	39	0	30	0.4614258E-01
438.8315	32	0	31	0.4251099E-01
476.1595	36	0	32	0.4727173E-01
411.2444	34	0	33	0.4193115E-01
656.9990	42	0	34	0.4296875E-01
306.5242	9	0	35	-2.757263
627.5724	34	0	36	0.3924561E-01
1003.159	42	0	37	0.4711914E-01
304.7442	9	0	38	-0.6868896
482.4419	35	0	39	0.4019165E-01
332.0857	36	0	40	0.4968262E-01
501.3580	42	0	41	0.4687500E-01
212.8775	10	0	42	-1.317078
467.9837	38	0	43	0.4406738E-01
259.2044	7	0	44	-8.041779
236.6788	10	0	45	0.1422119E-01
460.0369	23	0	46	0.3665161E-01
137.6068	19	0	47	0.2258301E-01
596.7518	38	0	48	0.4626465E-01
327.6785	10	0	49	-0.9767761
373.9717	7	0	50	-10.44843

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308.5258	39	0	2	0.4742432E-01
248.3540	21	0	3	0.2410889E-01
221.8392	8	0	4	-6.983871
222.5883	33	0	5	0.4878235E-01
199.2782	35	0	6	0.4747009E-01
53.86822	8	0	7	-14.46934
73.66733	8	0	8	-17.96638
106.6675	9	0	9	-5.970970
232.5126	35	0	10	0.4441833E-01
313.8552	40	0	11	0.4617310E-01
579.8979	37	0	12	0.3930664E-01
323.3066	35	0	13	0.4763794E-01
199.6246	13	0	14	-0.7741394
359.9473	38	0	15	0.4074097E-01
62.74147	29	0	16	0.4799271E-01
159.8699	12	0	17	-1.906433
165.7603	34	0	18	0.4531860E-01
185.3884	12	0	19	-0.3530273
206.6702	14	0	20	-0.8389893
149.7317	20	0	21	-0.7875061E-01
323.9680	33	0	22	0.4293823E-01
159.1677	19	0	23	0.3218079E-01
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122.9743	14	0	25	0.4051971E-01
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192.1443	10	0	29	-3.013962
406.6941	37	0	30	0.4565430E-01
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203.8003	16	0	46	-0.2223206
74.17188	14	0	47	-0.4953003E-01
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174.0390	8	0	50	-7.041611

SNR ≃ 49.41

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153.0431	9	0	3	-3.976700
122.8351	9	0	4	-2.446014
121.0378	32	0	5	0.4763031E-01
116.3247	26	0	6	0.3871918E-01
29.22083	9	0	7	-8.274797
40.17923	9	0	8	-12.15576
61.93649	10	0	9	-2.661903
158.1252	33	0	10	0.4873657E-01
204.7616	39	0	11	0.4098511E-01
315.1651	36	0	12	0.4089355E-01
181.0638	34	0	13	0.4646301E-01
109.4734	14	0	14	-0.5046921
195.6644	37	0	15	0.4035950E-01
38.15772	28	0	16	0.4912186E-01
87.21001	13	0	17	-0.6695328
90.19677	32	0	18	0.4949188E-01
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112.7725	15	0	20	-0.2418594
85.51025	21	0	21	-0.3456116E-01
176.1143	32	0	22	0.4394531E-01
86.59995	21	0	23	-0.4055786E-01
90.36866	9	0	24	-7.257210
75.84650	15	0	25	-0.8345032E-01
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84.13059	9	0	45	-3.608658
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74.04153	31	0	5	0.4864502E-01
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55.19588	31	0	18	0.4703522E-01
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69.08038	16	0	20	-0.1193466
55.63025	21	0	21	0.3388596E-01
107.6880	31	0	22	0.4671478E-01
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58.17639	10	0	24	-4.990639
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90.75588	16	0	28	0.1458740E-01
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82.48637	30	0	31	0.4010010E-01
75.66213	33	0	32	0.4410553E-01
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157.2278	38	0	37	0.4440308E-01
70.51305	10	0	38	-3.363914
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67.08566	18	0	40	0.3771210E-01
72.45010	37	0	41	0.4714203E-01
49.71371	10	0	42	0.2013016E-01
85.35841	15	0	43	-0.2291794
40.65769	10	0	44	-1.959652
51.95418	10	0	45	-4.369297
68.13503	18	0	46	0.4991150E-01
34.37984	16	0	47	-0.2195969
128.4130	32	0	48	0.4780579E-01
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60.21098	10	0	50	-1.735809

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49.77763	11	0	4	-1.898148
48.46958	31	0	5	0.3997040E-01
46.58303	26	0	6	0.4194641E-01
12.04029	10	0	7	-0.4722958
16.19208	10	0	8	-1.432205
29.31822	12	0	9	-1.643305
113.8062	10	0	10	-0.5820465E-01
110.7174	13	0	11	-2.175446
126.0927	34	0	12	0.4646301E-01
78.44510	32	0	13	0.4888153E-01
43.94887	16	0	14	-0.2698822
78.33073	35	0	15	0.4254913E-01
20.21334	27	0	16	0.3607368E-01
35.00590	15	0	17	-0.3328857
36.18601	30	0	18	0.4639816E-01
41.20903	15	0	19	0.3606415E-01
45.25984	17	0	20	-0.9866714E-01
39.24335	22	0	21	0.7972717E-03
70.47828	31	0	22	0.3900909E-01
34.70752	22	0	23	0.3797913E-01
40.60053	11	0	24	-4.058949
43.68491	13	0	25	-0.4473343
31.89360	13	0	26	-0.7295322
39.00897	11	0	27	-2.453533
59.38395	17	0	28	-0.2468872E-01
50.85405	12	0	29	-0.9377060
92.80140	25	0	30	0.2542877E-01
60.73524	29	0	31	0.4589462E-01
52.22959	32	0	32	0.4722977E-01
85.10739	11	0	33	-2.214195
73.67779	35	0	34	0.4835510E-01
65.19262	11	0	35	-0.8453751
64.92013	24	0	36	0.3964996E-01
104.1380	34	0	37	0.4871368E-01
46.90796	11	0	38	-3.114838
61.27835	28	0	39	0.3676224E-01
43.96483	19	0	40	0.2397919E-01
47.47142	36	0	41	0.4526901E-01
34.92305	11	0	42	-0.8603554
59.37278	16	0	43	-0.2244530
26.58983	11	0	44	-2.104954
34.44878	11	0	45	-3.602940
44.63489	19	0	46	0.3601837E-01
25.07042	16	0	47	-0.1427021
98.95547	30	0	48	0.4489136E-01
34.05371	16	0	49	-0.4737053
39.73991	11	0	50	-1.682320

SN12=94,7

34.44641	11	0	1	-0.7133064
45.81894	35	0	2	0.4141235E-01
47.95374	11	0	3	-0.2527847
34.18847	12	0	4	-1.862335
33.08688	30	0	5	0.4283524E-01
31.76961	26	0	6	0.3950119E-01
7.945647	11	0	7	-1.235637
10.95609	11	0	8	-2.054105
22.23633	12	0	9	-0.1906528
78.78017	11	0	10	-0.6159134
76.22347	13	0	11	-0.2441483
85.92512	34	0	12	0.3928375E-01
56.32268	32	0	13	0.3971481E-01
29.97500	17	0	14	-0.2815781
53.43219	34	0	15	0.4419708E-01
16.33556	26	0	16	0.4481316E-01
23.89496	16	0	17	-0.2974644
24.72723	29	0	18	0.4709625E-01
28.11508	16	0	19	-0.5549240E-01
30.86602	18	0	20	-0.9340286E-01
29.30986	22	0	21	0.1573563E-01
48.07905	30	0	22	0.4311752E-01
23.64613	23	0	23	0.1912689E-01
28.38948	11	0	24	-1.553532
29.84025	14	0	25	-0.5079937
21.94747	14	0	26	-0.6268826
29.37893	12	0	27	-2.469400
40.45992	18	0	28	-0.5463791E-01
35.59515	12	0	29	-0.4043617
63.26262	25	0	30	0.4328156E-01
46.75271	24	0	31	0.2981949E-01
37.36970	27	0	32	0.3727722E-01
58.80682	12	0	33	-2.438702
53.44244	34	0	34	0.4561996E-01
51.07757	10	0	35	-1.149464
44.26473	24	0	36	0.4396057E-01
70.97198	34	0	37	0.4035950E-01
32.59589	11	0	38	-0.1021576E-01
46.84825	27	0	39	0.4697418E-01
29.98705	20	0	40	0.7703781E-02
32.41075	35	0	41	0.4458237E-01
26.04378	12	0	42	-1.300526
43.40669	17	0	43	-0.2436752
18.29097	12	0	44	-2.088423
23.78576	11	0	45	-0.2125378
30.42914	20	0	46	0.1955795E-01
17.22369	16	0	47	-0.2446156
75.58464	12	0	48	-0.6420364
23.29574	16	0	49	-0.5141258E-01
27.37485	12	0	50	-1.594700

23.90156	12	0	1	-1.364120	SNR = 113
31.96876	34	0	2	0.4198837E-01	
33.65518	12	0	3	-1.691650	
24.06006	12	0	4	-0.7442665E-01	
23.11053	29	0	5	0.4652786E-01	
22.15045	26	0	6	0.3645325E-01	
5.592407	12	0	7	-1.436312	
7.873727	12	0	8	-2.134081	
17.40167	13	0	9	-0.5538845	
55.56758	12	0	10	-0.8503456	
53.44126	14	0	11	-0.4428101	
59.89230	33	0	12	0.4311371E-01	
41.90983	31	0	13	0.4116821E-01	
20.91276	18	0	14	-0.2682266	
37.27662	33	0	15	0.4621887E-01	
13.73923	26	0	16	0.3934193E-01	
16.67303	16	0	17	-0.1609421E-01	
17.29468	28	0	18	0.4879761E-01	
19.59705	17	0	19	-0.9687233E-01	
21.53606	18	0	20	0.2011299E-01	
22.78301	22	0	21	0.1408768E-01	
33.55075	29	0	22	0.4821777E-01	
16.49986	23	0	23	0.3734779E-01	
19.97325	12	0	24	-1.744419	
20.88397	15	0	25	-0.4892712	
15.39377	14	0	26	-0.6539536E-01	
22.76828	12	0	27	-0.4446011	
28.17650	19	0	28	-0.6655121E-01	
24.89537	13	0	29	-0.5555687	
44.04073	26	0	30	0.2519226E-01	
36.54005	16	0	31	0.3582382E-01	
26.04752	27	0	32	0.3588295E-01	
41.57813	12	0	33	-0.2482986E-01	
40.19574	32	0	34	0.4763794E-01	
36.12211	11	0	35	-3.210190	
30.85743	24	0	36	0.4557991E-01	
49.48284	33	0	37	0.4274368E-01	
22.59699	12	0	38	-0.6873455	
36.14025	23	0	39	0.3787613E-01	
20.89505	21	0	40	-0.3253937E-02	
22.63756	34	0	41	0.4434776E-01	
20.40860	13	0	42	-1.392441	
32.62019	17	0	43	-0.1427193	
12.91191	12	0	44	-0.1481819	
16.36705	12	0	45	-0.9062080	
21.19694	21	0	46	0.8306503E-02	
12.06479	16	0	47	0.4612923E-02	
53.02471	13	0	48	-0.7061462	
16.25610	17	0	49	-0.1038971	
19.32258	12	0	50	-0.6010246E-01	

SNR=135.5

16.93273	13	0	1	-1.474108
22.47457	33	0	2	0.4275513E-01
23.93915	13	0	3	-1.693954
16.76691	13	0	4	-0.4815884
16.22690	29	0	5	0.3936577E-01
15.59970	25	0	6	0.4711819E-01
4.100123	12	0	7	-0.3213549E-01
5.565190	12	0	8	-0.3265333
14.17911	13	0	9	0.2454472E-01
39.45364	13	0	10	-0.8559341
37.70930	15	0	11	-0.4859962
42.05120	32	0	12	0.4722977E-01
31.95486	30	0	13	0.4130745E-01
14.67214	18	0	14	-0.3305340E-01
26.20359	32	0	15	0.4839325E-01
11.96764	25	0	16	0.4756737E-01
11.67303	17	0	17	-0.7289982E-01
12.15162	28	0	18	0.4054642E-01
13.77080	18	0	19	-0.1027231
15.09079	19	0	20	-0.1093197E-01
17.29910	18	0	21	-0.1340485E-01
23.54566	29	0	22	0.4126358E-01
11.60736	23	0	23	0.4863930E-01
14.22820	12	0	24	-0.8699036E-01
14.65784	15	0	25	-0.7885742E-01
10.80681	15	0	26	-0.1646585
17.90152	13	0	27	-0.9927673
19.77439	19	0	28	0.1839066E-01
17.57073	14	0	29	-0.5523720
30.89507	26	0	30	0.3179169E-01
25.64954	17	0	31	-0.5132103E-01
18.33230	26	0	32	0.4976273E-01
29.15350	13	0	33	-0.5459137
29.19014	24	0	34	0.4356384E-01
25.61855	11	0	35	-0.3400764
21.66290	24	0	36	0.4533768E-01
34.75429	32	0	37	0.4529953E-01
15.94775	13	0	38	-0.8755980
27.92092	22	0	39	0.2757072E-01
14.67964	21	0	40	0.2680397E-01
15.93729	33	0	41	0.4448986E-01
16.21349	13	0	42	-0.3570080
23.04657	16	0	43	0.2470207E-01
8.915112	13	0	44	-0.5794773
11.54338	13	0	45	-1.076946
14.88913	21	0	46	0.2740574E-01
8.456334	17	0	47	-0.4909801E-01
37.45935	14	0	48	-0.6493416
11.42592	18	0	49	-0.1149893
13.47897	13	0	50	-0.4060402

SNR = 198

11.90036	13	0	1	-0.9561729E-01
15.68347	32	0	2	0.4338455E-01
16.71826	13	0	3	-0.2372837
11.69010	14	0	4	-0.5663280
11.34117	28	0	5	0.4299164E-01
10.87184	25	0	6	0.4246521E-01
2.722842	13	0	7	-0.3697076
3.788225	13	0	8	-0.6389887
10.32186	13	0	9	-0.1101713
27.77347	14	0	10	-0.7305908
26.40139	16	0	11	-0.4330311
29.24373	32	0	12	0.3992844E-01
24.79788	28	0	13	0.4683304E-01
10.18695	19	0	14	-0.6872368E-01
18.23479	32	0	15	0.4008865E-01
10.61546	25	0	16	0.3622627E-01
8.114297	18	0	17	-0.8343124E-01
8.510128	27	0	18	0.4278469E-01
9.600787	18	0	19	0.5393028E-02
10.53299	19	0	20	0.4671478E-01
12.02218	19	0	21	-0.4152012E-01
16.43055	28	0	22	0.4631615E-01
8.055092	24	0	23	0.2797222E-01
9.795925	13	0	24	-0.4433193
10.18263	16	0	25	-0.1409483
7.546101	16	0	26	-0.1754422
12.88958	13	0	27	-0.8037539
13.72868	20	0	28	-0.6417274E-02
12.26824	14	0	29	-0.5711746E-01
21.49310	26	0	30	0.3550720E-01
17.85151	18	0	31	-0.7843018E-01
12.77190	26	0	32	0.4571152E-01
20.38666	14	0	33	-0.6732292
20.32366	24	0	34	0.4866791E-01
17.73736	12	0	35	-0.9146328
15.08484	24	0	36	0.4421806E-01
24.22191	31	0	37	0.4792786E-01
11.23262	14	0	38	-0.8116255
19.95430	18	0	39	0.2931023E-01
10.24667	21	0	40	0.4896259E-01
11.14346	32	0	41	0.4452801E-01
12.31932	13	0	42	-0.2717924
16.03689	17	0	43	-0.3812790E-01
6.223435	14	0	44	-0.6575141
8.189889	13	0	45	0.1890182E-01
10.38360	21	0	46	0.4140759E-01
5.886945	18	0	47	-0.6241989E-01
26.17271	14	0	48	-0.5954552E-01
7.981010	18	0	49	0.1419115E-01
9.407668	14	0	50	-0.4701605

SNR = 248.7

7.970299	14	0	1	-0.3063674
10.65584	31	0	2	0.4338360E-01
11.30085	14	0	3	-0.3968906
7.954021	15	0	4	-0.4858890
7.729578	27	0	5	0.4678774E-01
7.368311	25	0	6	0.3767586E-01
1.834916	14	0	7	-0.4058694
2.595644	14	0	8	-0.6207819
6.939866	14	0	9	-0.2454467
18.88777	14	0	10	-0.8181000E-01
17.91644	16	0	11	-0.2617073E-01
19.80516	31	0	12	0.4292297E-01
18.19764	22	0	13	0.2957153E-01
6.879318	20	0	14	-0.6800508E-01
12.37363	31	0	15	0.4116154E-01
8.499771	19	0	16	-0.1341248E-01
5.504381	18	0	17	0.1930237E-01
5.817314	26	0	18	0.4551172E-01
6.479457	19	0	19	-0.1369858E-01
7.099954	20	0	20	0.1949167E-01
8.171535	19	0	21	0.4894066E-01
11.11993	28	0	22	0.3909302E-01
5.464785	24	0	23	0.3277445E-01
6.633966	14	0	24	-0.4757686
6.889392	17	0	25	-0.1337795
5.153561	16	0	26	0.2661228E-01
8.749807	14	0	27	-0.7650938
9.304233	20	0	28	0.4051685E-01
8.282936	15	0	29	-0.1179953
14.53664	26	0	30	0.3693771E-01
12.07755	19	0	31	-0.7202053E-01
8.653407	26	0	32	0.4127026E-01
13.88222	15	0	33	-0.5875883
13.71101	25	0	34	0.2983093E-01
12.06834	13	0	35	-0.9196463
10.21533	24	0	36	0.4225254E-01
16.37903	31	0	37	0.3939056E-01
7.591088	14	0	38	-0.1106949
13.48076	19	0	39	-0.2737999E-02
6.910966	22	0	40	0.2736568E-01
7.592921	31	0	41	0.4400682E-01
8.306330	14	0	42	-0.3941031
10.84536	18	0	43	-0.5031776E-01
4.266781	15	0	44	-0.5613394
5.447583	14	0	45	-0.1945834
7.003865	22	0	46	0.2401018E-01
4.010821	18	0	47	0.2602911E-01
17.71633	15	0	48	-0.1238785
5.388953	19	0	49	-0.1038456E-01
6.410289	15	0	50	-0.4008927

SNR=335.5

5.055864	15	0	1	-0.2590671
6.824227	30	0	2	0.4221916E-01
7.200621	15	0	3	-0.3139486
5.072502	15	0	4	0.1223564E-02
4.932108	27	0	5	0.3800392E-01
4.744932	24	0	6	0.4605865E-01
1.174778	15	0	7	-0.2999179
1.675503	15	0	8	-0.4463962
4.413108	15	0	9	-0.2012281
12.05336	15	0	10	-0.7747078E-01
11.39501	17	0	11	-0.3451538E-01
12.62373	30	0	12	0.4474735E-01
11.54081	23	0	13	0.1824856E-01
4.387040	20	0	14	0.2527046E-01
7.910239	30	0	15	0.4102468E-01
5.438128	19	0	16	0.4159737E-01
3.484026	19	0	17	0.4670143E-02
3.768118	25	0	18	0.4856801E-01
4.108239	20	0	19	-0.1285458E-01
4.498002	21	0	20	0.9470940E-02
5.177781	20	0	21	0.2466488E-01
7.117172	27	0	22	0.4275656E-01
3.495623	24	0	23	0.3507233E-01
4.229722	15	0	24	-0.3488641
4.411436	17	0	25	0.3584433E-01
3.267880	17	0	26	0.2391577E-02
5.578569	15	0	27	-0.5451841
5.890993	21	0	28	0.2168608E-01
5.263236	16	0	29	-0.9402466E-01
9.244332	26	0	30	0.3667355E-01
7.698808	19	0	31	0.2877569E-01
5.516049	26	0	32	0.3623199E-01
8.862247	16	0	33	-0.4048357
8.718934	25	0	34	0.3154278E-01
7.718092	14	0	35	-0.6648932
6.508666	24	0	36	0.3944874E-01
10.44576	30	0	37	0.3984070E-01
4.817629	15	0	38	-0.1199908
8.557023	20	0	39	-0.5894661E-02
4.418223	22	0	40	0.3913546E-01
4.883997	30	0	41	0.4233122E-01
5.290816	15	0	42	-0.3058939
6.886571	19	0	43	-0.3657198E-01
2.709599	15	0	44	-0.2449775E-01
3.445220	15	0	45	-0.1799760
4.469075	22	0	46	0.3136969E-01
2.541563	19	0	47	0.1044512E-01
11.27062	16	0	48	-0.9533119E-01
3.418586	20	0	49	-0.1138735E-01
4.103198	15	0	50	0.1049089E-01

SNR = 566.9

2.801324	16	0	1	-0.8972001E-01
3.874930	28	0	2	0.4864812E-01
3.985937	16	0	3	-0.1179991
2.822345	16	0	4	0.4276752E-01
2.784073	26	0	5	0.3863406E-01
2.653681	24	0	6	0.3842592E-01
0.6408105	16	0	7	-0.1351981
0.9103184	16	0	8	-0.2088424
2.443353	16	0	9	-0.7419968E-01
6.705827	16	0	10	0.4361629E-02
6.311452	18	0	11	0.1027393E-01
7.023406	29	0	12	0.4362011E-01
6.395780	23	0	13	0.3838825E-01
2.422282	21	0	14	0.2376914E-01
4.471245	28	0	15	0.4877663E-01
3.007164	20	0	16	0.3127241E-01
1.921839	20	0	17	0.1024997E-01
2.115597	25	0	18	0.3780627E-01
2.301121	20	0	19	0.3670192E-01
2.512858	21	0	20	0.3546357E-01
2.857318	21	0	21	0.2133870E-01
3.996600	26	0	22	0.4490447E-01
1.962174	24	0	23	0.3484416E-01
2.327867	16	0	24	-0.1543794
2.443430	18	0	25	0.3679633E-01
1.813055	18	0	26	0.1614618E-01
3.055306	16	0	27	-0.2529056
3.244273	22	0	28	0.1649880E-01
2.906466	17	0	29	-0.3187084E-01
5.122540	26	0	30	0.3450012E-01
4.252464	20	0	31	0.2765274E-01
3.110379	25	0	32	0.4254675E-01
4.883904	17	0	33	-0.1868606
4.831912	25	0	34	0.3167677E-01
4.250121	15	0	35	-0.3075476
3.619117	24	0	36	0.3544092E-01
5.864690	28	0	37	0.4868984E-01
2.675834	16	0	38	-0.2428460E-01
4.719037	21	0	39	0.5514622E-02
2.484569	22	0	40	0.4766512E-01
2.807137	28	0	41	0.4822636E-01
2.926423	16	0	42	-0.1213307
3.797740	20	0	43	-0.1023388E-01
1.517690	16	0	44	0.3102660E-01
1.910095	16	0	45	-0.5667388E-01
2.500427	22	0	46	0.3693819E-01
1.405777	20	0	47	0.1276374E-01
6.231014	17	0	48	-0.2507734E-01
1.932369	20	0	49	0.4642868E-01
2.290145	16	0	50	0.4476476E-01

SNR=754.6

0.9871277	18	0	1	-0.2605504E-01
1.492797	26	0	2	0.4717052E-01
1.406904	18	0	3	-0.3525758E-01
0.9941593	18	0	4	0.1910794E-01
1.100990	24	0	5	0.4703283E-01
1.020948	23	0	6	0.4176420E-01
0.2247713	18	0	7	-0.4498616E-01
0.3197943	18	0	8	-0.7027906E-01
0.8617552	18	0	9	-0.2237064E-01
2.376528	18	0	10	0.9768486E-02
2.225874	20	0	11	0.8506536E-02
2.588060	27	0	12	0.4529738E-01
2.322641	23	0	13	0.4888630E-01
0.8859618	22	0	14	0.3574628E-01
1.704416	26	0	15	0.4839623E-01
1.091879	21	0	16	0.3395081E-01
0.7015883	21	0	17	0.2731973E-01
0.8218436	24	0	18	0.3578079E-01
0.8479682	21	0	19	0.3915238E-01
0.9119016	22	0	20	0.2995390E-01
1.032103	22	0	21	0.2880669E-01
1.493984	25	0	22	0.4110634E-01
0.7854152	23	0	23	0.4652184E-01
0.8189338	18	0	24	-0.5040932E-01
0.8591746	20	0	25	0.1481158E-01
0.6391506	20	0	26	0.7579684E-02
1.071784	18	0	27	-0.8408928E-01
1.196545	22	0	28	0.4038417E-01
1.022713	19	0	29	-0.8577228E-02
1.882257	25	0	30	0.4025507E-01
1.535568	21	0	31	0.4089952E-01
1.189838	24	0	32	0.4572761E-01
1.759874	18	0	33	0.3935611E-01
1.783576	24	0	34	0.4278588E-01
1.497264	17	0	35	-0.1028072
1.359977	23	0	36	0.4325843E-01
2.146393	27	0	37	0.3839827E-01
0.9445468	18	0	38	-0.4088163E-02
1.681966	22	0	39	0.2405608E-01
0.9034459	23	0	40	0.3080064E-01
1.117136	26	0	41	0.4669559E-01
1.032394	18	0	42	-0.3758001E-01
1.356658	21	0	43	0.2215743E-01
0.5350699	18	0	44	0.1472944E-01
0.6722392	18	0	45	-0.1603734E-01
0.9418645	22	0	46	0.4034156E-01
0.5192065	21	0	47	0.2481225E-01
2.195434	19	0	48	-0.4155636E-02
0.7269934	21	0	49	0.4679102E-01
0.8087191	18	0	50	0.1987976E-01

0.5614773	19	0	1	-0.6479025E-02
0.9303470	25	0	2	0.4764706E-01
0.7985430	19	0	3	-0.1151127E-01
0.5669717	19	0	4	0.1734418E-01
0.6642579	24	0	5	0.3870302E-01
0.6172256	23	0	6	0.3711575E-01
0.1705117	18	0	7	0.4337683E-01
0.2211902	18	0	8	0.4131038E-01
0.4895848	19	0	9	-0.7001936E-02
1.351145	19	0	10	0.1225734E-01
1.262311	21	0	11	0.8977652E-02
1.545795	26	0	12	0.4602516E-01
1.365174	23	0	13	0.4829800E-01
0.5534959	22	0	14	0.4925460E-01
1.052668	25	0	15	0.4916358E-01
0.6652553	21	0	16	0.4444772E-01
0.4412039	21	0	17	0.4192916E-01
0.5411193	23	0	18	0.4393545E-01
0.4830924	22	0	19	0.2441984E-01
0.5530910	22	0	20	0.3521329E-01
0.6237317	22	0	21	0.3768373E-01
0.9277288	24	0	22	0.4721433E-01
0.4898293	23	0	23	0.4227808E-01
0.5123098	18	0	24	0.4895434E-01
0.5304880	20	0	25	0.4267943E-01
0.3973408	20	0	26	0.3406432E-01
0.6045461	19	0	27	-0.4009777E-01
0.7253532	22	0	28	0.4588962E-01
0.6158116	19	0	29	0.3641367E-01
1.149370	24	0	30	0.4891634E-01
0.8721537	22	0	31	0.2584243E-01
0.7151781	24	0	32	0.3949535E-01
1.004116	19	0	33	0.3133678E-01
1.049536	24	0	34	0.3841567E-01
0.8464316	18	0	35	-0.4875505E-01
0.8098775	23	0	36	0.3842902E-01
1.283729	26	0	37	0.3920388E-01
0.5382210	19	0	38	0.4180372E-02
0.9894337	22	0	39	0.3612542E-01
0.5443932	23	0	40	0.3131539E-01
0.7175561	25	0	41	0.4723662E-01
0.5863377	19	0	42	-0.1397824E-01
0.8107970	21	0	43	0.4127330E-01
0.3074049	19	0	44	0.1532885E-01
0.3828639	19	0	45	-0.2379954E-02
0.5760897	22	0	46	0.4045385E-01
0.3327047	21	0	47	0.3654245E-01
1.290431	19	0	48	0.4668891E-01
0.4154657	22	0	49	0.2904931E-01
0.4622554	19	0	50	0.1726216E-01

SNR=754.6

		Sm			
972.0029	12	5	1	-9.777649	
2847.074	43	93	2	0.4736328E-01	
1196.707	40	7	3	0.4333496E-01	SNR=11.9
1285.916	29	6	4	0.4528809E-01	
1964.725	36	11	5	0.4064941E-01	
1631.166	34	87	6	0.4345703E-01	
276.5204	28	5	7	-0.1829834	
271.4885	30	5	8	0.3723145E-02	
703.1106	43	7	9	0.4925537E-01	
1460.891	40	94	10	0.4223633E-01	
2201.029	43	77	11	0.4809570E-01	
5181.108	38	8	12	0.3906250E-01	
2433.563	39	10	13	0.3979492E-01	
1631.730	35	12	14	0.3918457E-01	
3348.460	38	16	15	0.4077148E-01	
461.6884	32	23	16	0.3744507E-01	
1129.710	33	7	17	0.4772949E-01	
1352.466	41	12	18	0.4101563E-01	
1495.482	14	7	19	-2.532227	
1671.524	40	8	20	0.4504395E-01	
1166.359	37	16	21	0.4516602E-01	
2549.708	43	9	22	0.4956055E-01	
1229.145	34	9	23	0.4443359E-01	
942.1805	14	5	24	-2.491028	
917.5815	31	101	25	0.3863525E-01	
764.8041	34	15	26	0.4180908E-01	
971.5093	30	10	27	0.4663086E-01	
2007.433	33	82	28	0.4479980E-01	
1189.939	41	7	29	0.4406738E-01	
3719.975	41	96	30	0.4174805E-01	
1460.355	44	10	31	0.4943848E-01	
1865.725	38	16	32	0.3894043E-01	
1232.338	42	11	33	0.4943848E-01	
2576.944	44	27	34	0.4370117E-01	
977.5753	20	10	35	0.1733398E-01	
2494.369	36	94	36	0.4248047E-01	
3816.882	41	6	37	0.4907227E-01	
769.6909	31	6	38	0.4083252E-01	
1663.462	40	12	39	0.4504395E-01	
1155.879	38	12	40	0.4528809E-01	
1991.053	45	16	41	0.4980469E-01	
433.8921	37	9	42	0.4470825E-01	
1589.157	41	16	43	0.4589844E-01	
681.6814	16	6	44	-1.869446	
608.4707	28	12	45	0.4034424E-01	
1525.703	38	7	46	0.4577637E-01	
364.7610	43	103	47	0.4370117E-01	
2024.107	42	8	48	0.4321289E-01	
1100.630	15	9	49	-2.525757	
1189.333	32	5	50	0.3991699E-01	

SNR=23,9

		Sm		
320.7111	17	7	1	--0.5338745
710.7223	41	88	2	0.4241943E-01
403.7106	38	9	3	0.4840088E-01
395.6339	23	8	4	-0.8419189
508.8336	36	25	5	0.3988647E-01
422.3438	38	86	6	0.4547119E-01
101.1336	17	8	7	-0.5492249
104.9927	19	7	8	-1.269440
204.1229	39	9	9	0.4643250E-01
432.8459	37	98	10	0.4437256E-01
616.3859	42	79	11	0.4522705E-01
1336.360	37	71	12	0.4968262E-01
698.5887	37	19	13	0.4235840E-01
432.1707	17	16	14	-0.5959167
829.3373	39	75	15	0.4205322E-01
129.4591	32	36	16	0.4875183E-01
340.8265	32	11	17	0.4879761E-01
366.2652	37	27	18	0.4577637E-01
410.0880	14	13	19	-0.7765198
441.6157	35	13	20	0.3958130E-01
308.9416	32	25	21	0.4446411E-01
721.0298	38	17	22	0.4388428E-01
349.1456	26	17	23	0.8636475E-02
294.6292	24	7	24	-0.4693298
244.1019	15	95	25	-0.2154236
254.1149	32	16	26	0.4867554E-01
300.3936	13	10	27	-3.381104
506.6789	34	93	28	0.4913330E-01
364.4591	33	9	29	0.4772949E-01
916.9801	39	106	30	0.4626465E-01
425.7479	37	19	31	0.4956055E-01
476.1626	36	73	32	0.4733276E-01
385.5058	37	16	33	0.4251099E-01
657.0051	42	81	34	0.4296875E-01
282.6532	27	11	35	0.4452515E-01
627.5797	34	82	36	0.3918457E-01
1003.167	42	70	37	0.4699707E-01
253.2555	30	10	38	0.4678345E-01
463.2896	35	19	39	0.4714966E-01
329.2451	36	25	40	0.4971313E-01
501.3684	42	78	41	0.4696655E-01
158.1406	35	11	42	0.4295349E-01
473.6692	20	14	43	-0.1014404
208.0881	25	8	44	-0.6039429
209.6488	31	13	45	0.4605103E-01
441.7466	31	14	46	0.4052734E-01
138.3282	24	31	47	0.4966736E-01
596.7563	38	84	48	0.4620361E-01
305.1434	27	12	49	0.3552246E-01
352.0202	35	8	50	0.4776001E-01

Sm

SNR=36,4

161.2765	16	9	1	-0.4564514
308.5316	39	80	2	0.4757690E-01
219.8469	36	11	3	0.4605103E-01
188.4247	20	10	4	-0.2565918
222.2529	34	36	5	0.4031372E-01
199.2804	35	87	6	0.4739380E-01
50.62238	19	9	7	-0.6547585
54.73404	18	9	8	-0.6706467
96.06194	36	11	9	0.4901886E-01
232.5171	35	88	10	0.4441833E-01
313.8578	40	84	11	0.4629517E-01
579.9048	37	86	12	0.3936768E-01
320.1167	35	27	13	0.4888916E-01
195.6639	17	18	14	-0.6296387
359.9539	38	85	15	0.4064941E-01
62.92031	29	34	16	0.4786301E-01
158.5146	21	14	17	-0.1201782
165.0715	34	31	18	0.4763794E-01
183.1389	15	17	19	-0.8748016
196.6551	36	15	20	0.4780579E-01
147.3471	24	23	21	0.8697510E-02
321.6472	35	26	22	0.4925537E-01
155.7504	24	23	23	0.4048157E-01
142.6421	26	9	24	-0.1901550
122.9744	14	101	25	0.4003906E-01
125.8790	14	14	26	-0.5983582
138.0878	12	13	27	-1.212189
232.2522	33	91	28	0.4269409E-01
175.5204	34	11	29	0.4904175E-01
406.6985	37	107	30	0.4580688E-01
203.2298	34	26	31	0.4707336E-01
211.5424	35	78	32	0.4307556E-01
212.8780	35	18	33	0.4919434E-01
297.3130	40	84	34	0.4122925E-01
148.0738	26	13	35	0.4344177E-01
284.8705	31	82	36	0.4885864E-01
445.5804	41	79	37	0.4104614E-01
139.3685	29	12	38	0.4551697E-01
216.5710	33	23	39	0.4487610E-01
161.0729	35	37	40	0.4484558E-01
217.7257	40	90	41	0.4716492E-01
95.33861	32	13	42	0.4581451E-01
222.0761	26	15	43	-0.9582520E-02
98.78291	22	10	44	-0.3396225
132.8687	14	12	45	-0.1507111
198.0146	27	18	46	0.3375244E-01
74.32635	15	44	47	0.4384613E-01
291.1823	36	79	48	0.46850879E-01
139.0172	24	15	49	-0.4098511E-01
165.8570	34	9	50	0.2856445E-01

SNR = 49.4

		Sm		
95.64579	15	11	1	-0.7115173E-01
167.7350	38	79	2	0.4396057E-01
142.7267	13	12	3	-1.186539
107.8942	24	11	4	0.2507782E-01
121.1059	33	37	5	0.4999542E-01
116.2982	30	31	6	0.4717255E-01
29.24016	16	11	7	0.1152992E-01
32.98530	16	11	8	-0.6639709
56.61552	31	13	9	0.3353119E-02
158.1287	33	86	10	0.4869080E-01
204.8237	39	55	11	0.4997253E-01
315.1689	36	90	12	0.4061890E-01
180.7439	34	37	13	0.4716492E-01
107.7522	18	20	14	-0.2411270
195.6674	37	94	15	0.4039001E-01
38.34481	29	34	16	0.4961014E-01
86.84111	15	21	17	-0.4460983
90.00369	33	39	18	0.4138184E-01
101.7835	15	23	19	-0.4506454
108.1731	34	17	20	0.4982758E-01
84.78116	24	26	21	0.3264618E-01
175.9128	33	36	22	0.4937744E-01
85.46110	24	27	23	0.4184723E-01
83.14035	21	11	24	-0.7850647E-02
76.02973	16	38	25	0.3648376E-01
71.01344	15	16	26	-0.3025284
80.09119	14	14	27	-1.769218
137.0674	32	89	28	0.4164124E-01
105.5094	31	13	29	0.4913330E-01
232.4492	24	48	30	0.4937744E-01
121.4685	32	32	31	0.4972839E-01
118.7179	34	98	32	0.4265594E-01
179.3820	13	14	33	-0.1038666
167.4872	38	87	34	0.4467773E-01
99.46809	25	14	35	0.4327393E-01
161.6232	26	30	36	0.4797363E-01
248.9730	39	89	37	0.4670715E-01
95.08031	27	14	38	0.4478455E-01
126.6542	31	27	39	0.3781891E-01
105.3280	25	19	40	0.3865051E-01
118.3875	39	90	41	0.4135895E-01
66.56537	14	14	42	-1.417427
127.5202	25	17	43	0.2166748E-01
57.40092	16	12	44	-0.2122879
78.27119	13	13	45	-0.7514496
108.9451	25	21	46	0.2922821E-01
47.40625	16	88	47	-0.4192619
180.9762	34	85	48	0.4672241E-01
77.72788	28	16	49	0.4755402E-01
92.50740	29	11	50	-0.4296112E-01

Sm

SNR=63

61.92665	15	13	1	0.1123810E-01
102.5646	37	79	2	0.4210663E-01
93.95996	14	13	3	-0.5643997
68.54390	19	13	4	-0.1434097
74.06529	32	43	5	0.4995728E-01
71.15322	29	34	6	0.4815674E-01
18.55204	15	13	7	-0.1010704
21.26280	18	12	8	-0.1119518
37.61606	30	14	9	0.4255676E-01
121.8034	32	83	10	0.4592133E-01
144.8721	35	29	11	0.4855347E-01
192.6442	35	89	12	0.4310608E-01
114.7535	33	56	13	0.4733276E-01
66.05656	19	21	14	0.5523682E-02
119.6313	36	94	15	0.4114532E-01
26.77398	29	34	16	0.4736900E-01
53.23549	17	21	17	0.1031494E-01
55.23261	32	35	18	0.4980469E-01
62.63315	15	74	19	-0.5693092
66.64234	31	19	20	0.4778290E-01
55.37647	24	28	21	0.4964066E-01
107.6933	32	41	22	0.4978943E-01
52.45623	24	31	23	0.4218674E-01
54.16700	17	13	24	-0.2723274
55.05237	17	35	25	0.3734207E-01
44.44969	16	17	26	-0.2265167E-01
52.62212	15	15	27	-0.9725685
90.76813	17	47	28	0.4896545E-01
70.23665	32	13	29	0.4383087E-01
141.8490	24	92	30	0.3990173E-01
82.45973	31	36	31	0.4977417E-01
75.66578	33	91	32	0.4414368E-01
115.6827	14	15	33	-1.150734
106.8618	37	86	34	0.4154968E-01
76.18005	26	14	35	0.4743195E-01
98.85372	26	32	36	0.4991150E-01
157.2319	38	89	37	0.4444885E-01
66.15575	12	16	38	-2.158379
84.17868	30	30	39	0.3800964E-01
65.79874	23	23	40	0.1413727E-01
72.45277	37	90	41	0.4711151E-01
44.01163	15	15	42	-0.6510735
82.58121	24	19	43	-0.3204346E-03
35.67889	18	13	44	-0.3480911E-01
48.84126	13	15	45	-1.650837
66.97991	24	24	46	0.2870941E-01
34.81330	17	30	47	0.4598999E-01
128.7033	33	38	48	0.4977417E-01
48.02552	26	18	49	0.4555130E-01
58.08839	29	12	50	0.1034164E-01

		Sm			
42.11023	16	14	1	-0.9410477E-01	
67.16303	36	85	2	0.4134369E-01	SNR=78
65.73965	15	14	3	-0.5756683	
45.89807	20	14	4	-0.1058350	
48.47058	31	69	5	0.4000854E-01	
46.64002	29	34	6	0.4686737E-01	
12.19911	12	19	7	-1.725343	
14.39136	16	14	8	-0.4987135	
27.18764	29	15	9	0.4408264E-01	
114.0224	11	47	10	0.4572296E-01	
107.8000	15	20	11	-0.6446838E-02	
126.1004	34	79	12	0.4660034E-01	
78.45062	32	66	13	0.4885101E-01	
43.31120	20	22	14	0.4106522E-01	
78.33376	35	90	15	0.4258728E-01	
20.30026	28	38	16	0.4890060E-01	
34.89222	18	22	17	0.2566147E-01	
36.30876	31	35	18	0.4979706E-01	
41.45931	17	27	19	0.2536774E-01	
43.92286	28	21	20	0.4848099E-01	
39.18381	24	31	21	0.3890610E-01	
70.47872	31	80	22	0.3904724E-01	
34.46563	25	30	23	0.4935837E-01	
37.74096	16	15	24	-0.4734039E-02	
44.50380	15	23	25	0.2841187E-01	
29.59254	17	18	26	0.6849289E-02	
37.49074	16	16	27	-0.7382355	
59.44981	18	40	28	0.4370499E-01	
49.68532	29	15	29	0.4838181E-01	
92.80437	25	91	30	0.2546692E-01	
60.89030	31	33	31	0.4885483E-01	
52.23180	32	96	32	0.4724884E-01	
79.31036	15	16	33	-0.2212524E-03	
73.68142	35	89	34	0.4839325E-01	
63.19403	24	15	35	0.4469299E-01	
64.71375	26	34	36	0.4811859E-01	
104.1412	34	90	37	0.4863739E-01	
44.11425	13	17	38	-1.432156	
60.82013	30	30	39	0.4740906E-01	
43.56959	22	27	40	0.3717041E-01	
47.47461	36	84	41	0.4536819E-01	
31.45118	16	16	42	-0.4551640	
57.64444	25	20	43	0.1640320E-01	
23.63419	19	14	44	-0.8132935E-02	
32.37466	14	16	45	-0.2731323E-02	
44.00883	24	25	46	0.4409790E-01	
25.43327	17	33	47	0.3797531E-01	
99.31956	31	34	48	0.4964447E-01	
31.69715	24	20	49	0.5174637E-02	
38.91785	29	13	50	0.3932571E-01	

	S_m			
29.54462	15	16	1	-0.1544952
45.82074	35	81	2	0.4148102E-01
47.24968	15	15	3	-0.3512192E-01 SNR≈94.7
31.87272	20	15	4	-0.1150341
33.08749	30	75	5	0.4285431E-01
31.89907	29	33	6	0.4804611E-01
8.615120	14	17	7	-0.7051725
10.00419	17	15	8	-0.1248932E-01
20.88639	27	16	9	0.4445076E-01
79.74120	12	32	10	0.2699280E-01
74.20560	16	21	11	-0.7675171E-01
85.92776	34	89	12	0.3918457E-01
56.32366	32	84	13	0.3969193E-01
29.50509	20	25	14	-0.5830765E-02
53.43427	34	91	15	0.4415512E-01
16.43319	28	36	16	0.4831314E-01
23.79090	19	23	17	0.7839203E-02
24.78364	30	38	18	0.4988098E-01
28.22476	17	37	19	0.4600334E-01
30.11583	27	22	20	0.4803276E-01
29.32914	24	32	21	0.4391479E-01
48.07978	30	82	22	0.4315567E-01
23.49863	25	33	23	0.4498291E-01
26.81424	16	16	24	-0.3637867
30.22459	15	29	25	0.4659462E-01
20.40677	17	20	26	0.4255676E-01
28.19305	16	17	27	-0.1605778
40.57350	19	36	28	0.3804398E-01
35.53957	27	15	29	0.3710556E-01
63.60318	26	43	30	0.4831314E-01
46.27763	28	28	31	0.4874039E-01
37.37229	27	89	32	0.3728104E-01
55.14020	15	18	33	-0.3353004
53.44741	34	83	34	0.4564667E-01
48.82252	13	15	35	-1.627346
44.12358	26	35	36	0.4805374E-01
70.97554	34	86	37	0.4036713E-01
30.46691	14	18	38	-0.7596779E-01
46.70992	28	27	39	0.4656601E-01
29.88837	22	30	40	0.4461098E-01
32.41228	35	95	41	0.4453659E-01
23.74616	18	16	42	-0.2197380
42.34027	25	21	43	0.3483963E-01
16.23384	17	16	44	-0.2721405
22.27638	14	18	45	-0.8486347
30.04839	24	27	46	0.3844643E-01
17.22403	16	97	47	-0.2444572
77.99440	15	18	48	0.4205322E-01
21.73590	24	21	49	0.4508591E-01
27.00797	22	15	50	-0.1697350E-01

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21.05836	16	17	1	-0.3271008
31.97024	34	81	2	0.4197502E-01
33.73204	15	17	3	0.4787445E-01 SNR=113
22.52611	18	17	4	-0.1509075
23.31264	30	38	5	0.4977226E-01
22.23341	28	36	6	0.4716492E-01
6.026171	14	20	7	-0.7382250E-01
7.009984	15	18	8	-0.7266569E-01
16.77944	25	17	9	0.3812790E-01
55.56937	12	87	10	-0.8495903
52.07759	16	23	11	-0.3245850
59.89462	33	90	12	0.4304504E-01
41.91189	31	82	13	0.4125214E-01
20.56720	21	25	14	0.4674149E-01
37.27885	33	90	15	0.4622650E-01
13.78177	27	41	16	0.4917622E-01
16.56364	19	25	17	0.4659271E-01
17.26136	29	47	18	0.4990005E-01
19.77216	18	33	19	0.4016304E-01
21.07536	27	23	20	0.4539680E-01
22.87070	24	32	21	0.4422569E-01
33.57139	30	47	22	0.4984665E-01
16.38981	25	35	23	0.4738998E-01
18.82586	15	18	24	-0.3811798
20.88384	15	83	25	-0.4886360
14.34500	18	21	26	-0.5616188E-02
22.04562	17	18	27	-0.2821350
28.33268	20	33	28	0.4340363E-01
25.09236	26	16	29	0.2915573E-01
44.04302	26	91	30	0.2514648E-01
36.35224	18	28	31	0.8190155E-02
26.04887	27	100	32	0.3588867E-01
38.94089	15	20	33	0.2436829E-01
40.19833	32	88	34	0.4761887E-01
34.16325	13	18	35	-0.1752357
30.76731	26	35	36	0.4925728E-01
49.48586	33	89	37	0.4273224E-01
21.45070	14	20	38	-0.5986252
35.44088	27	28	39	0.4693604E-01
20.99896	23	29	40	0.4644966E-01
22.63951	34	86	41	0.4443550E-01
18.63126	19	17	42	-0.3623390E-01
32.22933	24	22	43	0.4798889E-01
11.37223	18	17	44	0.2510166E-01
15.62144	15	19	45	-0.8262539E-01
20.98367	24	28	46	0.4341316E-01
12.14223	17	44	47	0.4473591E-01
53.02660	13	85	48	-0.7055855
15.18050	25	22	49	0.3240490E-01
19.14521	22	16	50	-0.1671791E-01

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15.07899	16	19	1	-0.2194481
22.47550	33	94	2	0.4270363E-01 SNR=135
24.14104	16	18	3	-0.1919918
15.95719	19	18	4	0.6988525E-02
16.22732	29	84	5	0.3937340E-01
15.71455	28	34	6	0.4899025E-01
4.314827	15	20	7	0.2014637E-02
4.944471	15	20	8	-0.5087886
13.90344	24	18	9	0.4578781E-01
39.45467	13	89	10	-0.8554611
36.70868	18	22	11	-0.2590179E-02
42.05462	32	85	12	0.4730606E-01
31.95677	30	83	13	0.4138374E-01
14.45238	24	24	14	0.4446030E-01
26.20560	32	89	15	0.4840279E-01
12.06044	27	36	16	0.4977226E-01
11.60579	20	26	17	0.1410961E-01
12.15113	28	66	18	0.4065323E-01
13.96932	19	31	19	0.3836727E-01
14.86169	25	25	20	0.3927803E-01
17.36676	19	40	21	0.4343605E-01
23.54637	29	84	22	0.4128838E-01
11.50964	25	37	23	0.4809952E-01
13.24620	16	19	24	-0.4433727E-01
14.76131	16	38	25	0.4104042E-01
10.13524	19	22	26	-0 2567482E-01
17.71481	16	20	27	-0.3547935
19.95499	21	31	28	0.4932404E-01
17.84549	25	17	29	0.3751755E-01
30.89666	26	90	30	0.3184891E-01
25.66025	18	36	31	0.4636574E-01
18.30821	27	64	32	0.4997826E-01
27.64583	16	20	33	-0.3954277
29.52918	25	40	34	0.4921532E-01
24.02607	14	18	35	0.3311157E-02
21.61173	26	35	36	0.4920959E-01
34.75676	32	89	37	0.4530716E-01
15.17219	16	19	38	-0.4380798E-01
27.63905	26	27	39	0.4791069E-01
14.75588	23	32	40	0.4312229E-01
15.93838	33	94	41	0.4448414E-01
15.11155	18	19	42	-0.1639090
23.01911	20	24	43	0.2822876E-01
8.045821	17	19	44	-0.5186272E-01
11.02031	15	21	45	-0.5040293
14.75416	24	29	46	0.4584312E-01
8.648230	18	36	47	0.3977489E-01
37.46067	14	84	48	-0.6489372
10.69587	25	23	49	0.4507637E-01
13.67912	22	17	50	0.2682209E-01

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7.300606	17	22	1	-0.6204319E-01
10.65668	31	82	2	0.4345131E-01 SNR = 198
11.76406	17	21	3	-0.4205990E-01
7.619865	19	21	4	-0.3988934E-01
7.806854	28	41	5	0.4989052E-01
7.544759	27	34	6	0.4981136E-01
2.144774	17	21	7	0.2677274E-01
2.339085	16	23	8	-0.2300501
7.226731	16	25	9	0.5967617E-02
19.06684	15	39	10	0.3529739E-01
17.31522	19	25	11	-0.8485222E-01
19.80651	31	91	12	0.4291534E-01
18.34063	23	39	13	0.4744530E-01
6.780623	23	28	14	0.4428101E-01
12.37447	31	101	15	0.4113865E-01
8.712429	21	28	16	0.4709911E-01
5.456039	21	28	17	0.4291630E-01
5.855826	27	40	18	0.4959202E-01
6.721491	21	29	19	0.4478168E-01
7.065330	24	28	20	0.4701614E-01
8.341397	21	33	21	0.4848576E-01
11.12055	28	83	22	0.3912544E-01
5.590551	26	32	23	0.4862595E-01
6.262197	18	21	24	-0.5626965E-01
7.060160	18	31	25	0.4927969E-01
4.834067	20	24	26	0.2978277E-01
8.989324	16	23	27	0.2985477E-01
9.373713	22	34	28	0.4309082E-01
8.615378	22	20	29	0.3451061E-01
14.76085	27	41	30	0.4918575E-01
12.07865	19	79	31	-0.7171631E-01
8.654314	26	97	32	0.4128361E-01
13.18638	17	24	33	0.4837036E-02
13.71237	25	91	34	0.2985573E-01
11.32237	15	21	35	-0.4379377
10.22028	26	35	36	0.4697227E-01
16.38091	31	89	37	0.3936386E-01
7.158859	17	22	38	0.3823853E-01
13.42065	21	31	39	0.3680611E-01
7.115049	24	31	40	0.4926157E-01
7.593863	31	91	41	0.4401255E-01
7.902246	17	22	42	-0.3901625E-01
10.89171	24	24	43	0.4737473E-01
3.806877	19	21	44	-0.6470942E-01
5.222053	17	22	45	-0.1898236
6.983627	24	31	46	0.4744816E-01
4.212800	20	31	47	0.4938173E-01
18.08397	16	34	48	0.3742218E-01
5.078793	24	26	49	0.3994274E-01
6.600604	18	22	50	0.3222799E-01

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4.680528	18	23	1	-0.1697779E-01
6.825141	30	80	2	0.4227352E-01
7.555922	17	24	3	-0.2375503
4.868286	19	23	4	0.1116085E-01
4.932267	27	90	5	0.3802872E-01
4.816488	26	37	6	0.4851103E-01
1.276901	16	29	7	0.4485142E-01
1.482597	18	23	8	-0.3001046E-01
4.638671	17	26	9	0.1769543E-02
12.21819	16	37	10	0.4255486E-01
10.98513	21	25	11	0.5921364E-02
12.62522	30	87	12	0.4474163E-01
11.54189	23	85	13	0.1829243E-01
4.309546	24	29	14	0.3884459E-01
7.911348	30	89	15	0.4104948E-01
5.517523	21	32	16	0.4730082E-01
3.492533	22	28	17	0.4771376E-01
3.734546	26	50	18	0.4998708E-01
4.233728	21	33	19	0.4948187E-01
4.504707	24	30	20	0.4130697E-01
5.407928	22	32	21	0.4976654E-01
7.286848	28	38	22	0.4930210E-01
3.641893	26	32	23	0.4816318E-01
3.984138	19	22	24	-0.1296306E-01
4.519800	19	31	25	0.4475260E-01
3.092238	21	25	26	0.2683043E-01
5.694894	17	24	27	0.2750731E-01
6.026015	23	32	28	0.4660606E-01
5.510090	19	24	29	0.4416370E-01
9.461118	27	40	30	0.4993057E-01
7.730673	20	43	31	0.4928207E-01
5.517193	26	91	32	0.3627968E-01
8.402245	18	25	33	0.1332951E-01
8.719447	25	101	34	0.3156185E-01
7.165835	17	21	35	-0.9017897E-01
6.654451	26	32	36	0.4995155E-01
10.44736	30	91	37	0.3983593E-01
4.551963	18	23	38	0.4692888E-01
8.584443	22	31	39	0.3694153E-01
4.549679	24	33	40	0.4815578E-01
4.884920	30	91	41	0.4236841E-01
5.036064	18	23	42	-0.1490593E-02
6.906091	22	28	43	0.3415489E-01
2.430028	19	23	44	-0.2451897E-02
3.317616	18	24	45	-0.3871679E-01
4.467884	24	32	46	0.4739952E-01
2.723176	21	31	47	0.4259181E-01
11.59033	17	33	48	0.4876614E-01
3.232672	24	28	49	0.3611898E-01
4.205908	18	25	50	0.3779411E-01

		Sm		
2.607276	19	25	1	0.9457350E-02
3.862724	29	50	2	0.4994202E-01
4.297771	19	24	3	0.3134251E-01 SNR=335
2.697208	20	25	4	0.1167178E-01
2.784248	26	91	5	0.3865719E-01
2.725186	25	39	6	0.4965329E-01
0.8036318	19	24	7	0.2765483E-01
0.8429780	19	24	8	0.4982847E-01
2.581500	18	28	9	0.2182317E-01
6.904471	18	30	10	0.3530455E-01
6.063796	22	26	11	0.4294634E-01
7.024533	29	87	12	0.4364443E-01
6.510364	24	40	13	0.4967928E-01
2.413373	25	30	14	0.4103923E-01
4.550313	29	45	15	0.4999781E-01
3.106006	22	32	16	0.4427838E-01
1.953743	23	29	17	0.4130232E-01
2.291960	26	34	18	0.4887223E-01
2.380933	22	33	19	0.4567504E-01
2.548991	24	31	20	0.4656219E-01
3.087490	23	32	21	0.4684091E-01
4.052025	27	42	22	0.4938459E-01
1.989641	25	38	23	0.4891670E-01
2.203553	19	25	24	0.1946402E-01
2.613531	21	28	25	0.4517961E-01
1.746227	22	26	26	0.3398347E-01
3.119280	18	26	27	0.4321766E-01
3.423219	24	31	28	0.4543233E-01
3.067541	20	26	29	0.3380609E-01
5.362074	27	38	30	0.4907608E-01
4.319921	21	40	31	0.4953146E-01
3.302283	26	40	32	0.4985189E-01
4.659715	20	25	33	0.5211353E-02
4.832435	25	97	34	0.3168058E-01
3.919983	18	23	35	-0.2608418E-01
3.662370	25	37	36	0.4964781E-01
5.927515	29	48	37	0.4992771E-01
2.504066	19	25	38	0.4521513E-01
4.815331	23	31	39	0.4345369E-01
2.555568	24	35	40	0.4782844E-01
2.823952	29	49	41	0.4998708E-01
2.786933	19	25	42	0.1525402E-01
3.843440	23	29	43	0.4176879E-01
1.346059	20	25	44	0.5472660E-02
1.834986	19	25	45	0.4238129E-01
2.511940	24	33	46	0.4686189E-01
1.566470	22	31	47	0.4342818E-01
6.400833	18	36	48	0.4865265E-01
1.810999	24	30	49	0.4025316E-01
2.348811	19	27	50	0.3551078E-01

		Sm		
0.9528179	21	27	1	0.4224437E-01
1.493047	27	46	2	0.4975390E-01
1.581721	21	27	3	0.3000796E-01 SNR = 566
0.9862027	21	28	4	0.4641724E-01
1.085425	25	47	5	0.4969931E-01
1.191361	25	33	6	0.4896069E-01
0.3446773	21	26	7	0.3703108E-01
0.3471086	21	26	8	0.4862133E-01
0.9923386	21	27	9	0.3055120E-01
2.570280	21	28	10	0.4022670E-01
2.125952	23	30	11	0.3846025E-01
2.849287	28	37	12	0.4966116E-01
2.528025	25	34	13	0.4757524E-01
0.9216231	25	33	14	0.4679751E-01
1.720314	27	47	15	0.4998219E-01
1.203989	23	32	16	0.4746974E-01
0.7261358	23	33	17	0.4532480E-01
0.9700875	25	34	18	0.4965395E-01
0.9283318	23	33	19	0.4943311E-01
0.9864120	24	33	20	0.4606247E-01
1.111542	23	38	21	0.4926372E-01
1.595460	26	38	22	0.4971933E-01
0.8334672	25	35	23	0.4779720E-01
0.8353712	21	26	24	0.4843730E-01
0.9674882	22	31	25	0.4492545E-01
0.6549036	22	30	26	0.4599762E-01
1.155022	21	26	27	0.4655373E-01
1.269680	24	34	28	0.4895830E-01
1.133987	21	29	29	0.4694474E-01
1.998017	26	40	30	0.4945576E-01
1.735088	23	32	31	0.4712427E-01
1.212637	25	47	32	0.4971325E-01
1.642700	21	29	33	0.3943753E-01
1.882886	25	40	34	0.4960787E-01
1.379445	20	25	35	0.4717410E-01
1.503767	25	32	36	0.4950786E-01
2.146844	27	101	37	0.3839374E-01
0.9022354	21	27	38	0.4813880E-01
1.798716	24	32	39	0.4549527E-01
0.9969205	24	36	40	0.4907697E-01
1.150492	27	45	41	0.4969084E-01
1.008775	21	27	42	0.4193372E-01
1.425299	24	31	43	0.4346454E-01
0.5005233	21	28	44	0.4655188E-01
0.6744756	21	27	45	0.4691565E-01
0.9900661	24	33	46	0.4830879E-01
0.6723589	23	31	47	0.4848701E-01
2.413922	21	30	48	0.4035997E-01
0.7194581	24	32	49	0.4905677E-01
0.9054163	21	28	50	0.4777318E-01

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0.5739186	22	28	1	0.4316205E-01
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0.9487003	22	28	3	0.3906226E-01
0.5847874	22	29	4	0.3907871E-01
0.7711008	25	36	5	0.4969227E-01
0.6854243	24	38	6	0.4973823E-01
0.2024804	21	29	7	0.3976692E-01
0.2357015	22	27	8	0.4170983E-01
0.5711311	21	30	9	0.3953755E-01
1.469230	21	31	10	0.4629135E-01
1.294818	24	29	11	0.4905343E-01
1.658005	27	40	12	0.4981828E-01
1.540181	25	34	13	0.4806113E-01
0.5857002	25	34	14	0.4627490E-01
1.022102	26	55	15	0.4990530E-01
0.7213948	23	34	16	0.4759598E-01
0.5040377	24	31	17	0.4403606E-01
0.7075338	25	32	18	0.4891652E-01
0.6371870	24	31	19	0.4511213E-01
0.6411923	24	33	20	0.4716629E-01
0.8157693	24	32	21	0.4951572E-01
1.130117	26	33	22	0.4975712E-01
0.6094967	25	33	23	0.4962617E-01
0.5100623	22	27	24	0.4078859E-01
0.6374987	23	30	25	0.4512489E-01
0.4549548	23	29	26	0.4659709E-01
0.6979728	22	27	27	0.4736537E-01
0.8351840	25	32	28	0.4524672E-01
0.7055932	22	29	29	0.4505628E-01
1.377695	26	34	30	0.4942381E-01
1.001077	23	35	31	0.4825521E-01
0.8520954	25	38	32	0.4949892E-01
0.9741096	22	29	33	0.4941165E-01
1.188982	25	37	34	0.4900169E-01
0.7729356	21	27	35	0.3117818E-01
0.8439671	24	38	36	0.4954600E-01
1.284367	26	91	37	0.3923988E-01
0.5342939	22	28	38	0.4306012E-01
1.084423	24	33	39	0.4891407E-01
0.6343260	24	36	40	0.4871202E-01
0.7290098	26	46	41	0.4985744E-01
0.6007808	22	28	42	0.4128367E-01
0.8746784	24	32	43	0.4686552E-01
0.3067014	22	29	44	0.3979364E-01
0.4104702	22	28	45	0.4319203E-01
0.6360570	24	33	46	0.4776371E-01
0.4200637	23	33	47	0.4692554E-01
1.440819	22	30	48	0.4143929E-01
0.4659101	24	33	49	0.4847553E-01
0.5914759	22	28	50	0.4780018E-01

APPENDIX C

Always-Convergent for Positive Data (Wide Guassian)

See E.J. Murphy, 1986 M.S. Thesis U.N.O. For Documentation.

```
C       FORTRAN PROGRAM FOR DECONVOLUTION - DCONP.FOR
C       GM TRANSFORM HAS LARGEST ACTUAL MAGNITUDE OF 1.
C       USES ITERATIVE TECHNIQUE.  HANDLES POSITIVE GOING DATA
C       AUGUST 1984
C       READS DATA FILE FOR20.DAT AND FOR21.DAT
C       WRITES FOR22.DAT TO FOR37.DAT AS STANDARD OUTPUT
C       WRITES FOR38.DAT TO FOR55.DAT AS NON-STANDARD OUTPUT
C       WRITES FOR59.DAT = FOURIER DECON, X AND Y FOR
C       PLOTTER, ORIGINAL WINDOW
C       WRITES FOR60.DAT = LAST SMOOTHING, XY FOR
C       PLOTTER, ORIGINAL WINDOW
C       WRITES FOR61.DAT = FOURIER DECON, 5
C       NUMBERS/LIN FOR LPT, 2048 PTS
C       WRITES FOR62.DAT = FOURIER DECON, XY FOR PLOTTER,
C       2048 PTS
C       WRITES FOR63.DAT = IERRH, IERRF
C       G(I) = RESPONSE (APPARATUS) FUNCTION
C       H(I)=BROADENED FUNCTION
        DIMENSION XX(2048),H(2081,3),GS(256),HO(1000)
        DIMENSION G(2048),GNEW(257),I1OUT(23),QAZ(10000)
        COMPLEX X(2048),GM(257),CAPG(2048),Z(2048)
        COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY
        EXTERNAL FFT
C       RESPONSE AND BROADENED FUNCTIONS ARE READ FROM DATA FILE

        I=1
105     READ(118,7,END=110) G(I)
7       FORMAT (2G)
777     FORMAT(4G)
        I = I + 1
        GOTO 105
110     NG = I - 1
C       TYPE 71, NG
```

```
C       TYPE 200, (G(I),I=1,NG)
200     FORMAT (1PE16.6)
        I = 1
120     READ(117,7,END=125) HO(I)
        I = I+1
        GOTO 120
125     NHORIG=I-1
        NH =NHORIG
C       TYPE 71,NH
C       TYPE 200, (H(I,1),I=1,NH)
        NHSV = NH
        DO 45 I = 1,NH
        45      XX(I) = I-1

C       DO 666 IR=3,5
C       NS=IR

C       FIRST MOMENT CALCULATION
        SUM = 0.
        DO 20 I = 1,NG
        GS(I)=G(I)
C       SUM = SUM OF G
C       SUM2 = FIRST MOMENT OF G
20      SUM = SUM+G(I)
C       TYPE 122, SUM
122     FORMAT (' SUM = ',1PE16.6)
C       FIND FIRST MOMENT - FIND ORIGIN
        SUM2 = 0.
        DO 30 I = 1,NG
41      SUM2=SUM2 + I*G(I)
30      CONTINUE
C       TYPE 201,SUM2
201     FORMAT (' SUM2 = ',1PE16.6)
42      SUM2=SUM2/SUM
C40     ISUM2 = SUM2 +0.5
C       TYPE 43
C43     FORMAT (' USE SUM2 OR USER INPUT, 1 OR 2? '$)
C       ACCEPT 71,JSUI
C       GOTO (46,44),JSUI
C44     TYPE 50
C50     FORMAT (' ENTER INDEX OF ORIGIN '$)
C       ACCEPT 7, SUM2
C       NORMALIZE G
48      DO 21 I=1,NG
C       GS(I)=GS(I)/SUM
21      G(I)=G(I)/SUM
C       PROGRAM SPECIFICATIONS
C49     TYPE 1
C1      FORMAT(' NUMBER OF SMOOTHINGS AND UNFOLDINGS (2I3) ')
C       ACCEPT*, NS, NU
        NU=10
11      FORMAT(2I3)
```

```
C       NFT=NUM OF POINTS IN FOURIER DOMAIN FOR INVERSE
C       FILTER = 2048
C       NIT=NO. OF PTS. IN FOUR. DOM. FOR CALC. OF GM, MAX = 256
C       CHOOSE 16,32,64,128,256 - SHOULD BE > 2 * NG IF POSSIBLE
71      FORMAT(I)
        NFT = 2048
C       TYPE 72
C72     FORMAT(' NO. OF PTS. IN TRANSFORM FOR MODIFIED G= '$)
C       ACCEPT 71,NIT
        NIT=64
        DO 80 I=NH+1,NFT
80      XX(I)=I-1
C       TYPE 60
C60     FORMAT(' ONLY SMOOTHINGS 0,S AND U 1 '$)
C       ACCEPT 71,ISU
        ISU=1
        IF (ISU .EQ. 0) GOTO 68
        IF (NU .EQ. 0) GO TO 68
C       TYPE 61
C61     FORMAT(' STANDARD OUTPUT? NO=0 '$)
C       ACCEPT 71,IST
        IST=1
        NNS=0
C       TYPE 62
C62     FORMAT(' HOW MANY NON-STANDARD OUTPUTS? '$)
C       ACCEPT 71,NNS
        IF(NNS.EQ.0) GO TO 68
C       TYPE 63
C63     FORMAT(' TYPE NON-STANDARD ITERATIONS, ONE PER LINE ')
C       ACCEPT 71,(I1OUT(I),I=1,NNS)
68      CONTINUE
C       TAKE FFT OF G
        DO 22 I=1,NG
22      X(I)=CMPLX(G(I),0.)
        ND=NG+1
        DO 54 I=ND,NFT
54      X(I)=CMPLX(0.,0.)
        CALL FFT(NFT,X,CAPG,-1.)
        write(2,55)(I,CAPG(I), I=1,NFT)
c       TYPE 55,(CAPG(I),I=1,2)
55      FORMAT (3x,I3,10x,G,10X,G)
C       PHASE MULT TO GET CAPG CORRESPONDING TO SMALL
C       G IN RIGHT ORDER
C       USE SHIFT THEOREM TO PUT ORIGIN AT FIRST MOMENT
        Y=2*3.1415926*(SUM2-1)/NFT
        N21=(NFT/2)+1
        DO 140 I=1,NFT
        IF (I.LT.N21) Z(I)=CMPLX(COS((I-1)*Y),SIN((I-1)*Y))
        IF (I.EQ.N21) Z(I)=CMPLX(COS((NFT/2)*Y),0.)
        IF (I.GT.N21) Z(I)=CMPLX(COS((I-NFT-1)*Y),
      1 SIN((I-NFT-1)*Y))
140     CAPG(I)=CAPG(I)*Z(I)
```

```
C       TYPE 7,(CAPG(I),I=1,2)
C       FIND FFT OF GS
        DO 37 I=1,NG
37      X(I)=(CMPLX(GS(I),0.))
        DO 655 I=ND,NIT
655     X(I)=CMPLX(0.,0.)
        CALL FFT(NIT,X,GM,-1.)
C       TYPE 7,CAPG(1)
C       TYPE 71, NIT
        TEMP = CABS(GM(1))
        DO 23 I = 2,(NIT/2) + 1
   23   IF (CABS(GM(I)).GT.TEMP) TEMP = CABS(GM(I))
C       TYPE 79
C79     FORMAT (' DO YOU WANT MAG GM? Y=1,N=2 '$)
C       ACCEPT 71,MGM
        MGM=1
        DO 24 I=1,NIT
        XMAG=CABS(GM(I))/TEMP
        GOTO (81,24),MGM
81      IF (I.GT.((NIT/2)+1)) GOTO 24
C       TYPE 200,XMAG
C       SET IMAGINARY GM TO ZERO
24      GM(I)=CMPLX(XMAG,0.)*(-1)**(I-1)
C       TAKE INVERSE FFT OF GM
        CALL FFT(NIT,GM,X,+1.)
        DO 25 I = 1,NIT
25      GNEW(I) = REAL(X(I))
        NG = NIT + 1
        M = (NIT/2) + 1
        GNEW(1) = GNEW(1)/2.
        GNEW(NG)=GNEW(1)
        NS=1
C       DECONVOLUTION CALCULATION PERFORMED IN SUBROUTINE
31      CALL DCON(NG,NH,NS,M,H,GNEW,CAPG,QAZ,NHORIG,HO)
C       CALL EXIT
        END
C
        SUBROUTINE DCON(NG,NH,NS,M,H,G,CAPG,QAZ,NHORIG,HO)
C       SMOOTHING AND UNFOLDING SUBROUTINE
C       ALWAYS-CONVERGENT ITERATIVE NOISE REMOVAL AND
C       DECONVOLUTION
C       NS = NUMBER OF SMOOTHINGS, >=0
C       NU = NUMBER OF UNFOLDINGS, >=0
C       M = I OF THE PEAK OF G(I)
C       NH = NUMBER OF POINTS OF H
C       NG = NUMBER OF POINTS OF G
        DIMENSION H(2081,3),G(257),F(2081),
      1 HI(2081),M2(2081),XX(2048),GUS(1000)
        DIMENSION FS(2048),M3(2081),K(2081),I1OUT(23),
      1 GO(2048),ITERAVE(1000)
        DIMENSION XSME(1000),QAZ(10000),HP(1000),
      1 VAR(1000),Q(200),XMSEAVE(1000)
```

```
        DIMENSION LOP(1000),SH(1200,1),AN(200)
        COMPLEX CAPG(2048),CAPHF(2048),X(2048)
        COMMON X,NIT,NFT,ISU,IST,NNS,I1OUT,XX,ITTY
        I=1
776     READ(119,281,END=775)GUS(I)
        I=I+1
        GO TO 776
775     LGUS=I-1
8       NHN=NH
9       XNH = FLOAT(NH)
13      NHEAD = NG - M
14      NTAIL = M - 1
15      NHH1 = NHEAD + NH + 1

        TYPE*,'TYPE IN THE FOLLOWING INFORMATION IN ONE LINE'
        TYPE*,'    1)  HOW MANY SNR CASES DO YOU WISH ?
     1 TYPE BEGIN,END,STEP'
        TYPE*,'    2)  HOW MANY CASES FOR EACH SNR ?'
        TYPE*,'    3)  NUMBER OF SMOOTHING ITERATIONS ?
     1 BEGIN,END'
        TYPE*,'    4)  RESULT OF EACH SNR CASE TO BE
     1 STARTED AT ? I4OUT'
        TYPE*, '   5)  MAX UNFOLDING ITERATION ? NU'
        ACCEPT*,ITRB,ITREN,ITRST,N,ILB,ILE,I4OUT,NU


        DO 660 ITRUESNR=ITRB,ITREN,ITRST
        NH=NHORIG
C       TYPE*,'N=?'
C       ACCEPT*,N
        JRAN=888
        CALL AMINI(HO,NH,1.,0,1,JRAN,SNR,QAZ)
        OLDSNR=SNR
        SF=(OLDSNR/ITRUESNR)**2

        JRAN=888
        DO 661 JN=1,N
        CALL AMINI(HO,NH,SF,IOUT,JN,JRAN,SNR,QAZ)
661     AN(JN)=SNR
        P=0.
        DO 333 IA=1,N
333     P=AN(IA)+P
        AVRSNR=P/N
        TYPE*,AVRSNR
        JIJI=1
        DO 665 INC=1,1
        NH=NHORIG
        IQA=(INC*NH)-(NH-1)
        IWS=INC*NH
        L=1
        DO 664 IED=IQA,IWS
        H(L,1)=QAZ(IED)
```

```
664     L=L+1
        write(7,1001)(i,h(i,1),i=1,nhn)
1001    format(2x,i3,10x,g)
16      DO 19 IH = 1,NH
17      IH1 = NHH1 - IH
18      IH2 = NH + 1 - IH
19      H(IH1,1) = H(IH2,1)
20      NH = NH + NHEAD + NTAIL
21      DO 22 IH3 = 1,NHEAD
22      H(IH3,1) = 0.0
23      DO 24 IH4 = NHH1,NH
24      H(IH4,1) = 0.
55      XNHI = 1./XNH
60      ERRH = 0.
C       HI = RECIPROCAL ARRAY OF H
65      DO 69 I3 = 1,NH
        IF (H(I3,1)) 68,67,68
67      HI(I3) = 0.
        GOTO 69
68      HI(I3) = 1./H(I3,1)
69      CONTINUE

        DO 654 IK=1,NH
654     SH(IK,1)=H(IK,1)
        DO 666 IL=ILB,ILE
        NS=IL
        DO 653 IK=1,NH
653     H(IK,1)=SH(IK,1)

C       PERFORM THE SMOOTHINGS
70      DO 130 I3=1,NH
        H(I3,2) = 0.
75      M1 = I3 - M + 1
80      M2(I3) = MAX0(M1,1)
85      M3(I3) = MINO((I3 + NG - M),NH)
90      K(I3) = MAX0(1,(2-M1))
95      M4 = M2(I3)
100     M5 = M3(I3)
105     K1 = K(I3)
110     DO 120 I4 = M4,M5
115     H(I3,2) = H(I4,1) * G(K1) + H(I3,2)
120     K1 = K1 + 1
130     ERRH = ABS((H(I3,2) - H(I3,1))*HI(I3)) + ERRH
135     ERRH = ERRH * XNHI
C       SKIP SMOOTINGS AND PUT H BACK IF REQUESTED
        IF (NS.NE.0) GOTO 500
        DO 310 I = 1,NH
        H(I,3) = H(I,1)
310     H(I,2) = H(I,1)
        GOTO 320
500     I=1
C       TYPE 136, I, ERRH
```

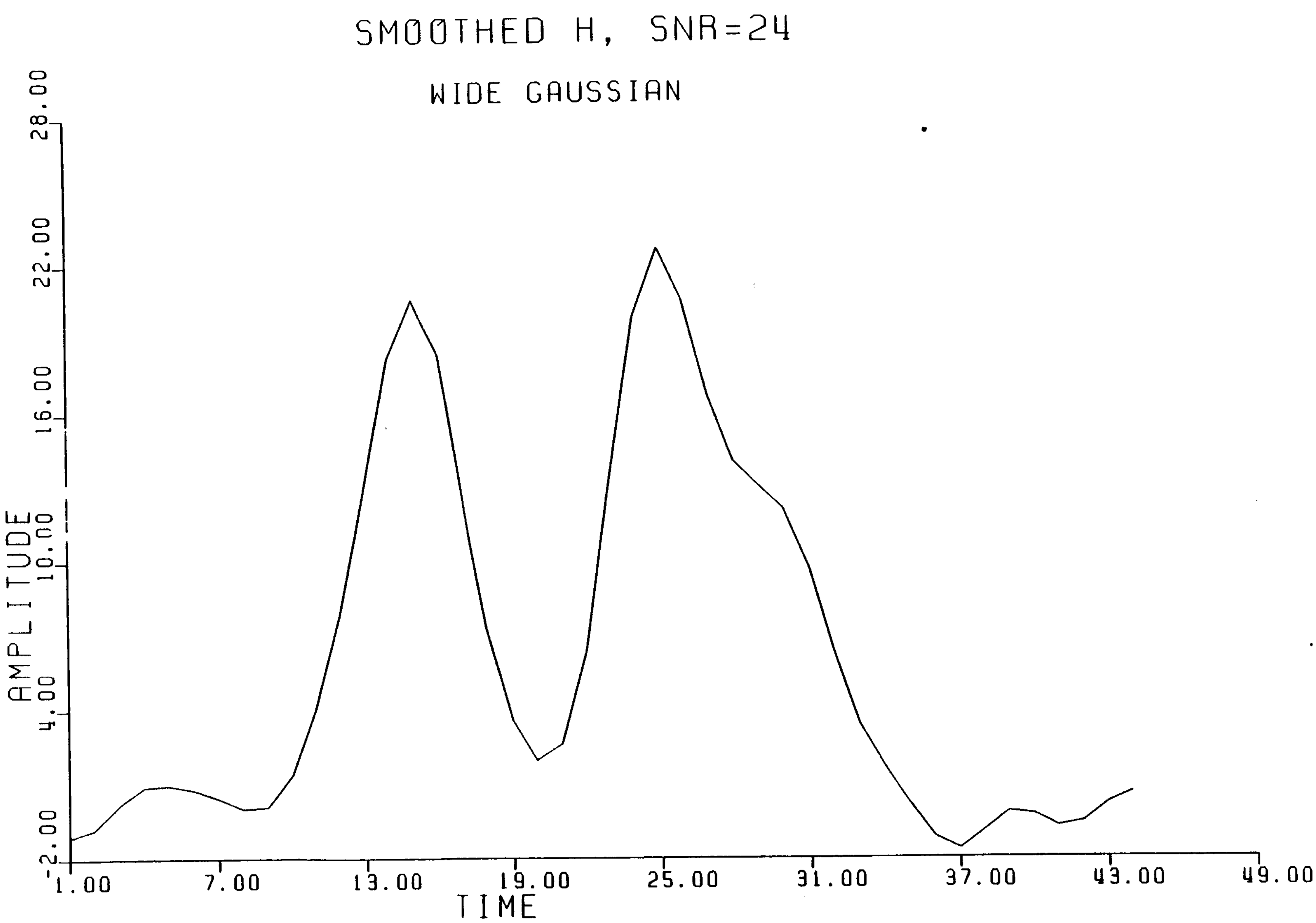
```
C       WRITE(63,136) I,ERRH
136     FORMAT(' ITERATION       ERRH/F'/I5,6X,1PE16.6)
        IF(NS.NE.1) GO TO 140
        DO 330 I=1,NH
330     H(I,3)=H(I,2)
        GO TO 320
140     DO 200 I5 = 2,NS
145     ERRH = 0.
150     DO 195 I6 = 1,NH
155     H(I6,3) = H(I6,2)
160     M4 = M2(I6)
165     M5 = M3(I6)
170     K1 = K(I6)
175     DO 185 I7 = M4,M5
180     H(I6,3) = (H(I7,1) - H(I7,2))*G(K1) + H(I6,3)
185     K1 = K1 + 1
        ERRH = ABS((H(I6,3) - H(I6,2))*HI(I6)) + ERRH
        H(I6,2) = H(I6,3)
195     CONTINUE
        ERRH = ERRH * XNHI
C       DO 196 I = 1,NH
C196    H(I,2) = H(I,3)
        I=I5
C       TYPE 405, I, ERRH
C       WRITE(63,405) I,ERRH
200     CONTINUE
405     FORMAT(I5,6X,1PE16.6)
320     CONTINUE
        IF(ISU.EQ.0) GO TO 290
C       CALCULATE INVERSE FILTERED F
        DO 201 K2=1,NH
201     X(K2)=CMPLX(H(K2,3),0.)
        K3=NH+1
        DO 202 K4=K3,NFT
202     X(K4)=CMPLX(0.,0.)
        CALL FFT(NFT,X,CAPHF,-1.)
        DO 204 K5 = 1,NFT
        IF (CAPG(K5).EQ.CMPLX(0.0,0.0)) GOTO 203
        CAPHF(K5) = CAPHF(K5)/CAPG(K5)
C       CAPG(0) = 1 SO AREAS ARE PRESERVED
        GOTO 204
203     CAPHF(K5) = CMPLX(0.0,0.0)
204     CONTINUE
        CALL FFT(NFT,CAPHF,X,+1.)
        NFT2=NFT/2
        NIT2=NIT/2
        SUMF=0
C       FIND WHAT PERCENTAGES OF F ARE IN VARIOUS WINDOWS
        DO 340 I=1,NFT
        FS(I)=REAL(X(I))
340     CONTINUE
```

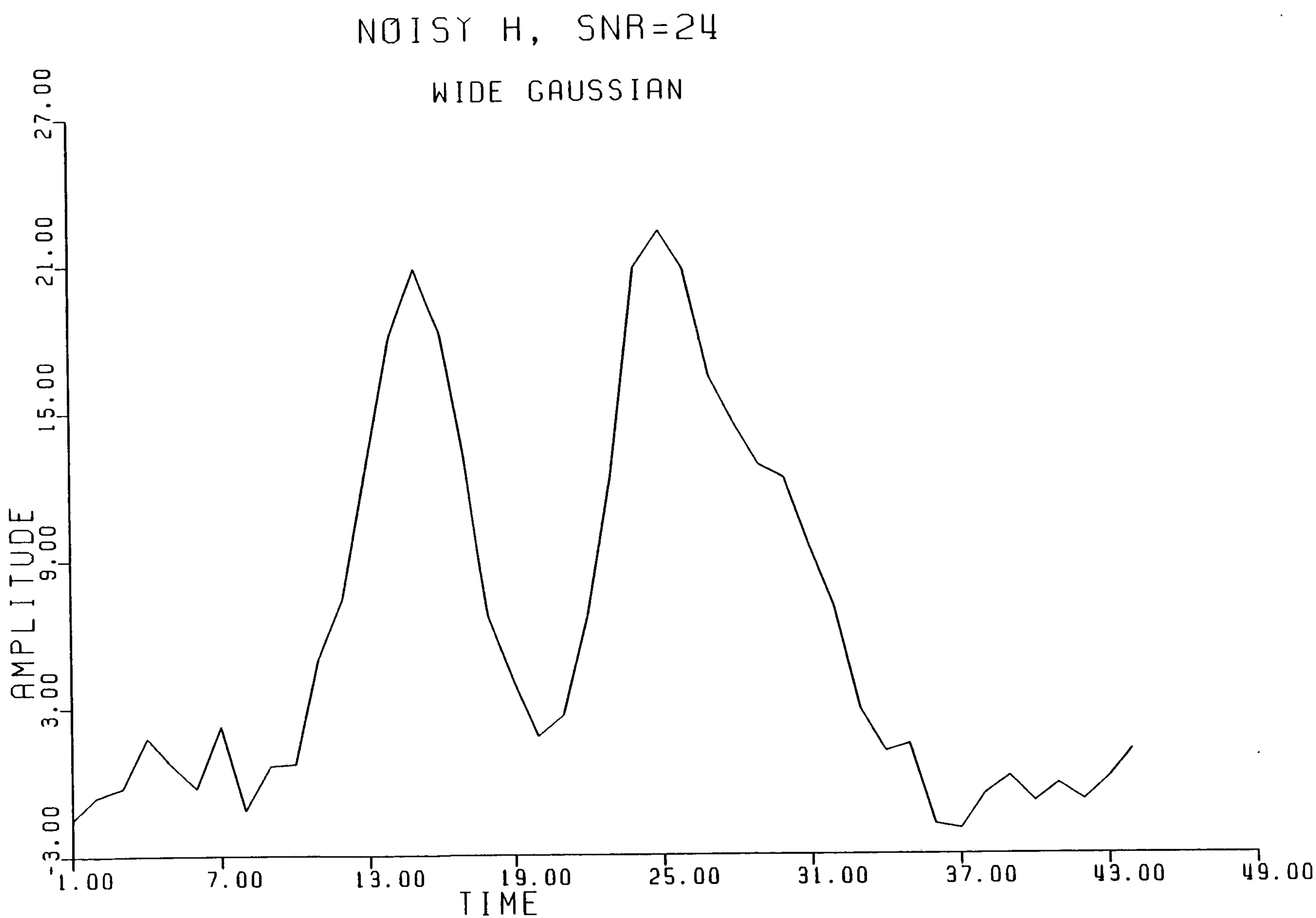
```
              IF(NU.EQ.0) GOTO 290
C             PERFORM THE UNFOLDINGS
C             IOUT AND I2OUT ARE OUTPUT DATA FILE NUMBERS
211           IOUT=22
              I2OUT=38
              IJ=1
              II=1
c             write(2,1001)(i,h(i+nhead,3),i=1,nhn)
              XTEMP=(10.01)**25
              XSME(ILB)=(10.01)**25
215           DO 285 I9 = 1,NU
220           ERRF = 0.
225           DO 280 I10 = 1,NH
240           F(I10)=H(I10,2)
245           M4 = M2(I10)
250           M5 = M3(I10)
255           K1 = K(I10)
260           DO 270 I11 = M4,M5
265           F(I10) = (FS(I11)-H(I11,2))*G(K1) + F(I10)
270           K1 = K1+ 1
275           F(I10) = AMAX1(F(I10),0.)
              ERRF = (ABS(F(I10)-H(I10,2))*HI(I10))+ERRF
C             POINT SUCCESSIVE
              H(I10,2)=F(I10)
280           CONTINUE
              ERRF = ERRF * XNHI
              I=I9
              IF(IST.EQ.0) GO TO 282
C             WRITE(IOUT,281)(F(I+NIT2),I=1,NHN)
281           FORMAT(G)


              DO 999 J=LGUS+1,NHN
999           GUS(J)=0.
              XMSE=0.

              DO 998 J=1,NHN
C             TYPE*,F(J+NIT2+10),GUS(J)

998           XMSE=XMSE+(F(J+NIT2+10)-GUS(J))**2
c             TYPE*,'   ',XMSE,I9,NS,

              CONV=XTEMP-XMSE
C             TYPE*,CONV,XTEMP,XMSE,I9,IL
              IF(XTEMP.LE.XMSE)GO TO 990
              IF(CONV.LE.0.05)GO TO 990
555           XTEMP=XMSE

              II=II+1
282           IF(NNS.EQ.0) GO TO 285
              IF(I.NE.I1OUT(IJ))GO TO 285
              IJ=IJ+1
```

```
285     CONTINUE
990     CONTINUE
C       TYPE*,XTEMP,I9-1,NS
        XSME(IL+1)=XTEMP
        LOP(IL+1)=I9-1
        IF(XSME(IL+1).GT.XSME(IL)) GO TO 291

C       WRITE(I3OUT,*)XTEMP,I9-1,NS
c       WRITE(3,1001)(i,F(I+NIT2+10),I=1,NHN)
C290    WRITE(60,281)(XX(I),H(I+NHEAD,3),I=1,NHN)
290     GO TO 666
666     CONTINUE
291     TYPE*,XSME(IL),LOP(IL),IL-1,INC,AVRSNR,CONV
c       WRITE(I4OUT,*)XSME(IL),LOP(IL),IL-1,INC,AVRSNR,CONV
        ITERAVE(JIJI)=I9-1
        XMSEAVE(JIJI)=XSME(IL)
665     JIJI=JIJI+1
        CLOSE(UNIT=I4OUT)
        I4OUT=I4OUT+1
        SNRAVRG=ALOG(AVRSNR)
        PLO=0
        OLP=0
        DO 659 IAVER=1,N
        PLO=PLO+ITERAVE(IAVER)
659     OLP=OLP+XMSEAVE(IAVER)
        AVRGITER=PLO/N
        AVRGMSE=OLP/N
c       WRITE(115,658)SNRAVRG,AVRGITER
c       WRITE(116,658)SNRAVRG,AVRGMSE
658     FORMAT(2G)
660     CONTINUE
        write(2,1001)(i,h(i+nhead,3),i=1,nhn)
        write(3,1001)(i,f(i+nit2+10),i=1,nhn)
300     RETURN
        END
C
        SUBROUTINE FFT(N,X,Y,SIGN)
C       COMPUTES FORWARD OR INVERSE FOURIER TRANSFORM
C       FOR ANY SET
C       OF DISCRETE DATA POINTS.
C       N = NUMBER OF DATA POINTS = POWER OF TWO
C       SIGN: -1 FOR A FORWARD TRANSFORM AND +1 FOR
C       AN INVERSE TRANSFORM
C       X = ORIGINAL DATA
C       Y = FOURIER TRANSFORM OF DATA
C       BOTH X AND Y ARE COMPLEX NUMBERS
        COMPLEX W,X(256),Y(256)
        INTEGER R
C       CALCULATIONS
        N2 = N/2
        FLTN = N
        NSTAGE = IFIX(ALOG(FLTN)/ALOG(2.))
```

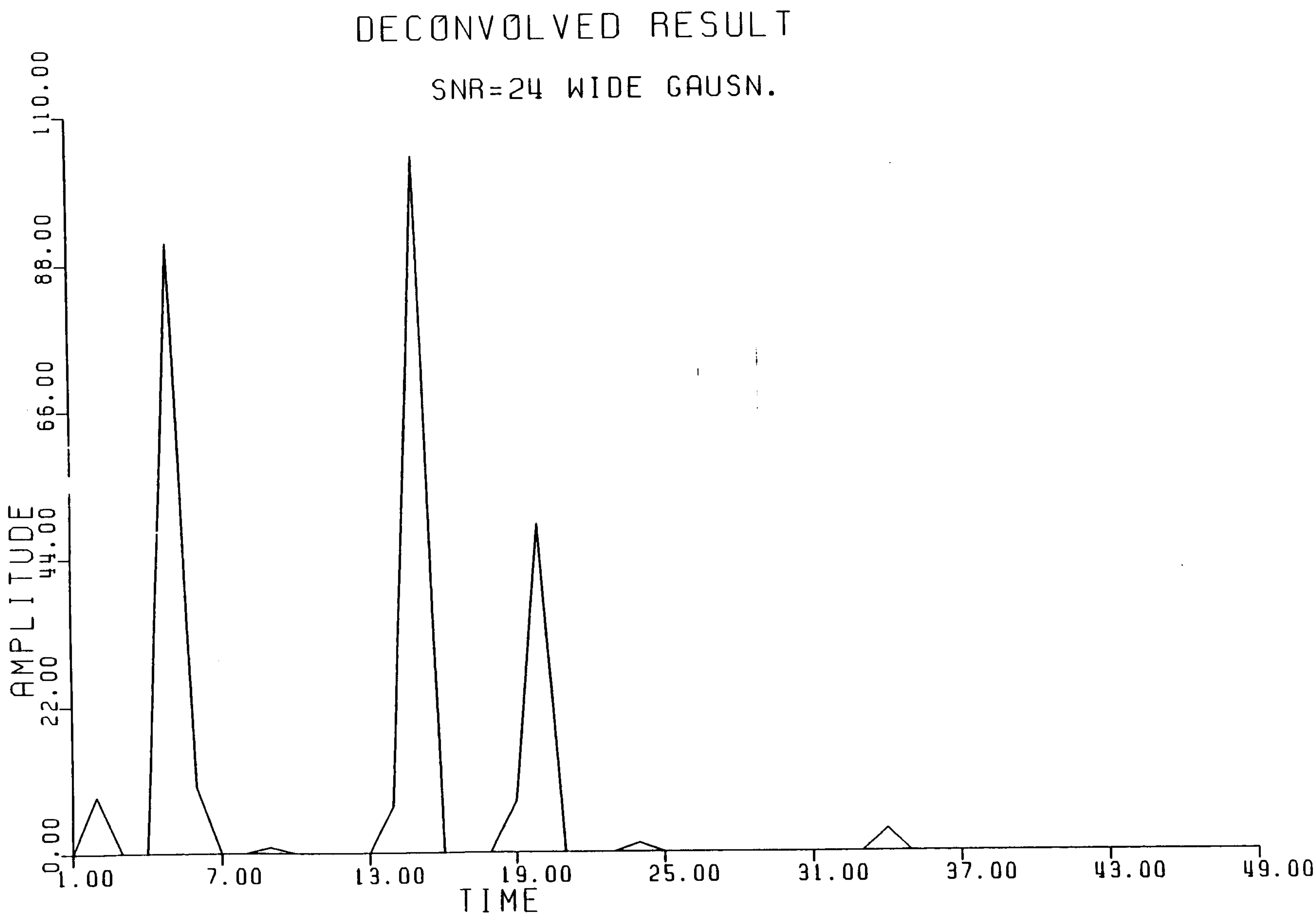
```
        PHI2N = 6.283185307179586/FLTN
        DO 3 J = 1,NSTAGE
        N2J = N/(2**J)
        NR = N2J
        NI = (2**J)/2
        DO 2 I = 1,NI
        IN2J = (I-1)*N2J
        FLIN2J = IN2J
        TEMP = FLIN2J*PHI2N*SIGN
        W = CMPLX(COS(TEMP),SIN(TEMP))
        DO 2 R = 1,NR
        ISUB = R + IN2J
        ISUB1 = R + IN2J*2
        ISUB2 = ISUB1 + N2J
        ISUB3 = ISUB + N2
        Y(ISUB) = X(ISUB1) + W*X(ISUB2)
        Y(ISUB3) = X(ISUB1) - W*X(ISUB2)
2       CONTINUE
        DO 3 R = 1,N
3       X(R) = Y(R)
C       FACTOR OF (1/N) IN INVERSE TRANSFORM
        IF (SIGN.LT.0.) GOTO 5
        DO 4 R = 1,N
4       Y(R) = Y(R)/FLTN
5       RETURN
        END

        SUBROUTINE AMINI(H,NH,SF,IOUT,JN,JRAN,SNR,QAZ)
        DIMENSION H(1000),HP(1000),VAR(1000),Q(1000),QAZ(10000)
15      FORMAT (G)
        RMS = 0.
        AMAX = ABS(H(1))
        SD = SQRT(SF)
        DO 230  I = 1, NH

        IF (ABS(H(I)).GT.AMAX) AMAX = ABS(H(I))
        CALL GAUSS(SD,H(I),HP(I),JRAN)
        RMS = (HP(I) - H(I))**2 + RMS
230     CONTINUE
        RMS = SQRT(RMS/(NH+1))
        SNR = AMAX/RMS

c       WRITE (IOUT,15) (HP(I),I=1,NH)
        IBG=(NH*JN)-(NH-1)
        IED=NH*JN
        L=1
        DO 888 ICA=IBG,IED
        QAZ(ICA)=HP(L)
888     L=L+1
        RETURN
        END
```

```
      SUBROUTINE GAUSS(S,AM,V,JRAN)
      A=0.0
      DO 1 I=1,12
1     A=A+RAN(JRAN)
      V=(A-6.0)*S+AM
      RETURN
      END
```


SMOOTHED H, SNR=24
WIDE GAUSSIAN
AMPLITUDE
28.00
22.00
16.00
10.00
4.00
-2.00
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
TIME

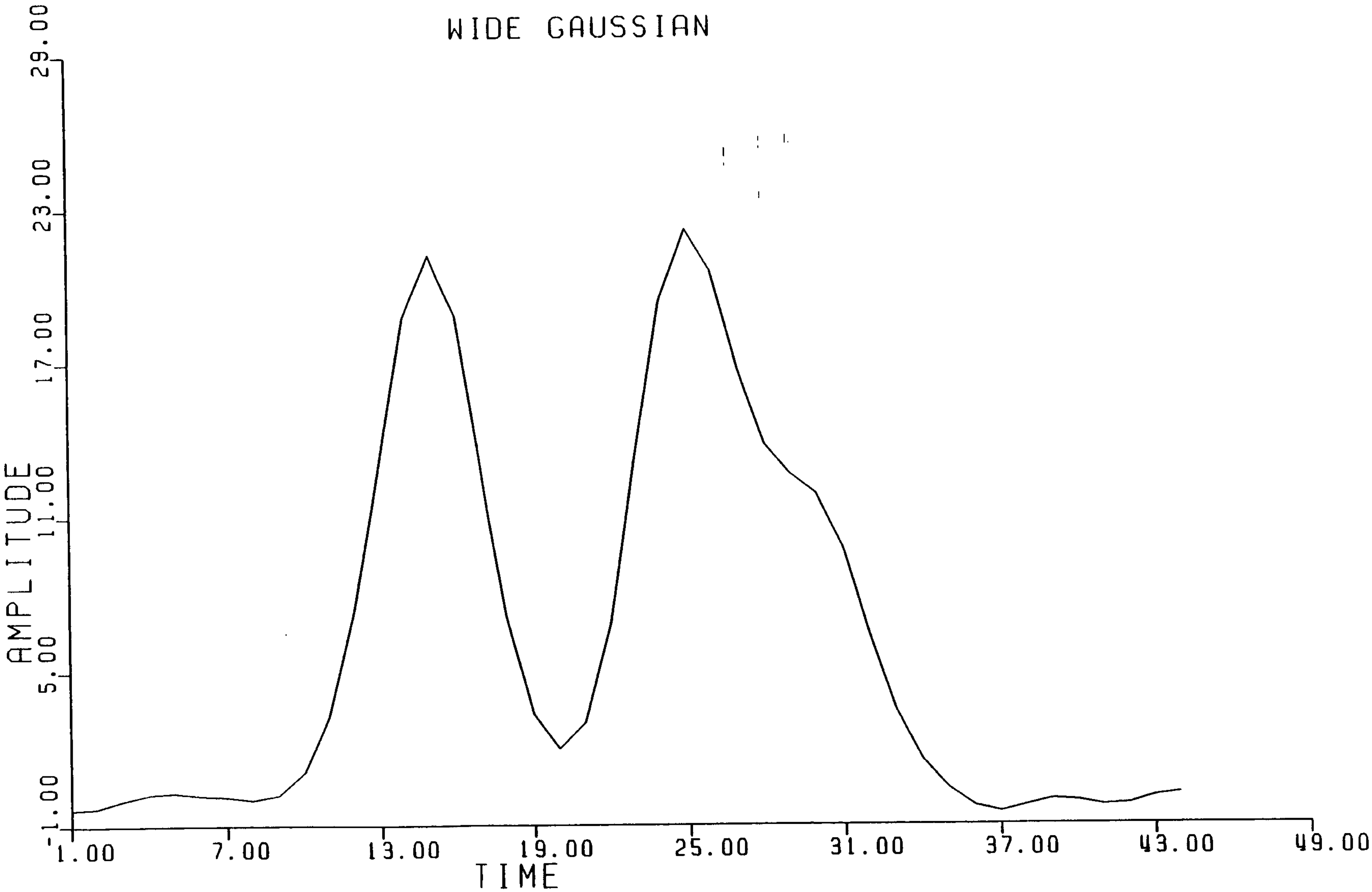


NØISY H, SNR=24
WIDE GAUSSIAN
AMPLITUDE
-3.00
3.00
9.00
15.00
21.00
27.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00


DECONVOLVED RESULT
SNR=24 WIDE GAUSN.
AMPLITUDE
0.00
22.00
44.00
66.00
88.00
110.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00

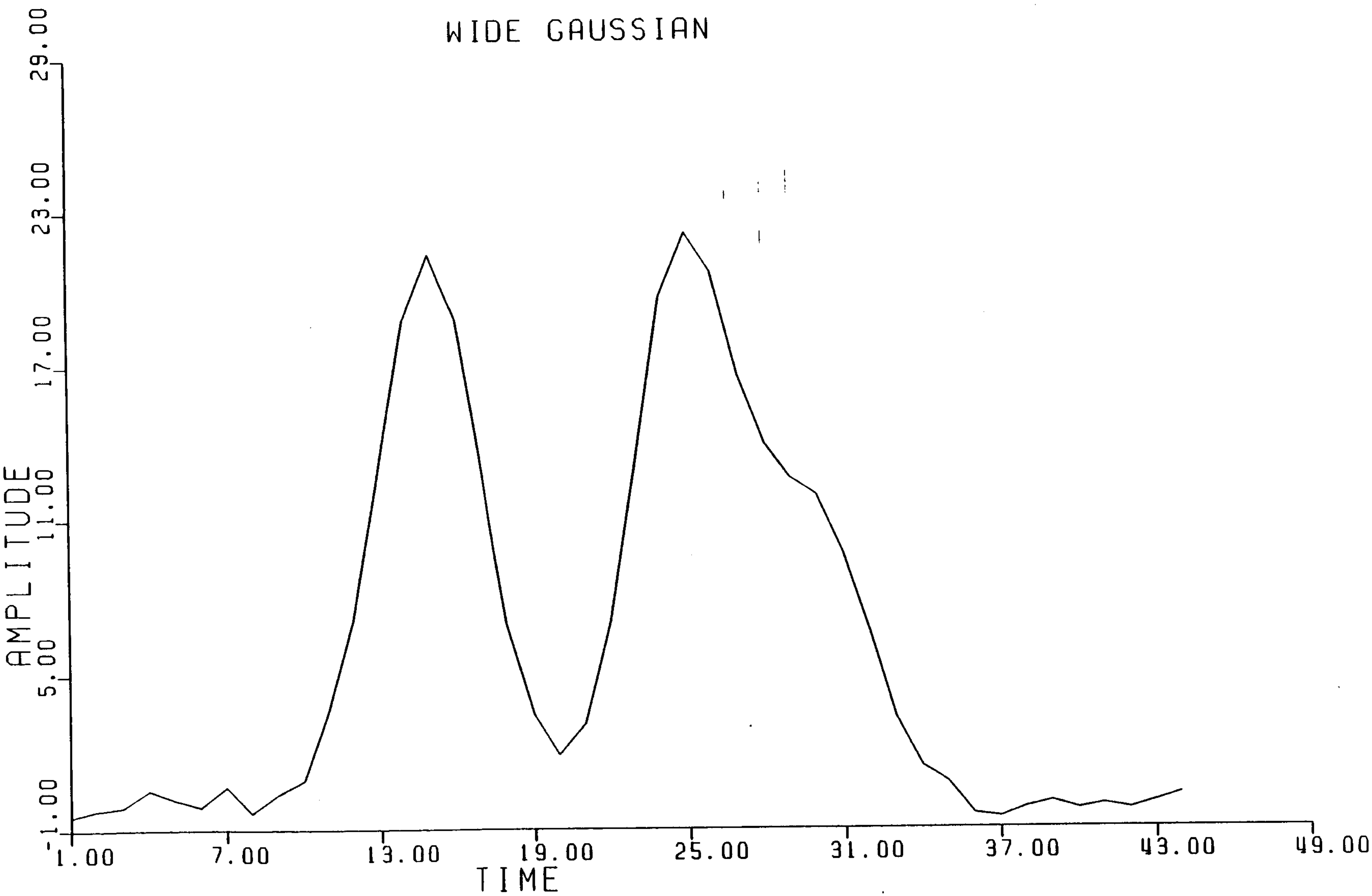
SMOOTHED H, SNR=78

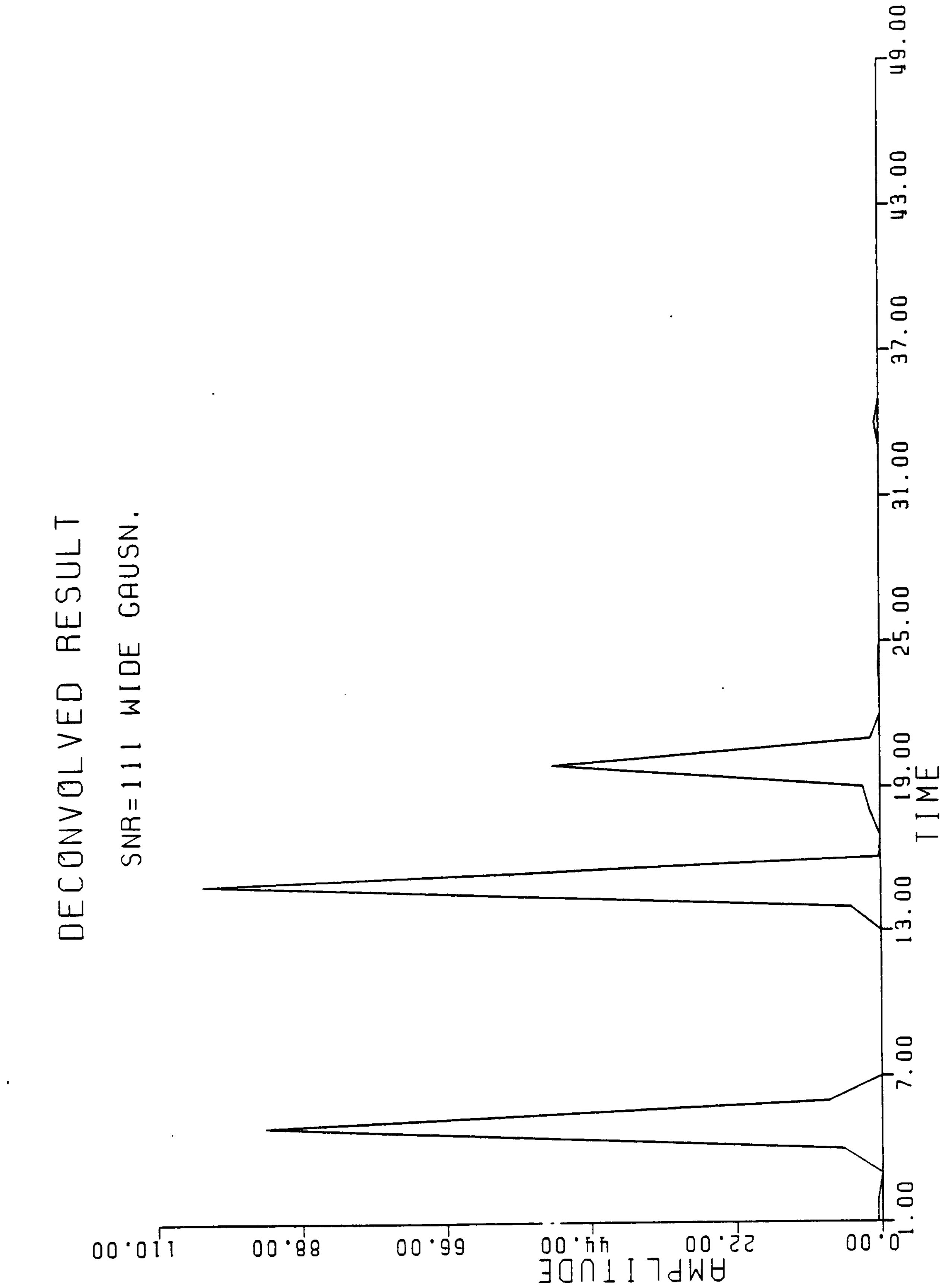
WIDE GAUSSIAN

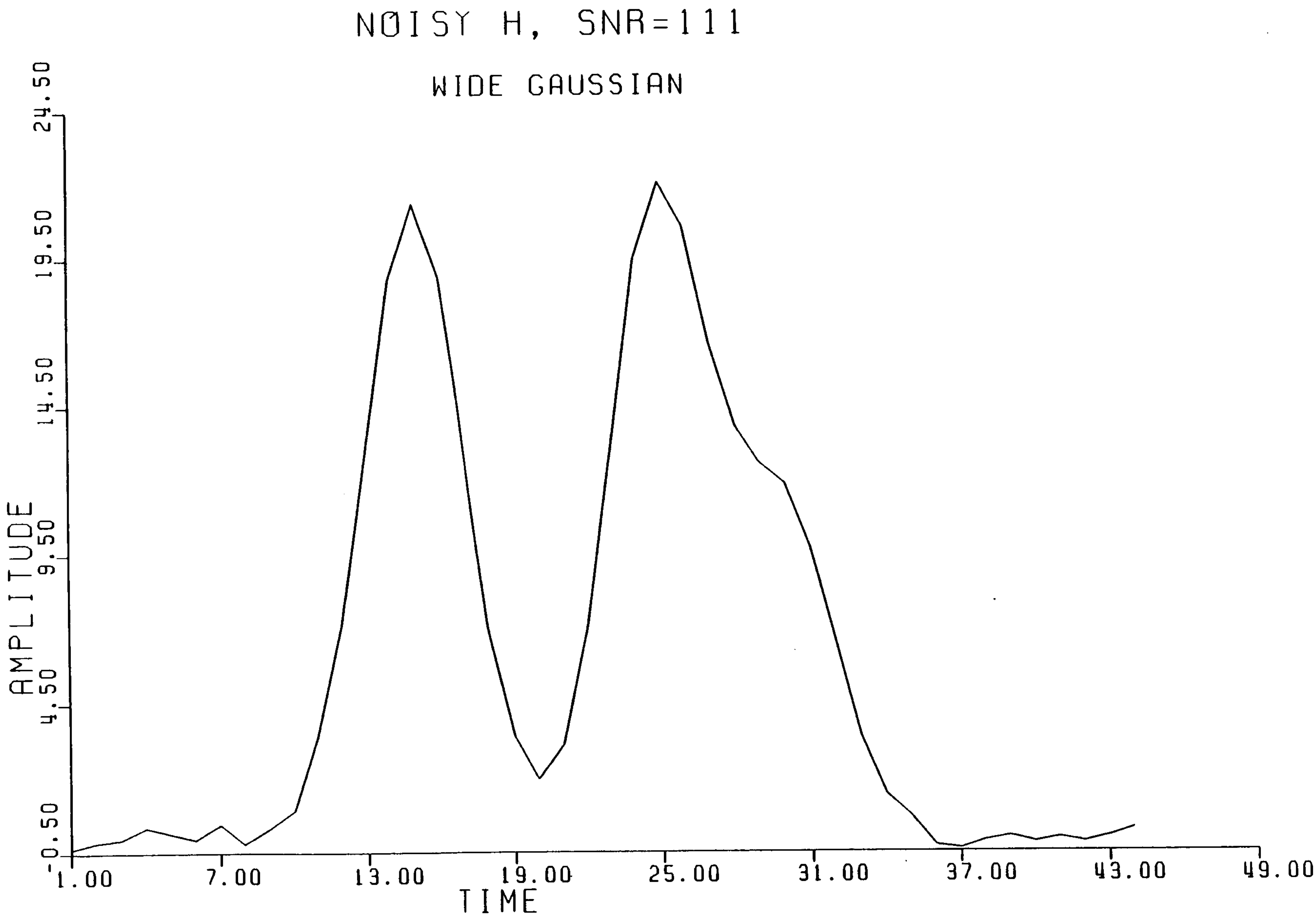


NØISY H, SNR=78

WIDE GAUSSIAN

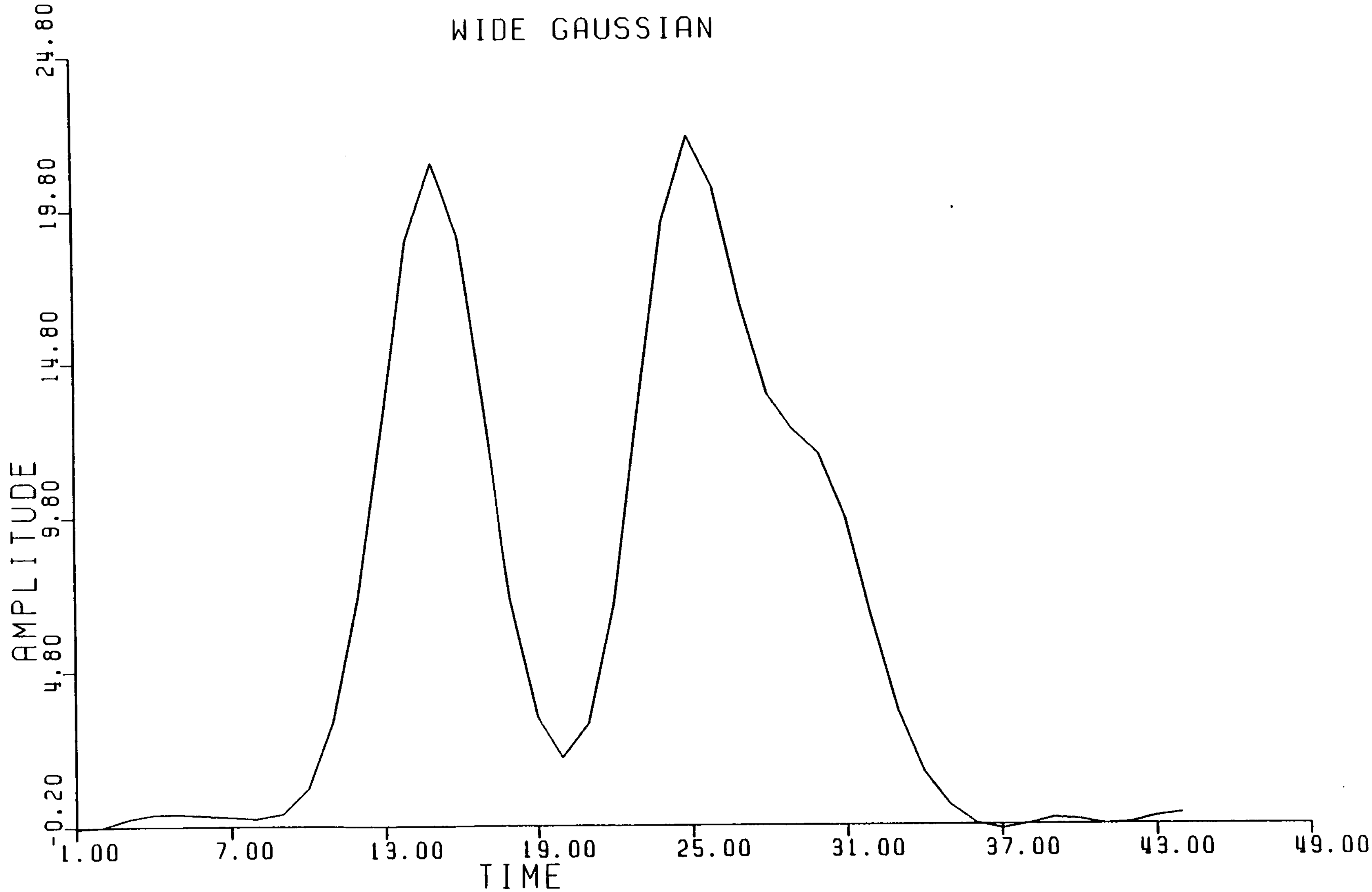


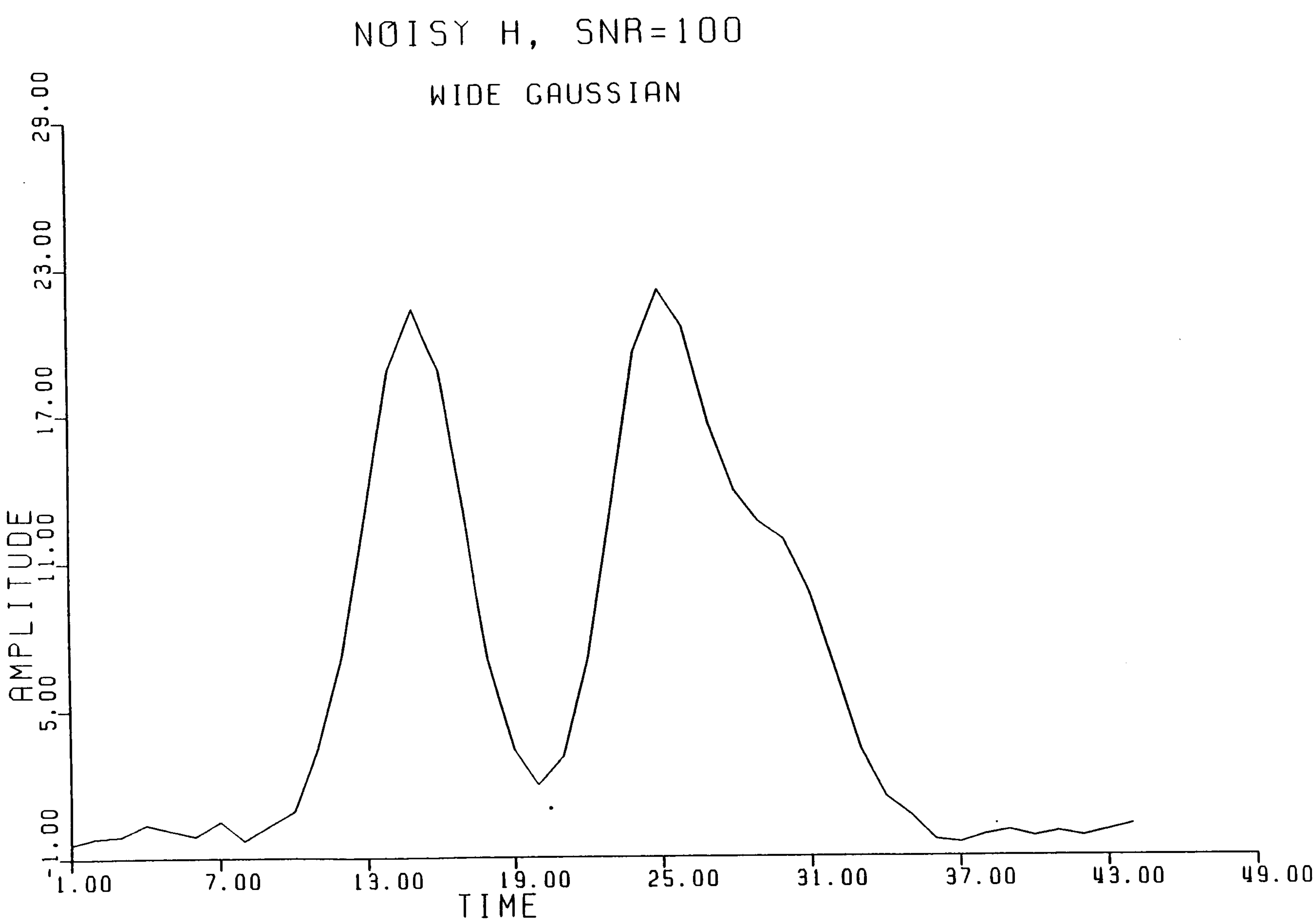

DECONVOLVED RESULT
SNR=111 WIDE GAUSN.
AMPLITUDE
0.00
22.00
44.00
66.00
88.00
110.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00

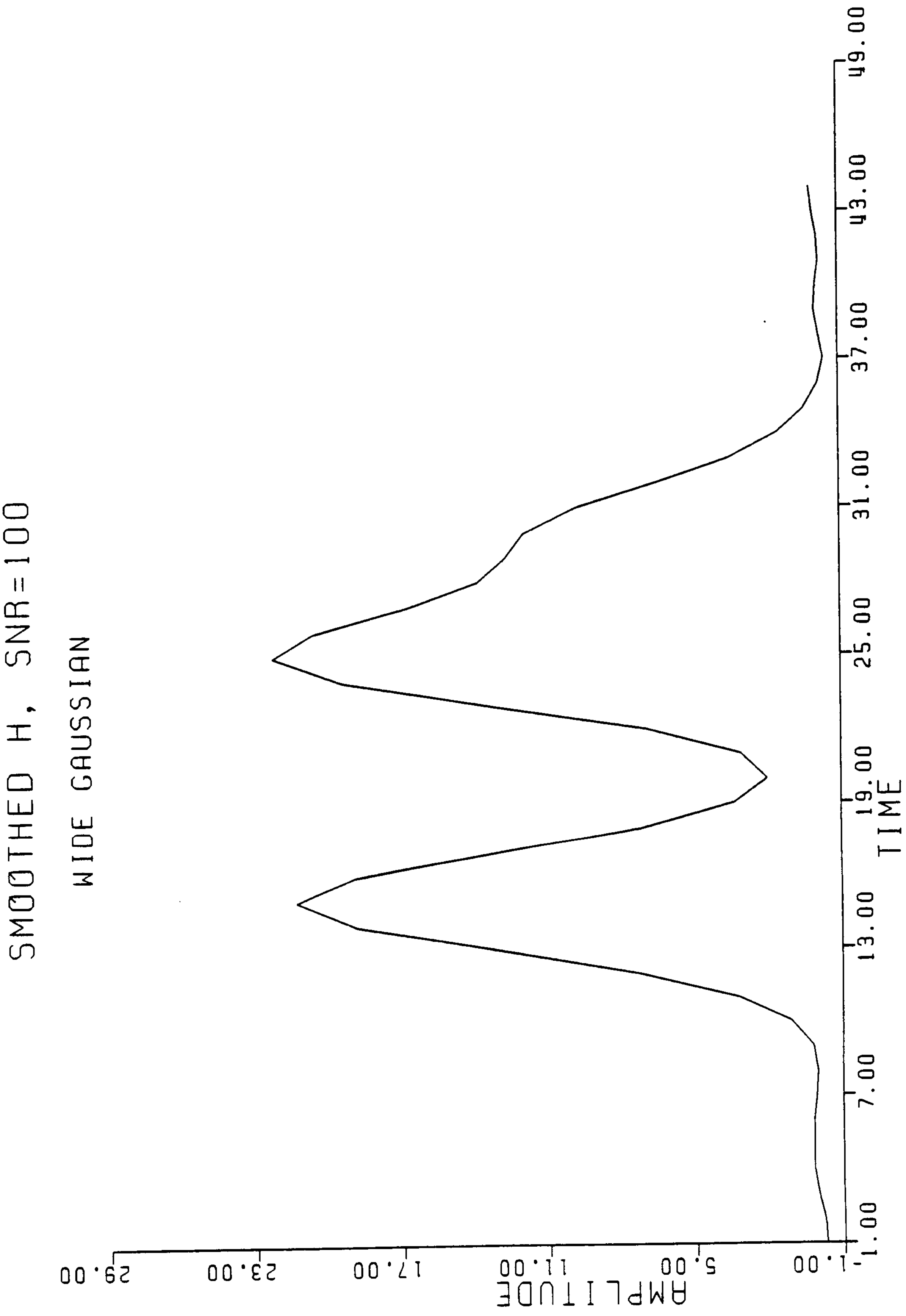

NØISY H, SNR=111
WIDE GAUSSIAN
AMPLITUDE
24.50
19.50
14.50
9.50
4.50
-0.50
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
TIME

SMOOTHED H, SNR=111

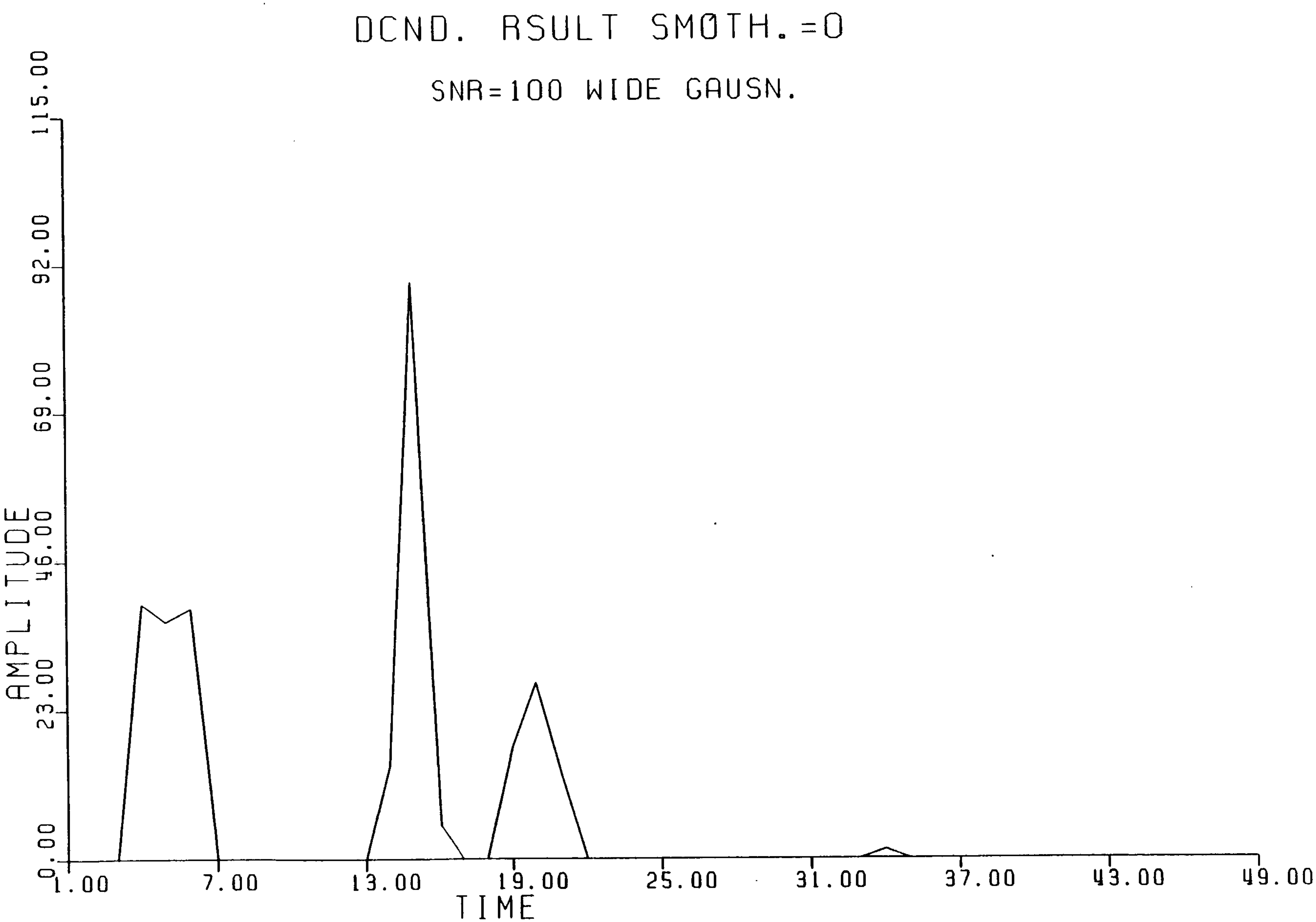
WIDE GAUSSIAN

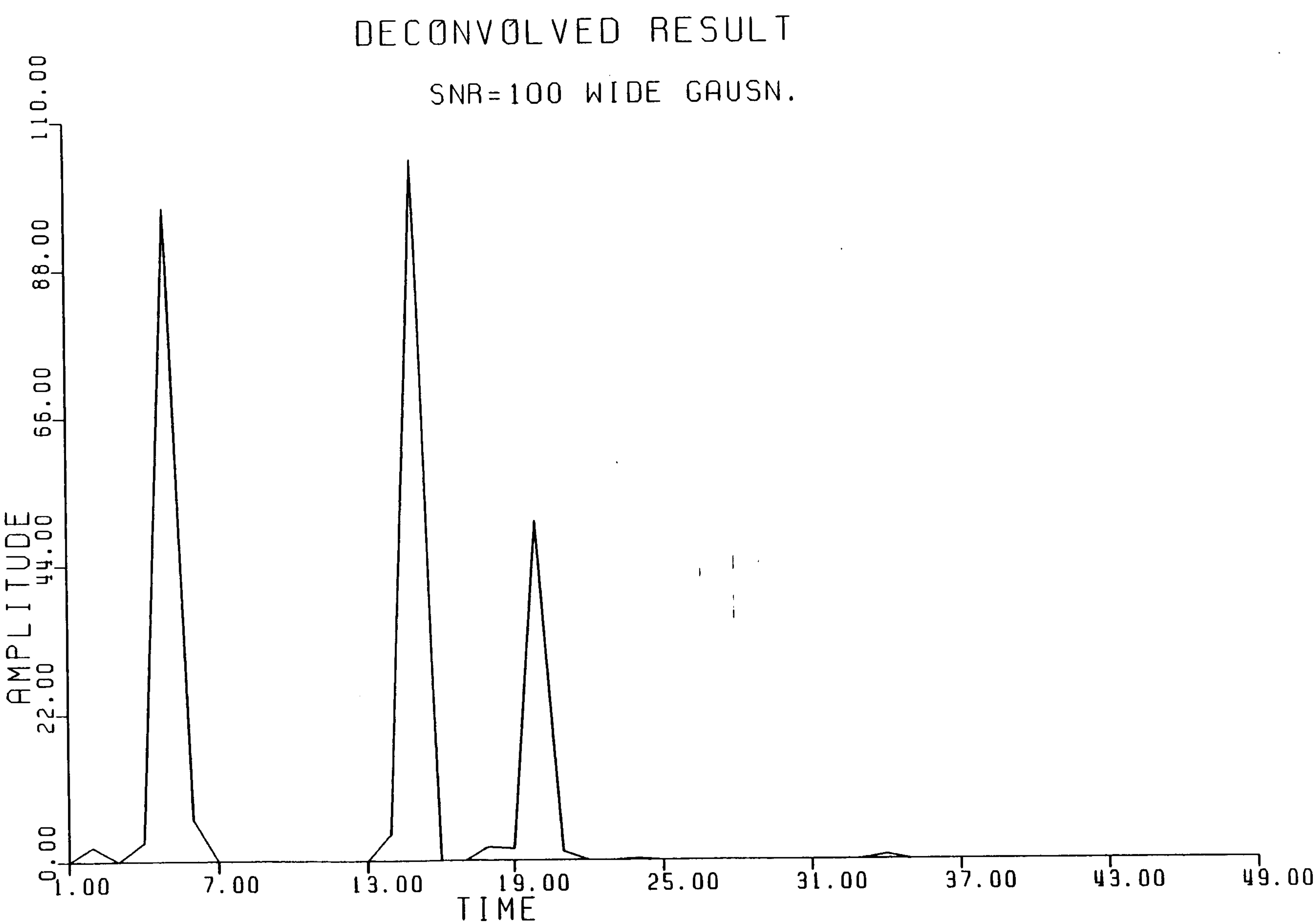


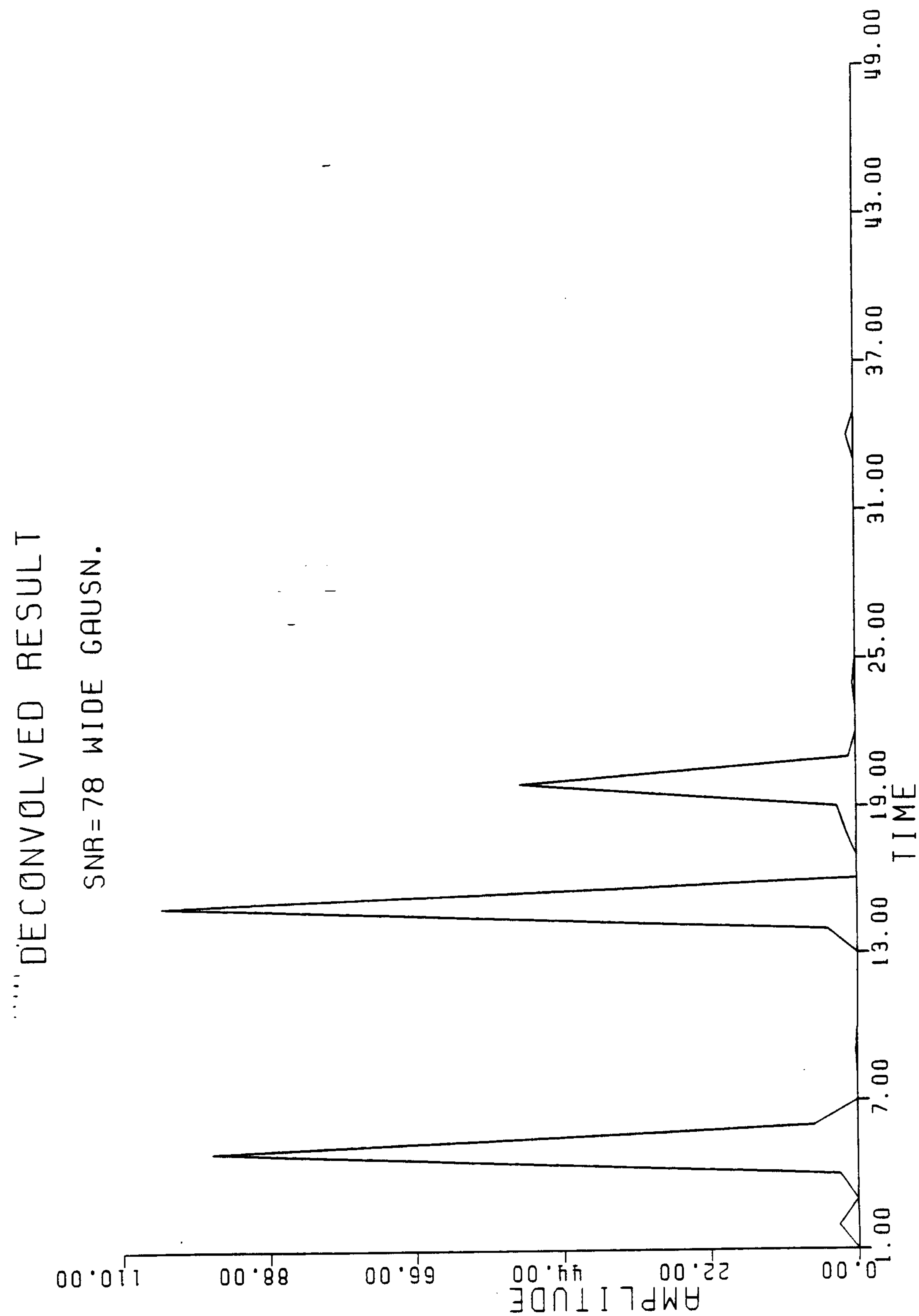

NØISY H, SNR=100
WIDE GAUSSIAN
AMPLITUDE
-1.00
5.00
11.00
17.00
23.00
29.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00



SMOOTHED H, SNR=100
WIDE GAUSSIAN
TIME
AMPLITUDE
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
-1.00
5.00
11.00
17.00
23.00
29.00


DCND. RSULT SMØTH.=0
SNR=100 WIDE GAUSN.
AMPLITUDE
0.00
23.00
46.00
69.00
92.00
115.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00


DECONVOLVED RESULT
SNR=100 WIDE GAUSN.
AMPLITUDE
0.00
22.00
44.00
66.00
88.00
110.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00


DECONVOLVED RESULT
SNR=78 WIDE GAUSN.
AMPLITUDE
0.00
22.00
44.00
66.00
88.00
110.00
TIME
1.00
7.00
13.00
19.00
25.00
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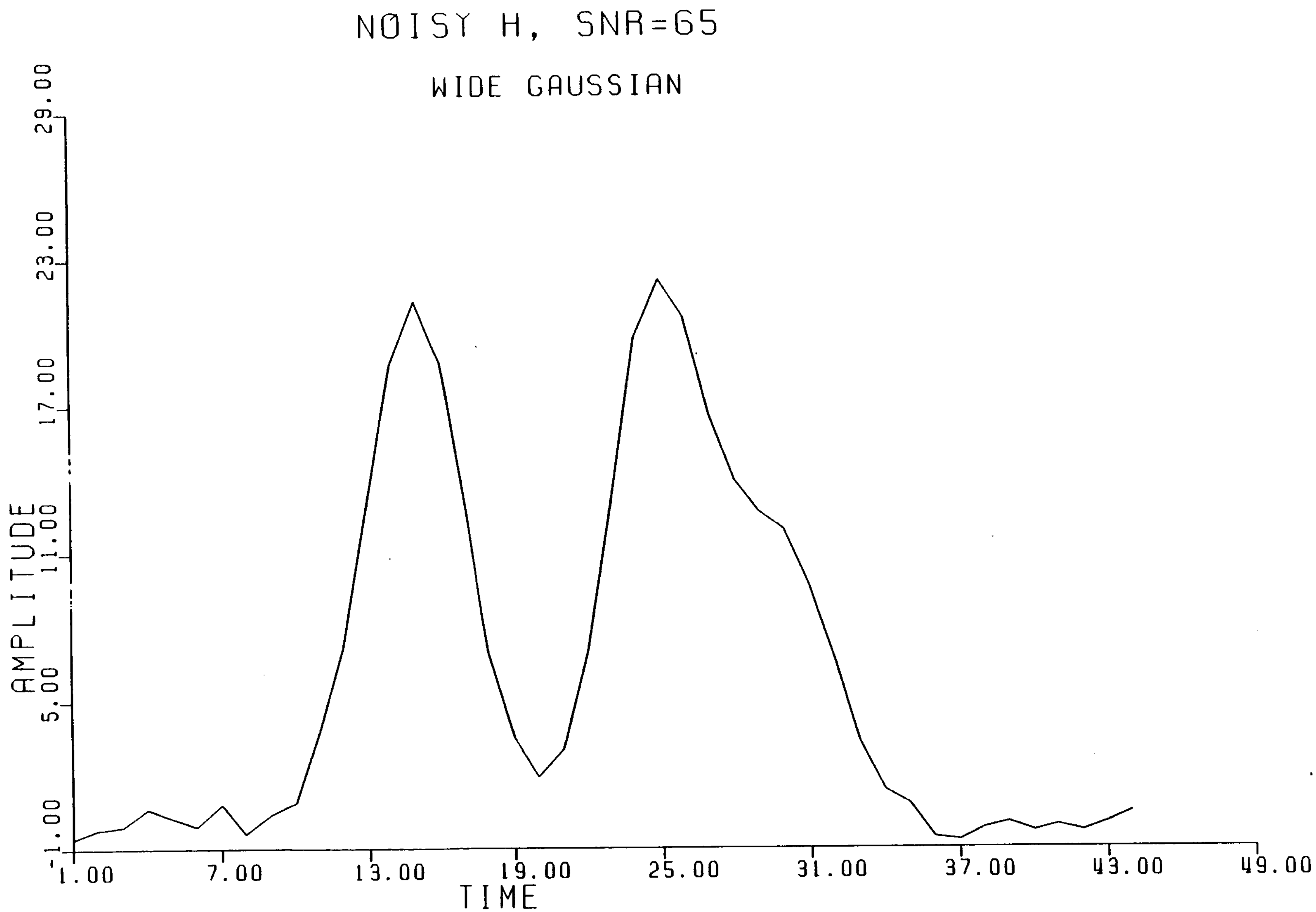
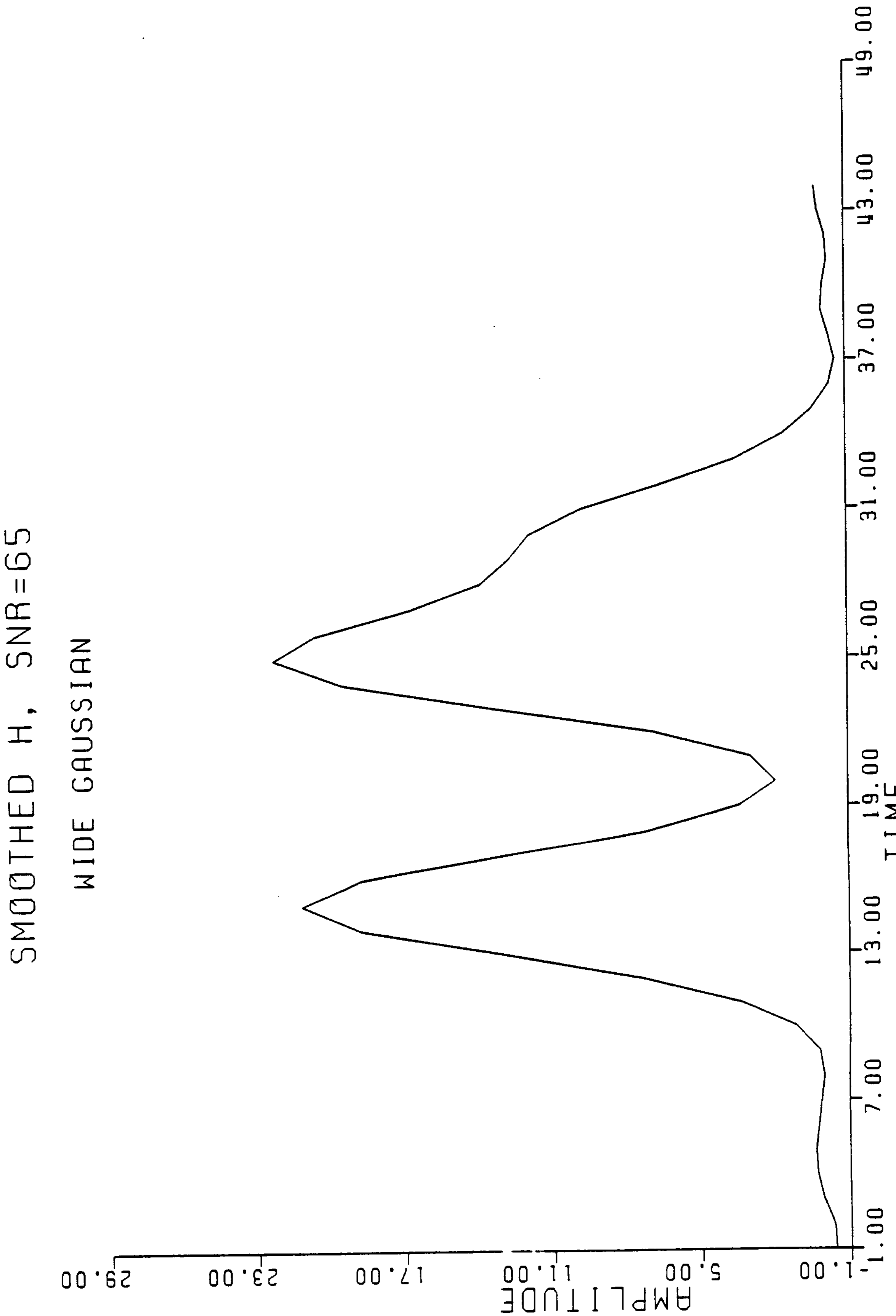
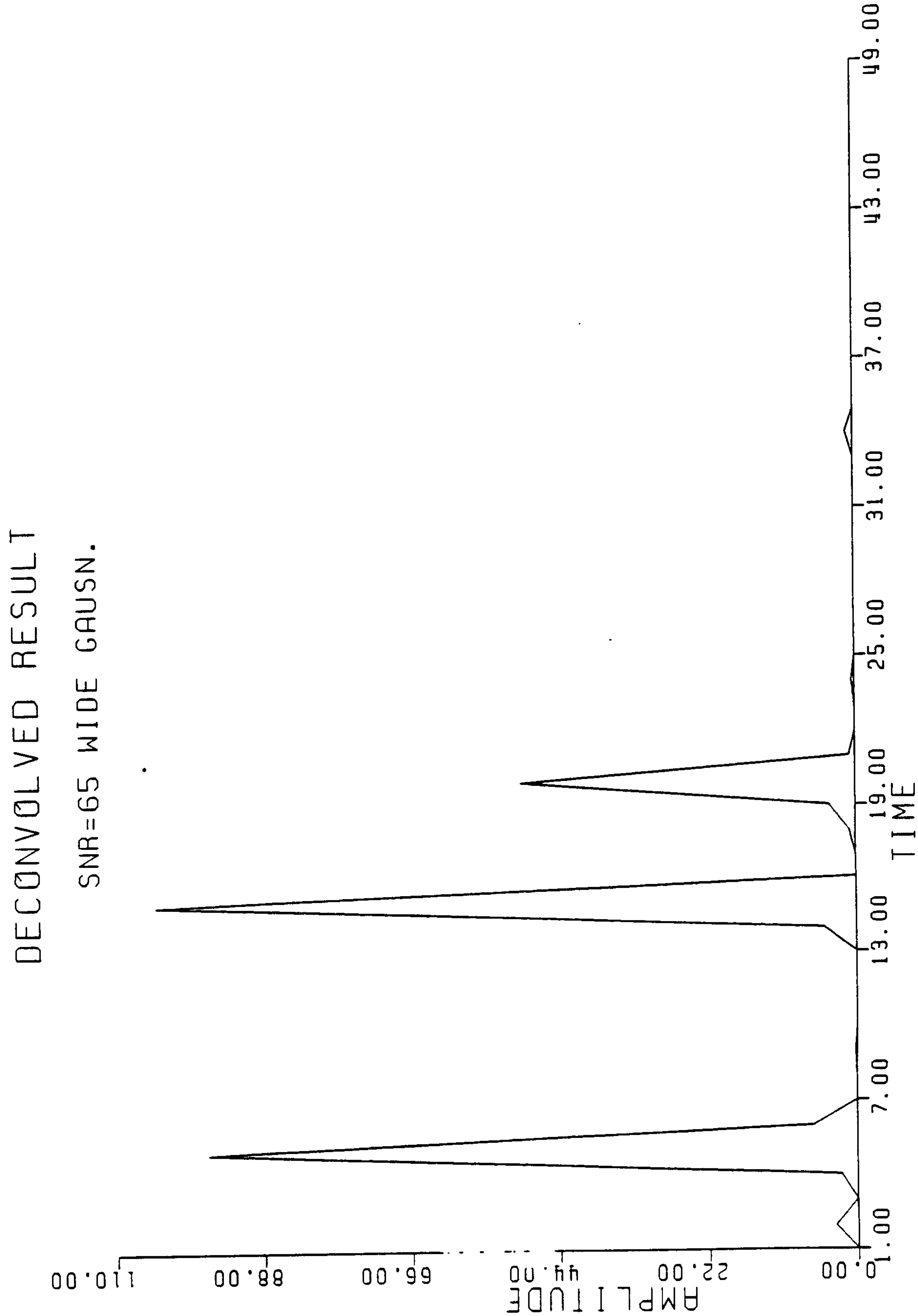
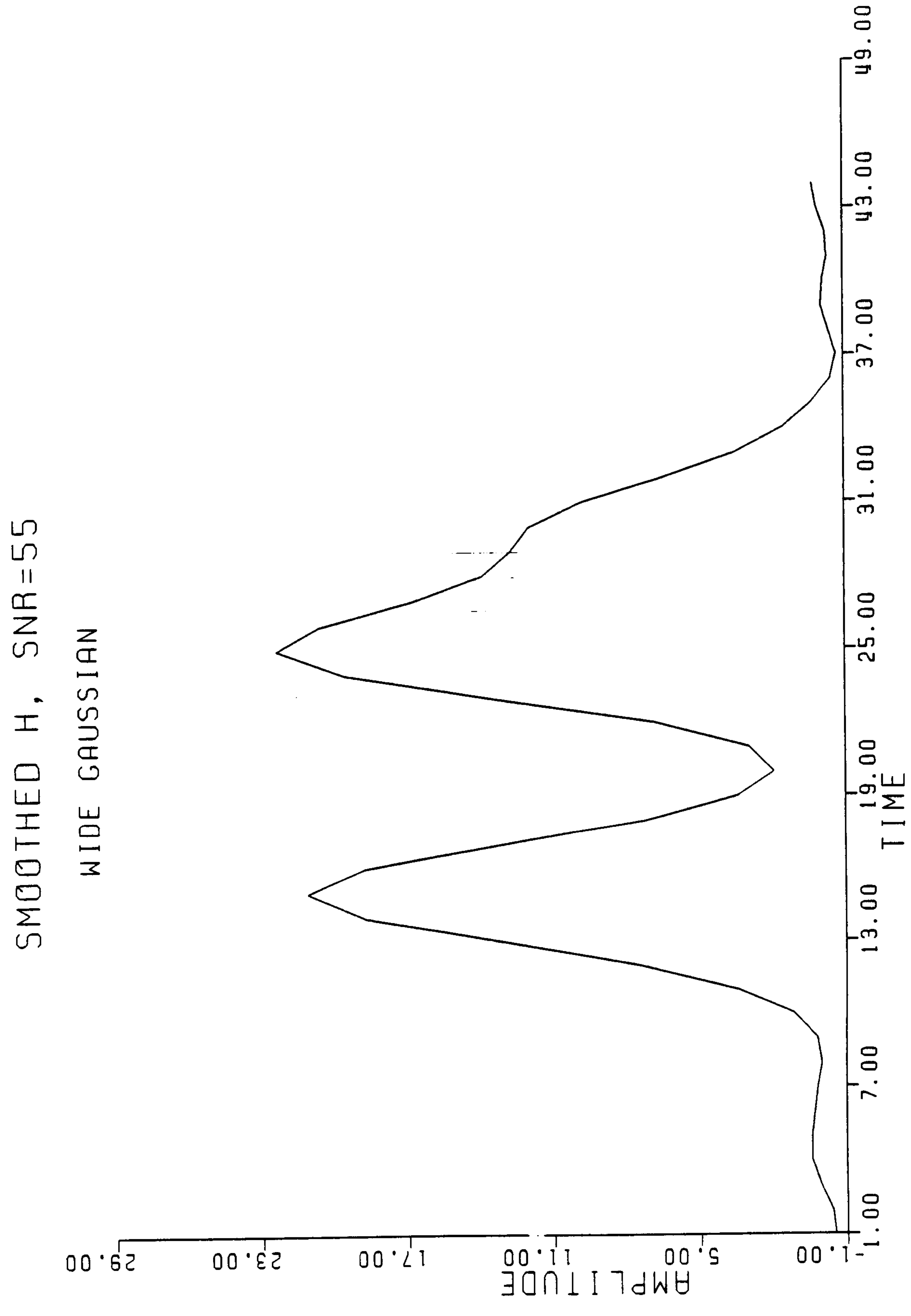
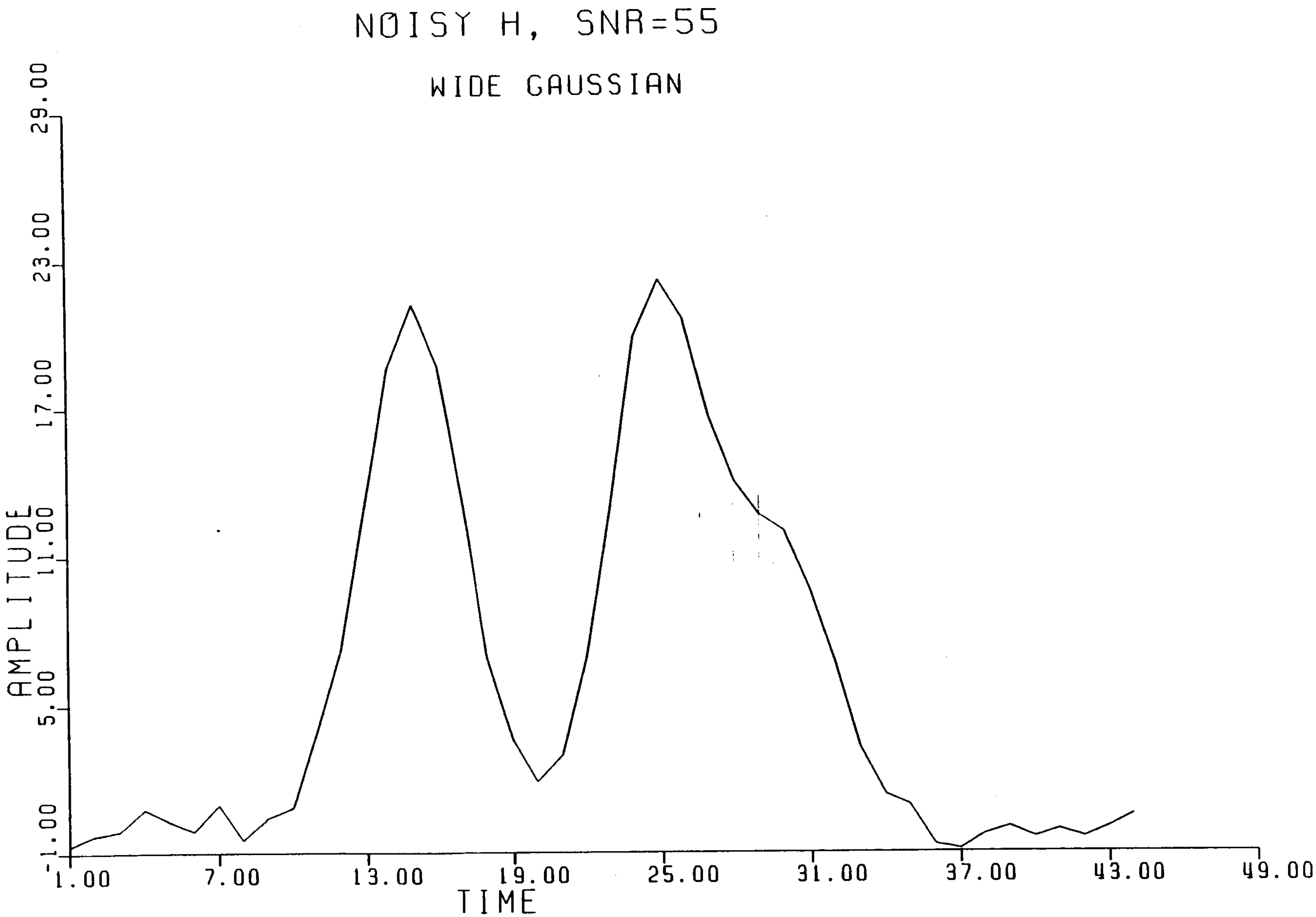
37.00
43.00
49.00


NØISY H, SNR=65
WIDE GAUSSIAN
AMPLITUDE
29.00
23.00
17.00
11.00
5.00
-1.00
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
TIME


SMOOTHED H, SNR=65
WIDE GAUSSIAN
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
AMPLITUDE
-1.00
5.00
11.00
17.00
23.00
29.00

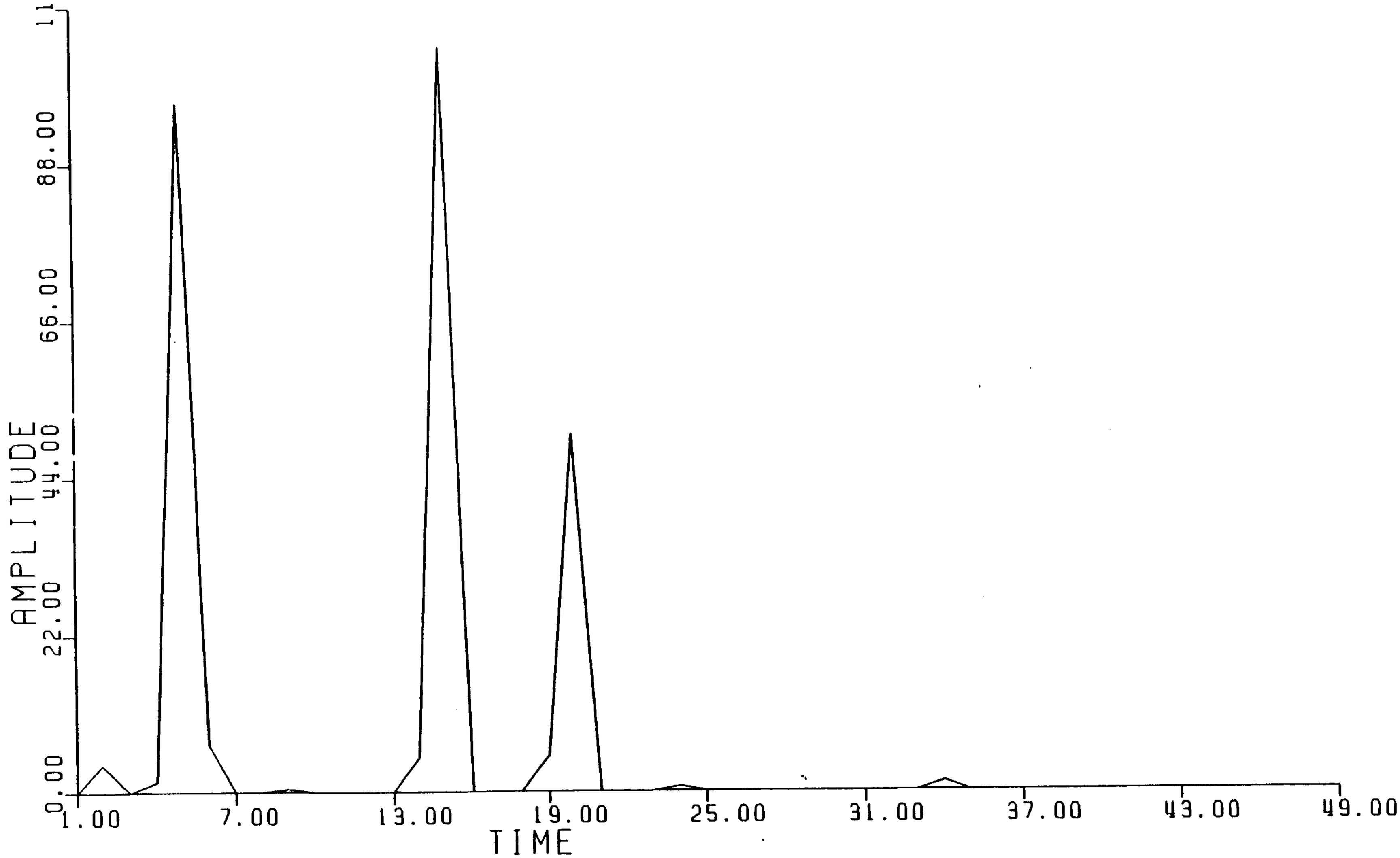

DECONVOLVED RESULT
SNR=65 WIDE GAUSN.
AMPLITUDE
0.00
22.00
44.00
66.00
88.00
110.00
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00


SMOOTHED H, SNR=55
WIDE GAUSSIAN
TIME
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
AMPLITUDE
-1.00
5.00
11.00
17.00
23.00
29.00


NØISY H, SNR=55
WIDE GAUSSIAN
AMPLITUDE
-1.00
5.00
11.00
17.00
23.00
29.00
1.00
7.00
13.00
19.00
25.00
31.00
37.00
43.00
49.00
TIME

DECONVOLVED RESULT

SNR=55 WIDE GAUSN.



SNR=24.6

MSE	U.I	Sm		D.E
4190.459	1148	45	1	0.4882813E-01
7726.021	2000	35	2	0.3305664
3786.167	2000	110	3	0.4123535
784.1273	413	101	4	0.4956055E-01
2238.682	2000	60	5	0.2824707
3565.603	1048	43	6	0.4956055E-01
1258.040	1221	33	7	0.4919434E-01
7080.026	2000	30	8	0.4521484
1227.349	2000	55	9	0.2518311
2007.494	1389	38	10	0.4968262E-01
2029.134	1613	72	11	0.4968262E-01
135.7355	687	101	12	0.4998779E-01
366.3747	750	53	13	0.4937744E-01
361.6091	393	104	14	0.4885864E-01
8427.795	197	61	15	0.1562500E-01
6788.716	156	61	16	0.4589844E-01
2062.760	2000	36	17	0.4980469E-01
602.7864	910	110	18	0.4986572E-01
11230.54	51	48	19	-0.1708984
1836.939	1369	88	20	0.4992676E-01
1415.014	2000	41	21	0.4956055E-01
455.1632	191	62	22	-0.2923584E-01
982.0967	2000	56	23	0.1465454
4899.405	402	40	24	0.3662109E-01
107.7116	610	41	25	0.4873657E-01
1028.869	537	33	26	0.4882813E-01
5256.689	1256	50	27	0.4980469E-01
773.8219	852	35	28	0.4888916E-01
1245.156	2000	110	29	0.2308350
3673.247	2000	20	30	0.4882813E-01
95.35586	556	98	31	0.4961395E-01
2285.434	2000	110	32	0.3159180
8812.910	213	110	33	0.4980469E-01
4892.741	2000	33	34	0.1772461
12543.95	35	25	35	-1.287109
1750.238	1263	74	36	0.4968262E-01
3446.640	1868	43	37	0.4931641E-01
446.2111	1198	79	38	0.4974365E-01
1077.014	2000	53	39	0.4980469E-01
404.2288	2000	44	40	0.9832764E-01
2541.203	1219	52	41	0.4980469E-01
321.5919	1467	57	42	0.4983521E-01
644.8037	1739	52	43	0.4992676E-01
624.5284	834	26	44	0.4809570E-01
4221.136	2000	33	45	0.2250977
2125.069	1279	38	46	0.4980469E-01
6500.285	2000	110	47	0.4252930
197.5141	477	55	48	0.4977417E-01
5807.934	190	62	49	0.4589844E-01
11544.98	42	46	50	-0.4365234

SNR = 43,8

1835.680	1247	61	1	0.4980469E-01
3449.408	2500	53	2	0.4038086
2317.346	2500	111	3	0.2451172
249.7668	509	111	4	0.4286194E-01
888.5016	2500	70	5	0.7434082E-01
1556.226	1271	60	6	0.4870605E-01
677.0530	2051	43	7	0.4949951E-01
3239.666	2500	45	8	0.4140625
669.1708	2500	59	9	0.9912109E-01
705.6562	2158	59	10	0.4986572E-01
784.8752	1338	111	11	0.4968262E-01
110.1804	692	76	12	0.4905701E-01
195.6899	828	68	13	0.4983521E-01
151.7477	506	95	14	0.4936218E-01
3568.639	1388	96	15	0.4980469E-01
5041.245	374	63	16	0.4199219E-01
965.1442	2500	47	17	0.6127930E-01
236.2415	905	111	18	0.4968262E-01
5119.501	2500	65	19	0.2680664
694.9226	1358	111	20	0.4962158E-01
582.0333	2490	72	21	0.4998779E-01
139.7663	287	66	22	0.3280640E-01
126.8761	1935	111	23	0.4986572E-01
1856.027	1944	77	24	0.4992676E-01
101.7400	864	52	25	0.4987335E-01
318.6688	757	43	26	0.4956055E-01
3942.792	986	41	27	0.4736328E-01
253.8878	640	79	28	0.4951477E-01
716.6593	1377	106	29	0.4949951E-01
493.5203	1699	109	30	0.4940796E-01
51.76822	726	89	31	0.4948044E-01
844.0268	2500	111	32	0.1049194
4548.678	2500	49	33	0.2797852
2406.656	2500	48	34	0.2492676
10516.36	80	82	35	-0.2246094E-01
551.9867	2310	81	36	0.4986572E-01
1446.369	2189	69	37	0.4992676E-01
2199.677	2500	32	38	0.4956055E-01
387.1719	1524	95	39	0.4971313E-01
351.1992	2500	57	40	0.5316162E-01
1175.728	1265	65	41	0.4980469E-01
235.7274	1556	71	42	0.4997253E-01
536.6804	2500	55	43	0.1000366
336.6414	820	45	44	0.4827881E-01
1784.468	2500	40	45	0.1076660
1213.364	1308	50	46	0.4992676E-01
3398.163	2500	111	47	0.2255859
130.5279	558	57	48	0.4939270E-01
3508.549	510	66	49	0.4638672E-01
8420.363	325	111	50	0.4492188E-01

1292.947	1364	69	1	0.4968262E-01
2342.895	2500	65	2	0.2702637
2569.849	2157	72	3	0.4980469E-01
161.5626	611	111	4	0.4902649E-01
626.0742	2496	73	5	0.4986572E-01
1100.100	1406	68	6	0.4870605E-01
526.0294	2500	50	7	0.5999756E-01
2269.479	2500	52	8	0.3559570
577.2681	2500	61	9	0.8044434E-01
497.9467	1587	72	10	0.4998779E-01
539.3050	1212	111	11	0.4907227E-01
369.7806	1650	43	12	0.4977417E-01
203.6273	1050	54	13	0.4945374E-01
119.0938	558	89	14	0.4965973E-01
3192.147	2500	52	15	0.4980469E-01
3558.829	741	62	16	0.4882813E-01
702.7291	2486	54	17	0.4986572E-01
159.3736	1101	111	18	0.4971313E-01
3670.236	2500	75	19	0.2609863
509.2944	1320	111	20	0.4989624E-01
394.3931	2273	107	21	0.4986572E-01
93.27183	339	67	22	0.4299927E-01
551.5923	2459	61	23	0.4998779E-01
2906.856	2500	34	24	0.4980469E-01
116.1390	1517	47	25	0.4963684E-01
205.1159	844	49	26	0.4936218E-01
2761.607	1184	48	27	0.4931641E-01
165.6666	709	88	28	0.4985046E-01
536.6702	1885	88	29	0.4992676E-01
362.1279	1783	111	30	0.4983521E-01
38.01482	820	107	31	0.4979324E-01
594.4579	2500	111	32	0.8013916E-01
3097.900	2500	62	33	0.1735840
1741.901	2500	57	34	0.2359619
4873.411	2500	111	35	0.3310547
384.5823	2500	92	36	0.6561279E-01
1010.245	2062	79	37	0.4943848E-01
1625.936	2500	38	38	0.4992676E-01
279.7176	1771	101	39	0.4995728E-01
335.2545	2452	62	40	0.4974365E-01
868.8260	1258	71	41	0.4992676E-01
209.8327	1566	77	42	0.4983521E-01
619.0175	2500	48	43	0.4968262E-01
269.3122	920	54	44	0.4998779E-01
1242.719	2500	46	45	0.8666992E-01
948.4930	1302	56	46	0.4986572E-01
2698.441	2500	111	47	0.8520508E-01
110.9698	646	56	48	0.4891205E-01
2395.234	842	66	49	0.4980469E-01
6140.350	1193	111	50	0.4980469E-01

SNR=55.57

S/N R=66.6

992.9010	1401	77	1	0.4974365E-01
1749.685	2500	71	2	0.2304688
1832.946	2256	80	3	0.4992676E-01
119.8265	704	111	4	0.4809570E-01
488.6740	2279	77	5	0.4986572E-01
851.5078	1471	75	6	0.4827881E-01
473.1797	2500	56	7	0.8258057E-01
1666.030	2500	58	8	0.2835693
528.6294	2500	62	9	0.6573486E-01
378.9445	1263	90	10	0.4977417E-01
396.9560	1211	111	11	0.4965210E-01
255.6906	1798	47	12	0.4998779E-01
173.6844	1203	56	13	0.4945374E-01
102.8889	617	87	14	0.4952240E-01
2380.034	2500	58	15	0.4956055E-01
2640.543	1021	66	16	0.4956055E-01
541.5491	2310	60	17	0.4992676E-01
131.2470	1133	111	18	0.4971313E-01
2851.909	2500	82	19	0.2573242
475.2838	1328	93	20	0.4983521E-01
329.8961	2366	111	21	0.4995728E-01
72.20303	388	67	22	0.4241180E-01
487.4539	2475	63	23	0.4989624E-01
2166.140	2500	39	24	0.4956055E-01
117.8892	1314	53	25	0.4998779E-01
155.7485	781	56	26	0.4971313E-01
2042.908	1201	61	27	0.4895020E-01
242.5725	1660	53	28	0.4998779E-01
416.3424	1727	98	29	0.4995728E-01
301.5760	1822	111	30	0.4986572E-01
33.69416	914	111	31	0.4973221E-01
462.6482	2500	111	32	0.6423950E-01
2267.161	2500	67	33	0.1455078
1333.005	2500	65	34	0.2060547
3579.749	2500	111	35	0.3198242
317.3088	2500	97	36	0.5993652E-01
771.1363	1924	85	37	0.4980469E-01
1264.779	2500	42	38	0.4992676E-01
232.5859	1871	107	39	0.4981995E-01
309.0214	2500	65	40	0.5065918E-01
696.0218	1247	76	41	0.4974365E-01
192.8793	1565	82	42	0.4998779E-01
574.4134	1051	59	43	0.4913330E-01
231.4395	1016	62	44	0.4992676E-01
929.4664	2500	52	45	0.5194092E-01
791.8888	1231	54	46	0.4998779E-01
2180.533	1527	111	47	0.4956055E-01
124.6173	935	45	48	0.4797363E-01
1762.125	1015	71	49	0.4931641E-01
3534.256	1494	63	50	0.4980469E-01

SNR=77.7

798.7280	1426	84	1	0.4998779E-01
1374.237	2500	76	2	0.1958008
1412.149	2372	85	3	0.4992676E-01
95.16882	795	107	4	0.4982758E-01
397.7452	2127	80	5	0.4992676E-01
689.3594	1548	77	6	0.4943848E-01
427.6217	2500	62	7	0.6213379E-01
1266.188	2500	63	8	0.2302246
558.3214	2500	48	9	0.5633545E-01
299.6469	1090	111	10	0.4885864E-01
315.3671	1194	111	11	0.4989624E-01
196.3376	1769	51	12	0.4998779E-01
153.5888	1339	58	13	0.4948425E-01
124.7683	1037	47	14	0.4991150E-01
1852.333	2433	64	15	0.4980469E-01
2050.967	1129	71	16	0.4980469E-01
437.6107	2159	66	17	0.4998779E-01
110.3135	1228	111	18	0.4968262E-01
2279.018	2500	89	19	0.2316895
375.4233	1404	97	20	0.4971313E-01
325.1086	2221	111	21	0.4995728E-01
60.68363	431	68	22	0.4992294E-01
447.1847	2469	64	23	0.4992676E-01
1658.586	2500	43	24	0.4992676E-01
122.2771	1143	58	25	0.4995728E-01
233.1536	1230	43	26	0.4960632E-01
1577.118	1311	66	27	0.4968262E-01
193.5997	1861	58	28	0.4978943E-01
335.7919	1592	111	29	0.4956055E-01
264.9504	1788	111	30	0.4977417E-01
34.17465	990	111	31	0.4985428E-01
379.9004	2500	111	32	0.5334473E-01
1733.454	2500	71	33	0.1190186
1052.276	2500	72	34	0.1813965
2781.832	2500	111	35	0.3015137
283.0748	2500	100	36	0.5267334E-01
613.9236	1856	89	37	0.4937744E-01
1011.386	2471	46	38	0.4980469E-01
200.1544	2058	111	39	0.4978943E-01
271.8646	2489	70	40	0.4995728E-01
581.8481	1237	80	41	0.4974365E-01
180.2859	1549	88	42	0.4957581E-01
478.7369	1087	64	43	0.4962158E-01
206.9862	1073	72	44	0.4951477E-01
728.7515	2404	56	45	0.4980469E-01
665.5466	1250	59	46	0.4968262E-01
1734.739	1530	111	47	0.4882813E-01
95.16291	718	58	48	0.4974365E-01
1361.911	1097	76	49	0.4992676E-01
3497.208	1429	111	50	0.4980469E-01

SNR=100

568.6236	1411	98	1	0.4956055E-01
928.0660	2500	86	2	0.1524658
786.9232	1675	122	3	0.4937744E-01
181.4258	1538	55	4	0.4972839E-01
287.7179	1868	87	5	0.4989624E-01
491.0199	1502	91	6	0.4943848E-01
366.9711	2468	77	7	0.4986572E-01
801.2684	2500	72	8	0.1596680
419.2525	2424	55	9	0.4971313E-01
261.5950	1895	65	10	0.4995728E-01
240.0173	1134	92	11	0.4946899E-01
143.2219	1322	60	12	0.4930115E-01
147.7451	1707	59	13	0.4931641E-01
69.28896	845	63	14	0.4937744E-01
1221.376	2500	74	15	0.4980469E-01
1368.085	1195	80	16	0.4968262E-01
314.9291	1908	76	17	0.4998779E-01
87.62945	1223	122	18	0.4970551E-01
1579.591	2500	100	19	0.1782227
262.0608	1610	103	20	0.4992676E-01
301.5937	1260	122	21	0.4974365E-01
49.63319	518	68	22	0.4668808E-01
395.0535	2367	66	23	0.4995728E-01
1045.017	2461	51	24	0.4980469E-01
114.5885	980	68	25	0.4952240E-01
144.5958	1307	49	26	0.4939270E-01
1030.689	1433	75	27	0.4943848E-01
154.8509	1921	67	28	0.4971313E-01
248.8357	1562	122	29	0.4969788E-01
209.9953	1707	122	30	0.4994202E-01
38.31293	1058	122	31	0.4999542E-01
275.0349	2283	122	32	0.4995728E-01
1121.826	2500	79	33	0.7763672E-01
713.6606	2500	88	34	0.1206665
1839.563	2500	122	35	0.2619629
274.0554	2358	90	36	0.4995728E-01
425.6841	1916	95	37	0.4983521E-01
707.1358	2496	52	38	0.4980469E-01
174.1838	2167	122	39	0.4998779E-01
294.6561	2500	49	40	0.6866455E-01
442.1396	1215	85	41	0.4995728E-01
162.7368	1534	95	42	0.4963684E-01
359.1908	1133	71	43	0.4986572E-01
179.5359	1212	91	44	0.4969788E-01
492.1024	2150	65	45	0.4953003E-01
514.6094	1255	68	46	0.4992676E-01
1175.203	1521	122	47	0.4968262E-01
83.64483	786	65	48	0.4972839E-01
904.1519	1157	86	49	0.4974365E-01
2289.615	1465	122	50	0.4931641E-01

496.9725	1390	105	1	0.4983521E-01
790.3687	2500	88	2	0.1419067 SNR=111
687.3831	1679	122	3	0.4986572E-01
179.4472	1828	55	4	0.4937744E-01
252.2458	1780	90	5	0.4994202E-01
416.6563	1521	97	6	0.4977417E-01
355.2678	2397	83	7	0.4989624E-01
655.3206	2500	77	8	0.1329956
386.7451	2184	59	9	0.4980469E-01
222.9024	1760	70	10	0.4981995E-01
222.1130	1224	83	11	0.4911804E-01
354.0320	1807	45	12	0.4965210E-01
94.49271	876	92	13	0.4962921E-01
57.66848	888	66	14	0.4925156E-01
1025.906	2475	79	15	0.4992676E-01
1157.214	1208	83	16	0.4980469E-01
276.9224	1800	81	17	0.4977417E-01
124.4780	826	122	18	0.4847717E-01
1356.377	2500	106	19	0.1567383
236.3154	1684	104	20	0.4998779E-01
267.6845	1265	122	21	0.4986572E-01
55.10238	638	56	22	0.4758072E-01
158.9410	1420	122	23	0.4980469E-01
854.7485	2486	54	24	0.4998779E-01
109.0080	982	72	25	0.4994965E-01
128.8873	1285	51	26	0.4956055E-01
863.3383	1449	79	27	0.4974365E-01
146.0990	1944	71	28	0.4994202E-01
223.3320	1589	122	29	0.4995728E-01
221.3015	1858	97	30	0.4928589E-01
41.91877	1086	122	31	0.4979324E-01
248.3136	2220	122	32	0.4998779E-01
936.1021	2500	83	33	0.6250000E-01
596.3053	2500	89	34	0.1221313
1568.427	2500	122	35	0.2449951
266.8463	2210	93	36	0.4986572E-01
371.4833	1879	114	37	0.4974365E-01
613.4410	2500	54	38	0.4998779E-01
186.8479	2160	122	39	0.4995728E-01
263.9760	2500	52	40	0.6094360E-01
396.7161	1206	90	41	0.4995728E-01
156.1247	1547	95	42	0.4983521E-01
315.2099	1145	75	43	0.4995728E-01
172.3717	1283	99	44	0.4992676E-01
416.5833	2071	69	45	0.4953003E-01
465.3438	1247	72	46	0.4980469E-01
1022.003	1511	122	47	0.4992676E-01
102.5014	677	63	48	0.4707336E-01
765.6605	1180	89	49	0.4949951E-01
1944.477	1464	122	50	0.4992676E-01

SNR=122

441.5149	1362	113	1	0.4995728E-01
685.6334	2500	93	2	0.1260986
618.0797	1630	122	3	0.4986572E-01
181.0713	2001	55	4	0.4992676E-01
220.4333	1515	104	5	0.4986572E-01
360.2181	1532	103	6	0.4992676E-01
356.7214	2103	88	7	0.4995728E-01
548.7199	2500	80	8	0.1160889
365.6660	1865	63	9	0.4995728E-01
192.0178	1631	76	10	0.4981995E-01
190.7922	1231	88	11	0.4972839E-01
288.2063	1246	50	12	0.4949951E-01
86.28315	889	97	13	0.4972839E-01
54.51132	1074	61	14	0.4979706E-01
877.9106	2500	83	15	0.4998779E-01
996.8047	1217	87	16	0.4986572E-01
246.0427	1698	84	17	0.4995728E-01
106.1296	887	122	18	0.4926300E-01
1182.018	2500	111	19	0.1391602
210.7834	1758	107	20	0.4975891E-01
242.6548	1270	122	21	0.4985046E-01
50.39714	663	59	22	0.4973602E-01
158.4220	1392	122	23	0 4988098E-01
712.9257	2454	57	24	0.4986572E-01
104.4484	979	76	25	0.4999542E-01
109.4211	1267	54	26	0.4985809E-01
730.9874	1414	88	27	0.4968262E-01
145.2390	1930	73	28	0.4997253E-01
204.4396	1605	122	29	0.4981995E-01
316.9550	2500	59	30	0.4977417E-01
45.78909	1107	122	31	0.4983902E-01
227.1660	2163	122	32	0.4977417E-01
796.2143	2500	86	33	0.5035400E-01
510.1431	2500	93	34	0.1196594
1359.055	2500	122	35	0.2178955
263.8924	2184	89	36	0.4992676E-01
327.6909	1874	119	37	0.4986572E-01
537.2285	2500	56	38	0.4968262E-01
1034.926	2500	48	39	0.4992676E-01
239.2224	2500	56	40	0.5249023E-01
361.8343	1196	92	41	0.4989624E-01
150.4408	1535	99	42	0.4985046E-01
280.9372	1150	79	43	0.4998779E-01
168.2287	1330	111	44	0.4980469E-01
357.8250	2024	72	45	0.4968262E-01
425.9508	1240	76	46	0.4995728E-01
904.2603	1500	122	47	0.4992676E-01
88.25326	701	66	48	0.4768372E-01
660.7336	1194	92	49	0.4974365E-01
1682.127	1465	122	50	0.4968262E-01

SNR=133

398.0550	1340	120	1	0.4995728E-01
601.1368	2500	97	2	0.1152954
564.7921	1584	122	3	0.4986572E-01
193.1609	2155	54	4	0.4948425E-01
205.1570	1854	88	5	0.4972839E-01
315.9771	1544	108	6	0.4995728E-01
357.6590	1715	90	7	0.4995728E-01
465.4131	2500	83	8	0.1015625
351.3112	1555	65	9	0.4977417E-01
166.9711	1554	81	10	0.4975891E-01
175.7009	1125	94	11	0.4939270E-01
323.8304	1409	48	12	0.4998779E-01
79.63064	914	100	13	0.4966736E-01
47.70351	1095	64	14	0.4960632E-01
759.8972	2500	87	15	0.4962158E-01
871.0329	1234	90	16	0.4956055E-01
221.6919	1628	90	17	0.4980469E-01
93.18137	945	122	18	0.4959106E-01
1046.387	2500	115	19	0.1243896
191.5631	1754	112	20	0.4992676E-01
224.2909	1270	122	21	0.4994202E-01
46.63171	645	65	22	0.4909897E-01
156.8182	1386	122	23	0.4986572E-01
601.2182	2500	59	24	0.4998779E-01
100.1829	976	80	25	0.4990387E-01
94.61314	1246	57	26	0.4977417E-01
618.7025	1429	92	27	0.4919434E-01
143.1693	1872	75	28	0.4986572E-01
189.6033	1619	122	29	0.4995728E-01
273.5626	2469	60	30	0.4977417E-01
49.10252	1131	122	31	0.4990005E-01
210.9991	2114	122	32	0.4985046E-01
694.2234	2336	88	33	0.4980469E-01
444.8989	2500	95	34	0.1152649
1191.142	2500	122	35	0.1920166
261.6393	1984	92	36	0.4998779E-01
292.6001	1869	122	37	0.4949951E-01
476.6001	2500	58	38	0.4980469E-01
883.3346	2367	51	39	0.4992676E-01
220.0553	2477	59	40	0.4995728E-01
333.6457	1188	95	41	0.4992676E-01
151.8066	1755	69	42	0.4991150E-01
253.7242	1170	82	43	0.4994202E-01
263.7891	1008	64	44	0.4986572E-01
311.6641	1982	76	45	0.4968262E-01
469.9492	864	62	46	0.4998779E-01
811.6254	1489	122	47	0.4992676E-01
286.4071	1962	40	48	0.4980469E-01
578.7576	1193	97	49	0.4986572E-01
1479.700	1462	122	50	0.4968262E-01

363.4560	1307	122	1	0.4995728E-01
533.2213	2500	101	2	0.1065674 SNR=144
524.1432	1523	122	3	0.4998779E-01
209.0892	2223	53	4	0.4994202E-01
225.9464	2092	74	5	0.4997253E-01
281.5467	1553	113	6	0.4995728E-01
354.2477	1328	95	7	0.4986572E-01
398.0999	2500	87	8	0.8795166E-01
308.1270	1044	84	9	0.4992676E-01
146.2382	1458	88	10	0.4960632E-01
155.0161	1122	99	11	0.4949951E-01
328.5151	1462	48	12	0.4962158E-01
74.18105	923	105	13	0.4899597E-01
203.0838	1936	46	14	0.4948425E-01
666.7544	2491	91	15	0.4998779E-01
770.3853	1240	94	16	0.4998779E-01
202.2041	1566	94	17	0.4991150E-01
83.96616	1000	122	18	0.4978180E-01
936.4026	2500	120	19	0.1121216
176.9271	1734	117	20	0.4989624E-01
209.4420	1272	122	21	0.4995728E-01
44.62481	689	66	22	0.4890060E-01
156.1302	1380	122	23	0.4959106E-01
518.4996	2500	61	24	0.4998779E-01
96.35403	988	83	25	0.4992676E-01
83.19237	1270	59	26	0.4981232E-01
600.9502	1778	62	27	0.4986572E-01
142.7081	1731	78	28	0.4994202E-01
178.2179	1627	122	29	0.4980469E-01
241.7118	2397	62	30	0.4985046E-01
51.14214	1171	122	31	0.4990768E-01
197.8575	2073	122	32	0.4997253E-01
613.3833	2191	90	33	0.4992676E-01
392.4493	2500	97	34	0.1091003
1056.898	2500	122	35	0.1669922
261.7577	1864	91	36	0.4998779E-01
265.9476	1851	122	37	0.4992676E-01
436.1260	2413	59	38	0.4965210E-01
770.3757	2500	53	39	0.4992676E-01
206.9303	2406	62	40	0.4980469E-01
396.4771	871	64	41	0.4962158E-01
137.0457	1750	71	42	0.4988098E-01
232.2288	1166	86	43	0.4981995E-01
242.2139	984	69	44	0.4995728E-01
287.6216	1788	80	45	0.4977417E-01
425.9720	867	65	46	0.4846191E-01
737.6705	1480	122	47	0.4943848E-01
68.40355	752	71	48	0.4884338E-01
514.3665	1198	100	49	0.4998779E-01
1316.275	1460	122	50	0.4943848E-01

SNR=155

335.1023	1289	122	1	0.4989624E-01
479.4408	2500	104	2	0.1004639
489.7894	1434	122	3	0.4980469E-01
190.6001	2193	55	4	0.4971313E-01
156.5055	1485	115	5	0.4937744E-01
253.9954	1559	116	6	0.4911804E-01
331.2010	1268	95	7	0.4989624E-01
345.5790	2500	89	8	0.7897949E-01
278.9003	1056	88	9	0.4989624E-01
128.8719	1385	95	10	0.4986572E-01
137.6157	1116	105	11	0.4962158E-01
66.25671	684	119	12	0.4750824E-01
69.58777	942	108	13	0.4997253E-01
39.12747	1148	69	14	0.4983139E-01
591.3756	2500	94	15	0.4992676E-01
689.5703	1247	97	16	0.4998779E-01
186.0258	1509	98	17	0.4988098E-01
77.15353	1051	122	18	0.4965973E-01
847.9225	2500	122	19	0.1006470
165.6378	1727	121	20	0.4995728E-01
198.1549	1272	122	21	0.4992676E-01
43.49351	720	68	22	0.4991531E-01
155.0915	1373	122	23	0.4948425E-01
453.1523	2411	64	24	0.4992676E-01
93.00024	984	87	25	0.4957581E-01
74.08315	1242	62	26	0.4957581E-01
561.0971	1864	60	27	0.4980469E-01
95.81001	938	122	28	0.4959869E-01
168.7323	1621	122	29	0.4998779E-01
215.7959	2292	66	30	0.4980469E-01
52.23791	1212	122	31	0.4990005E-01
186.5437	2030	122	32	0.4989624E-01
548.4291	2056	92	33	0.4998779E-01

SNR = 10

MSE	U.I	S.m		D.E
14864.95	3	0	1	-148.5879
9310.105	11	0	2	-26.79492
12666.07	6	0	3	-17.68848
12798.87	5	0	4	-66.60352
11178.86	15	0	5	-16.78125
12764.64	12	0	6	-5.393555
11488.22	25	0	7	-16.38867
2066.412	47	0	8	-1.536377
3645.559	160	0	9	-0.7060547
4521.561	20	0	10	-4.703613
13005.14	9	0	11	-26.42383
2378.694	47	0	12	-0.5598145
8754.368	35	0	13	-14.90332
2628.487	94	0	14	-1.625244
13651.29	4	0	15	-48.51660
13478.68	5	0	16	-142.8760
14134.30	3	0	17	-16.35352
13916.50	5	0	18	-15.70703
14717.37	6	0	19	-22.57813
16228.46	2	0	20	-33.51465
11445.15	9	0	21	-18.96582
17129.52	1	0	22	-574.6660
7436.772	46	0	23	-0.8183594
13344.84	7	0	24	-13.67090
15932.03	1	0	25	-156.3818
14383.74	4	0	26	-16.49512
12703.98	6	0	27	-13.09375
4691.562	51	0	28	-3.601563
7484.368	14	0	29	-29.52295
694.8588	63	0	30	-0.9627075
14377.10	7	0	31	-12.14258
6956.015	15	0	32	-5.728516
12687.27	8	0	33	-6.417969
7308.281	93	0	34	-4.383301
14478.18	3	0	35	-78.66016
15298.50	3	0	36	-25.14063
8613.257	15	0	37	-10.13574
3402.754	195	0	38	-1.319336
688.5715	38	0	39	-10.41882
1990.130	123	0	40	-0.5131836
13949.65	7	0	41	-43.87695
13957.00	11	0	42	-37.51465
14071.63	4	0	43	-169.5928
6219.904	45	0	44	-3.294434
12880.40	11	0	45	-9.213867
14143.39	7	0	46	-74.60352
4149.961	38	0	47	-4.358398
14966.03	3	0	48	-117.2725
16434.27	1	0	49	-187.5645
14474.75	4	0	50	-121.9668

SNR=20

13287.46	7	0	1	-0.3994141
7493.615	23	0	2	-8.622070
10610.41	27	0	3	-1.783203
11725.79	13	0	4	-23.72266
7210.286	48	0	5	-12.21338
10113.91	32	0	6	-2.083008
4466.494	137	0	7	-1.114258
655.5355	90	0	8	-0.5143433
1010.064	246	0	9	-0.3877563
1015.905	108	0	10	-2.015564
9816.925	37	0	11	-1.977539
819.5394	72	0	12	-0.8530273
3015.395	205	0	13	-0.1999512
803.9548	151	0	14	-1.403320
12390.98	10	0	15	-42.08496
11044.88	15	0	16	-9.586914
11480.50	14	0	17	-6.288086
11577.62	14	0	18	-2.208008
9173.011	104	0	19	-2.038086
13720.08	12	0	20	-4.525391
6143.803	55	0	21	-7.516602
15616.61	3	0	22	-82.56641
5670.372	67	0	23	-6.190918
9559.143	26	0	24	-0.5341797
14600.79	6	0	25	-28.29590
11518.28	12	0	26	-4.037109
10869.12	28	0	27	-0.8203125
4094.992	79	0	28	-3.727051
6235.240	28	0	29	-13.81201
315.1109	95	0	30	-1.095306
9936.883	43	0	31	-4.241211
2190.015	198	0	32	-0.1506348
5126.535	231	0	33	0.3515625E-01
1795.718	188	0	34	-0.8679199
13080.18	7	0	35	-17.44434
12804.75	12	0	36	-12.01270
5466.964	41	0	37	-0.7822266
893.4382	313	0	38	-0.8099365E-01
345.9386	66	0	39	-2.120880
731.9552	164	0	40	-0.6497803
11109.94	17	0	41	-42.04688
9938.751	73	0	42	-0.4541016
11119.19	12	0	43	-18.35742
1257.447	453	0	44	-0.1579590
8094.549	116	0	45	-0.6694336
10636.22	19	0	46	-10.83301
2072.433	72	0	47	0.1147461E-01
13329.92	8	0	48	-33.79297
15025.49	5	0	49	-34.29492
12201.32	10	0	50	-30.08008

SNR = 30

12387.69	11	0	1	-2.732422
6610.577	36	0	2	-2.369629
8191.120	85	0	3	0.1123047E-01
10297.49	31	0	4	-22.71094
5713.351	73	0	5	-0.9746094
8143.379	78	0	6	-1.091309
2382.912	294	0	7	-1.202393
383.5834	141	0	8	-0.3851624
465.6938	329	0	9	-0.5233765E-01
654.1320	121	0	10	-0.9466553E-01
6994.798	93	0	11	-2.619141
493.8041	81	0	12	-3.031830
2432.872	277	0	13	-0.6599121
425.1472	217	0	14	-0.4929504
11630.30	13	0	15	-6.506836
9134.980	29	0	16	-2.684570
9688.483	32	0	17	-8.691406
10498.98	22	0	18	-2.256836
4942.977	274	0	19	-0.4829102
11959.35	27	0	20	-9.709961
3701.445	89	0	21	-3.484375
14568.64	7	0	22	-14.33105
4307.966	113	0	23	-2.833984
7224.814	54	0	24	-0.1162109
13307.45	11	0	25	-2.569336
9915.167	20	0	26	-2.055664
9656.320	56	0	27	-1.146484
4108.351	98	0	28	-1.691406
5360.852	42	0	29	-6.128418
178.4689	131	0	30	-0.5635223
6477.826	90	0	31	-6.152832
1350.637	269	0	32	-2.187134
4957.650	264	0	33	-2.670898
893.2999	219	0	34	-0.4016113
12217.85	11	0	35	-3.267578
11569.34	19	0	36	-6.381836
2708.479	176	0	37	-0.6013184
485.9681	398	0	38	0.7354736E-02
254.5505	89	0	39	-0.3668671
447.2129	192	0	40	-0.6123047
9831.774	27	0	41	-11.07324
6774.361	151	0	42	-1.374512
9181.601	24	0	43	-3.287109
865.5256	527	0	44	-0.3904419
4273.953	436	0	45	-0.5761719E-01
8861.335	40	0	46	-3.021484
980.1329	103	0	47	-0.3210449E-01
12416.99	12	0	48	-4.787109
13872.77	9	0	49	-33.32520
10785.66	18	0	50	-4.791016

SNR=40

11787.67	15	0	1	2 301758
6088.093	49	0	2	-2 384766
5980.963	286	0	3	0.4882813E-01
9895.440	41	0	4	0.1562500E-01
4531.432	128	0	5	-2.877930
6096.907	190	0	6	0.9765625E-03
1008.399	505	0	7	-0.4330444
309.0999	146	0	8	-0.2679443E-01
357.1975	254	0	9	-0.4711914E-01
434.6559	140	0	10	0.2868652E-01
3718.057	495	0	11	0.2685547E-01
286.7534	95	0	12	-0.6692505E-01
1905.564	319	0	13	-0.5587158
276.4796	282	0	14	0.1455688E-01
10800.06	33	0	15	-7.042969
8140.096	38	0	16	-6.594238
8746.259	44	0	17	-0.1269531E-01
9695.529	33	0	18	-0.8388672
2571.185	393	0	19	-0.3132324
10762.09	52	0	20	-2.463867
1903.885	199	0	21	-0.6137695
13625.78	11	0	22	-0.4130859
2096.458	306	0	23	-0.6228027
5950.299	74	0	24	-0.4111328
12373.12	16	0	25	-8.175781
8380.731	44	0	26	-4.468750
7633.820	251	0	27	-0.2368164
4199.981	128	0	28	-0.1196289
5018.195	57	0	29	-3.065430
164.3527	160	0	30	-0.3743896
5074.211	134	0	31	-1.136719
679.7376	381	0	32	-0.7739868
6722.920	93	0	33	-3.344238
541.5674	261	0	34	-0.2474365
11472.48	22	0	35	-0.9990234
10169.31	38	0	36	0.3906250E-01
1453.962	227	0	37	-0.2478027E-01
327.2321	464	0	38	-0.4418945E-01
221.1653	103	0	39	-0.1795197
349.3810	220	0	40	-0.5004883E-02
8892.230	40	0	41	-4.571289
5135.917	196	0	42	-0.3188477
7509.319	39	0	43	-1.228027
514.0090	581	0	44	0.4565430E-01
2557.845	546	0	45	0.3637695E-01
7671.144	70	0	46	-1.070313
610.1747	131	0	47	-0.6702881
11729.12	24	0	48	-0.5859375E-01
13079.03	11	0	49	-0.7294922
10187.92	22	0	50	-6.658203

SNR= 50

11082.97	28	0	1	-1.368164
5371.111	67	0	2	-0.1738281
5360.467	219	0	3	-0.2524414
9039.396	58	0	4	-5.928711
2907.745	383	0	5	-0.7480469
4824.830	298	0	6	-0.5908203E-01
956.4753	455	0	7	-0.2015381
219.3851	194	0	8	0.3616333E-01
268.9442	281	0	9	0.3378296E-01
335.8535	162	0	10	-0.1910400E-01
2315.310	709	0	11	-0.1406250
252.4814	114	0	12	0.3280640E-01
1866.180	302	0	13	-0.5539551
217.5393	346	0	14	-0.8041382E-02
9586.786	75	0	15	-0.1943359
7211.483	53	0	16	-9.677734
7890.863	57	0	17	0.0000000E+00
8994.461	51	0	18	-1.423828
1678.986	465	0	19	0.2221680E-01
8214.964	247	0	20	0.4687500E-01
1369.385	215	0	21	-0.8356934
12840.12	15	0	22	-2.297852
2300.208	248	0	23	-1.563477
3515.906	1009	0	24	-0.2978516E-01
11789.96	23	0	25	-6.875000
7071.784	74	0	26	-4.630859
5198.764	498	0	27	0.4394531E-02
4175.589	150	0	28	-0.2182617
4232.330	86	0	29	-0.2353516
133.6275	187	0	30	-0.2944946E-02
4457.335	155	0	31	-1.375488
587.4040	388	0	32	-0.2741089
5821.628	118	0	33	-0.5615234
340.3074	332	0	34	-0.3895874
10753.30	35	0	35	-2.731445
9394.570	47	0	36	-0.1601563
1028.197	257	0	37	-0.1928711
252.1362	557	0	38	-0.1831055E-03
172.7228	127	0	39	-0.4692078E-01
283.6513	261	0	40	0.1385498E-01
7968.894	56	0	41	-2.321289
3859.612	276	0	42	-0.2661133E-01
6140.367	56	0	43	-3.189941
433.6792	558	0	44	0.4379272E-01
1768.922	652	0	45	0.4882813E-03
6541.271	85	0	46	-0.3129883
397.4353	153	0	47	-0.2076111
10752.37	56	0	48	-0.8144531
12539.75	14	0	49	-2.511719
9636.151	29	0	50	-6.086914

SNR=60

10374.93	44	0	1	-0.1181641
4972.917	81	0	2	-1.709473
3735.193	295	0	3	-0.6677246
7433.423	87	0	4	-2.010254
2030.959	407	0	5	-0.9489746
3443.373	441	0	6	-0.2734375E-01
747.5515	481	0	7	-0.2136230E-02
187.0353	234	0	8	-0.2920074
197.3469	300	0	9	-0.6626892E-01
296.1530	173	0	10	-0.8508301E-01
1603.973	917	0	11	-0.4185791
159.8711	128	0	12	-0.2179718
1135.851	398	0	13	0.2026367E-01
182.0539	377	0	14	-0.5531311E-01
8390.240	111	0	15	-0.3369141
6664.556	63	0	16	-1.372070
6597.105	96	0	17	-2.724609
8222.968	72	0	18	-0.1132813
1224.292	513	0	19	0.2819824E-01
6117.647	417	0	20	-0.2001953
1335.257	155	0	21	-0.5579834
12317.86	18	0	22	-9.005859
1972.579	282	0	23	-0.3543701
2522.239	1061	0	24	0.2783203E-01
11288.70	29	0	25	-0.4033203
6081.049	81	0	26	-0.3408203
4087.651	448	0	27	-0.6860352E-01
5140.491	68	0	28	-1.150879
2440.479	295	0	29	-0.6013184
110.8860	210	0	30	-0.3386154
3720.373	199	0	31	-6.168701
414.6295	462	0	32	-0.4479370
4651.136	159	0	33	-0.9213867
247.7844	325	0	34	-0.2482452
4422.188	585	0	35	-0.1064453
8772.457	62	0	36	-0.3281250
627.2878	323	0	37	-0.5335083
258.8353	478	0	38	0.1214600E-01
157.9417	149	0	39	-0.6248932
295.5898	220	0	40	0.4562378E-01
7159.773	73	0	41	-1.861328
3029.280	296	0	42	-0.1494141
4325.420	185	0	43	0.3125000E-01
284.1585	697	0	44	0.6866455E-02
1142.435	845	0	45	0.3491211E-01
5976.710	118	0	46	-0.8886719
297.3314	178	0	47	-0.4648132
5843.591	657	0	48	0.2490234E-01
12061.65	16	0	49	-0.2724609
9081.037	34	0	50	-4.267578

SNR = 69

9689.973	61	0	1	-7.851563
4483.485	100	0	2	-1.737305
2716.131	451	0	3	-0.2258301
7451.832	92	0	4	-2.312988
1476.212	534	0	5	-0.4067383
2358.927	670	0	6	-0.8837891E-01
481.9648	663	0	7	-0.2214050
172.6035	221	0	8	-0.2754211E-01
165.1115	314	0	9	-0.3831482E-01
277.5292	182	0	10	-0.8514404E-01
1239.993	1086	0	11	-0.1184082E-01
133.9118	139	0	12	-0.3916321
507.2729	583	0	13	-0.4658508
159.3566	412	0	14	-0.5523682E-01
6951.711	168	0	15	-0.4863281
6306.073	74	0	16	-0.6630859
5492.692	154	0	17	-0.3647461
7339.929	94	0	18	-0.3222656E-01
904.9886	606	0	19	-0.1614990
4557.157	523	0	20	-0.3686523
1015.270	173	0	21	-0.1965332
11870.78	20	0	22	-4.783203
1341.943	312	0	23	-0.2115479
1816.264	1288	0	24	0.3173828E-01
8192.289	456	0	25	-0.2529297
4292.329	323	0	26	-0.3872070
2861.369	626	0	27	-0.1923828
4666.901	77	0	28	-1.127930
2240.140	302	0	29	0.3637695E-01
103.7801	244	0	30	-0.1008606E-01
3781.328	215	0	31	-0.6201172E-01
390.2868	569	0	32	-0.1833801
3872.286	188	0	33	-0.4450684
224.4448	332	0	34	-0.7690430E-01
4340.701	542	0	35	0.2587891E-01
8085.492	85	0	36	-0.3520508
557.2217	311	0	37	-0.1235962
226.4591	505	0	38	0.2618408E-01
151.7655	167	0	39	-0.2017822
255.0633	247	0	40	-0.1342926
6466.236	89	0	41	-1.082031
2066.136	397	0	42	-0.2014160
3162.085	266	0	43	-0.7202148E-01
403.5686	505	0	44	0.3091431E-01
956.0456	758	0	45	0.1586914E-02
5453.918	125	0	46	-0.6821289
210.0046	195	0	47	-0.4505920
5282.215	635	0	48	0.4345703E-01
11715.26	19	0	49	-4.332031
8630.121	45	0	50	-0.3027344E-01

SNR=79

8953.479	77	0	1	-0.3183594
4141.956	128	0	2	-0.3344727
2029.534	570	0	3	-0.1314697
6693.671	107	0	4	-0.6684570
1172.200	546	0	5	0.2172852E-01
1899.266	770	0	6	-0.1298828
269.6232	759	0	7	-0.1184082
161.1774	233	0	8	0.1138306E-01
142.7545	332	0	9	0.1101685E-01
237.6116	213	0	10	0.4425049E-03
1016.011	1127	0	11	0.3704834E-01
145.8598	139	0	12	-0.2104187
770.1638	458	0	13	-0.1484985
150.6387	471	0	14	-0.6819153E-01
6189.304	184	0	15	-1.296387
5424.584	103	0	16	0.1464844E-01
5326.877	113	0	17	-0.6840820
6706.651	110	0	18	-0.5380859
772.7823	589	0	19	-0.3887939E-01
3548.542	592	0	20	-0.3798828
785.4571	194	0	21	-0.4654541
11534.98	24	0	22	-0.5927734
838.0384	475	0	23	-0.2081299E-01
1446.195	1388	0	24	0.2502441E-01
6570.474	514	0	25	-0.6206055
3408.489	414	0	26	-0.8447266
2314.925	700	0	27	-0.3002930
4396.326	85	0	28	-1.999512
1839.277	337	0	29	-0.5195313
93.49227	257	0	30	-0.1625900
3311.982	215	0	31	-0.5095215
304.0497	593	0	32	-0.1358643
3251.484	217	0	33	-1.922852
193.3011	373	0	34	-0.6747437E-01
4281.479	625	0	35	-0.1806641E-01
7196.013	110	0	36	-0.4960938
766.0446	165	0	37	-0.1060791
192.1942	553	0	38	0.2926636E-01
144.9148	181	0	39	-0.8572388E-01
225.6593	268	0	40	-0.1717682
5747.710	120	0	41	-0.8349609E-01
2012.985	465	0	42	0.5859375E-02
2509.787	286	0	43	-0.1081543
244.0422	677	0	44	0.2149963E-01
697.1861	884	0	45	0.4370117E-01
4562.327	162	0	46	-0.7456055
171.6312	213	0	47	-0.6475830E-01
4778.354	680	0	48	-0.2290039
11399.76	21	0	49	-0.2773438
8329.031	51	0	50	0.3906250E-01

SNR=88

8310.877	89	0	1	-0.4521484
2612.044	451	0	2	-0.1130371
1923.786	519	0	3	0.3295898E-02
5818.965	155	0	4	-2.696289
969.4393	518	0	5	-0.7733154E-01
1662.943	775	0	6	-0.1739502
363.8427	650	0	7	-0.4327393E-01
140.9773	260	0	8	0.1196289E-01
133.1653	355	0	9	-0.6236267E-01
223.8058	217	0	10	-0.2861023E-01
811.8071	1225	0	11	-0.2148438E-01
133.1296	153	0	12	-0.1960754
567.6656	453	0	13	0.4046631E-01
143.4747	475	0	14	-0.4100037E-01
5095.032	241	0	15	-0.1411133
4784.985	134	0	16	0.1953125E-01
4623.177	154	0	17	-0.7392578
6035.088	129	0	18	-0.3374023
530.1218	759	0	19	-0.8300781E-01
2806.404	659	0	20	-0.5273438E-01
648.4249	214	0	21	-0.4199219
11221.85	28	0	22	-1.220703
588.5053	519	0	23	-0.2055664
1202.992	1233	0	24	0.2050781E-01
5422.692	646	0	25	-0.6152344E-01
2766.538	443	0	26	-0.2438965
1820.197	745	0	27	0.2795410E-01
4068.828	99	0	28	-0.9667969E-01
1738.055	397	0	29	-0.6691895
95.31499	271	0	30	-0.5035400E-03
2639.739	302	0	31	-0.1694336
262.3385	583	0	32	-0.1298828
2834.699	244	0	33	-0.4750977
150.9152	388	0	34	0.2273560E-02
4258.284	753	0	35	-0.3417969E-02
6386.656	134	0	36	-0.7080078
625.2742	183	0	37	-0.2684937
177.8367	557	0	38	-0.1548767E-01
139.3693	197	0	39	0.3013611E-01
203.0693	289	0	40	0.4049683E-01
4608.591	360	0	41	-0.3764648
1550.956	491	0	42	-0.9375000E-01
1939.669	320	0	43	0.1342773E-02
292.6205	608	0	44	-0.7186890E-01
542.7719	1037	0	45	0.3930664E-01
4427.715	203	0	46	-0.6132813
143.3404	238	0	47	-0.1866150E-01
6223.495	228	0	48	-0.9521484E-01
10988.33	45	0	49	-0.6640625
8097.312	60	0	50	-3.257324

SNR=98

7455.700	118	0	1	-1.234863
1981.383	571	0	2	0.1635742E-01
1695.413	593	0	3	-0.2391357
5834.973	189	0	4	-1.283203
802.5924	605	0	5	-0.2499390
1363.247	751	0	6	0.3442383E-01
293.9508	655	0	7	0.6774902E-02
138.0996	270	0	8	-0.2236938E-01
120.8074	364	0	9	-0.2525330E-02
217.7174	246	0	10	-0.1695251E-01
700.5664	1263	0	11	0.3552246E-01
108.6913	167	0	12	-0.3270721
345.6177	678	0	13	-0.3839111E-01
135.5540	515	0	14	0.4600525E-01
4605.958	254	0	15	-0.3164063
4447.122	147	0	16	-3.959961
4172.950	203	0	17	0.1220703E-01
4604.688	467	0	18	-0.1123047
438.7867	815	0	19	-0.4302979E-02
2283.772	718	0	20	-0.9033203E-02
561.4057	230	0	21	-0.3505249
10887.34	36	0	22	-0.8144531
734.6487	510	0	23	-0.4036255
966.7583	1247	0	24	0.2508545E-01
4821.969	604	0	25	-0.3061523
2735.656	427	0	26	0.4638672E-02
1514.881	778	0	27	0.1953125E-02
3883.856	103	0	28	-0.9099121
1684.475	331	0	29	0.1196289E-01
92.72151	293	0	30	-0.7060242E-01
2257.583	360	0	31	-0.3640137
231.4041	669	0	32	-0.7856750E-01
2473.912	257	0	33	-0.5214844
150.5818	390	0	34	0.3602600E-01
4272.018	744	0	35	0.3173828E-01
5959.505	160	0	36	-0.3549805
529.0435	191	0	37	0.3887939E-01
165.0999	610	0	38	0.3569031E-01
133.9268	217	0	39	-0.3239441E-01
188.1292	308	0	40	-0.6616211E-01
3974.953	360	0	41	-0.9765625E-01
1507.165	428	0	42	-0.3393555E-01
1623.185	364	0	43	-0.1220703E-03
284.2206	606	0	44	0.2166748E-01
445.4722	1126	0	45	0.3070068E-01
3932.502	213	0	46	-0.1501465
134.6271	254	0	47	-0.1182556
5341.394	268	0	48	-0.4648438
10384.03	87	0	49	-0.1699219
7870.304	64	0	50	-1.996582

SNR≈108

6970.548	141	0	1	-0.8725586
1662.402	604	0	2	-0.5151367E-01
1244.500	664	0	3	-0.3100586
5065.923	216	0	4	0.1025391E-01
640.3271	644	0	5	0.4345703E-01
1068.512	811	0	6	0.2368164E-01
183.1743	790	0	7	0.5035400E-02
118.4941	280	0	8	0.2709198E-01
117.7465	375	0	9	0.3818512E-01
210.1709	243	0	10	0.1472473E-01
688.3453	1358	0	11	0.1879883E-01
90.06785	177	0	12	-0.1125793
575.0732	488	0	13	-0.1040039
127.9320	524	0	14	0.4486084E-01
4199.059	281	0	15	-0.8378906
4133.717	156	0	16	-0.1904297E-01
3780.172	246	0	17	-0.4304199
4050.787	474	0	18	-0.5834961E-01
426.9803	774	0	19	-0.3030396E-01
1918.522	766	0	20	0.1501465E-01
471.8177	242	0	21	0.2545166E-01
10515.02	59	0	22	-0.1171875E-01
627.0608	516	0	23	-0.1543579
828.1987	1446	0	24	0.4302979E-01
3702.925	782	0	25	-0.8447266E-01
2423.497	414	0	26	-0.3002930E-01
1236.881	769	0	27	-0.1477051E-01
3614.089	114	0	28	-0.1833496
1043.483	496	0	29	-0.8544922E-03
91.44553	302	0	30	0.4886627E-01
1763.303	331	0	31	-0.9989014
210.5541	710	0	32	0.3094482E-01
2098.761	277	0	33	-0.2441406E-03
142.7265	384	0	34	0.3323364E-01
4237.600	708	0	35	-0.8300781E-02
5486.610	171	0	36	-0.2958984
467.3614	207	0	37	-0.9155273E-04
155.8003	625	0	38	0.3454590E-01
147.8253	196	0	39	-0.1573181
178.0852	324	0	40	0.1785278E-01
3263.129	446	0	41	-0.3635254
1065.520	624	0	42	-0.2469482
1341.960	412	0	43	0.4956055E-01
254.0229	552	0	44	-0.4913330E-02
399.3463	1054	0	45	0.4949951E-01
2875.727	395	0	46	0.3735352E-01
108.6977	270	0	47	0.2106476E-01
4635.799	303	0	48	0.4882813E-01
9673.244	131	0	49	-0.8066406
7282.134	82	0	50	-2.195313

SNR = 118

6217.252	159	0	1	-0.2553711
1629.051	676	0	2	-0.1093750
947.9904	811	0	3	-0.1037598
4884.596	219	0	4	-0.2294922E-01
580.9259	694	0	5	-0.4260254E-01
857.5873	863	0	6	-0.8850098E-02
211.3666	658	0	7	-0.5381775E-01
112.8633	298	0	8	-0.1775970
109.8853	397	0	9	0.2265930E-02
238.3354	219	0	10	-0.5661011E-02
514.2563	1444	0	11	0.3210449E-01
84.02280	189	0	12	-0.2132950
557.8589	508	0	13	-0.5920410E-02
127.6655	533	0	14	0.3440094E-01
3955.581	282	0	15	-0.3564453E-01
3644.578	251	0	16	-0.2592773
3004.065	311	0	17	-0.4418945E-01
3262.993	697	0	18	0.4003906E-01
364.4496	864	0	19	0.2478027E-01
1603.772	816	0	20	0.1794434E-01
381.7307	263	0	21	-0.2116089
9877.271	111	0	22	0.9765625E-02
418.9650	572	0	23	-0.1785278E-01
677.2011	1605	0	24	0.4925537E-01
2916.775	901	0	25	0.2197266E-02
1356.394	853	0	26	-0.8532715E-01
1110.731	808	0	27	0.2697754E-01
3440.988	129	0	28	-0.2590332
656.7145	673	0	29	0.3833008E-01
131.3890	264	0	30	-0.5575562E-01
1505.027	344	0	31	-0.2316895
209.7995	696	0	32	-0.3868103E-01
1803.494	297	0	33	-0.5301514
176.9231	341	0	34	0.1268005E-01
4205.804	721	0	35	-0.1513672E-01
5037.382	203	0	36	-0.8740234E-01
434.2062	219	0	37	0.3610229E-01
148.4209	630	0	38	0.4301453E-01
151.0170	209	0	39	0.1173401E-01
168.9248	338	0	40	-0.7781982E-02
2751.090	475	0	41	-0.7812500E-02
980.9355	626	0	42	0.4858398E-01
1192.121	379	0	43	-0.5456543E-01
212.7056	655	0	44	0.4867554E-01
355.8380	1082	0	45	0.2587891E-01
2665.146	379	0	46	-0.1489258E-01
101.7244	300	0	47	-0.2376556E-01
3990.899	328	0	48	-0.3525391
8831.945	174	0	49	-0.4824219
6703.302	95	0	50	-2.098145

SNR=128

6219.208	159	0	1	-1.071777
1391.769	648	0	2	-0.1008301
901.0778	752	0	3	-0.5102539E-01
4253.940	230	0	4	-0.8203125E-01
434.2947	725	0	5	-0.2304077E-01
760.9100	898	0	6	0.3515625E-01
211.0490	743	0	7	0.4803467E-01
96.62879	315	0	8	-0.8312225E-01
110.4692	396	0	9	0.4409790E-01
217.5987	235	0	10	-0.2486115
459.6951	1549	0	11	0.9521484E-02
77.41313	197	0	12	-0.1352463
229.1529	789	0	13	0.8255005E-02
121.9967	569	0	14	0.4948425E-01
3305.920	308	0	15	-1.088379
3801.895	174	0	16	-0.2006836
2560.347	417	0	17	-0.1369629
2784.495	780	0	18	0.4125977E-01
324.7407	902	0	19	0.3067017E-01
1375.031	887	0	20	0.4943848E-01
372.1323	279	0	21	-0.2932739
9337.582	129	0	22	-0.5371094E-01
391.0303	606	0	23	-0.1136780
586.7220	1564	0	24	0.3869629E-01
2817.712	876	0	25	0.3295898E-01
1465.941	772	0	26	-0.3549805
941.1183	926	0	27	0.3820801E-01
3214.254	150	0	28	-0.6079102E-01
686.7628	631	0	29	-0.1062012
119.8471	278	0	30	-0.2413788
1574.048	441	0	31	-0.4248047E-01
200.4359	709	0	32	0.3173828E-01
1715.345	306	0	33	-0.1835938
167.0241	356	0	34	-0.3417969E-02
5739.326	166	0	35	-0.5029297
4598.569	225	0	36	-0.8974609
361.1542	233	0	37	-0.7373047E-01
141.3857	671	0	38	0.2769470E-01
135.8455	219	0	39	-0.1031494E-01
161.0885	354	0	40	0.1519775E-01
2371.827	505	0	41	0.4565430E-01
966.5793	618	0	42	-0.1464844E-01
1012.141	490	0	43	0.2996826E-01
206.1678	648	0	44	0.3961182E-01
312.8195	1049	0	45	0.3848267E-01
2100.500	430	0	46	0.4589844E-01
97.85659	308	0	47	0.2960968E-01
3517.941	349	0	48	-0.1450195
7974.403	231	0	49	-0.5371094E-01
6463.950	102	0	50	-1.728027

SNR = 138

5437.322	199	0	1	-0.3125000E-01
1241.763	636	0	2	-0.3173828E-02
899.3762	724	0	3	-0.1320190
4357.390	281	0	4	-0.2685547E-01
423.6870	785	0	5	-0.4513550E-01
678.3036	892	0	6	0.4278564E-01
210.0582	671	0	7	0.1239014E-01
92.83072	331	0	8	0.2235413E-02
104.3342	406	0	9	0.3610992E-01
210.9229	247	0	10	-0.3764343E-01
384.0494	1711	0	11	0.3753662E-01
74.43938	203	0	12	0.1744843E-01
158.1701	762	0	13	0.5661011E-02
117.8880	584	0	14	0.2955627E-01
3050.605	321	0	15	-0.3803711
3143.759	302	0	16	-0.7756348
2359.035	416	0	17	-0.3078613
2466.532	724	0	18	-0.8496094E-01
271.8938	987	0	19	0.3103638E-01
1168.431	913	0	20	-0.1904297E-01
281.0707	286	0	21	-0.3457642
8204.594	315	0	22	-0.1494141
405.5789	633	0	23	0.1800537E-01
559.8490	1466	0	24	0.2648926E-01
2315.374	1116	0	25	0.3442383E-01
1130.793	933	0	26	-0.2344971
827.7775	922	0	27	0.3649902E-01
3066.774	163	0	28	0.4003906E-01
672.9080	557	0	29	-0.8404541E-01
145.0175	267	0	30	-0.2006531E-01
1260.972	489	0	31	-0.4227295
193.5134	679	0	32	0.4011536E-01
1382.854	349	0	33	-0.2913818
151.9236	366	0	34	0.2246094E-01
5245.367	182	0	35	-0.2543945
3426.643	502	0	36	-0.3447266
355.9297	247	0	37	0.3619385E-01
140.2664	668	0	38	0.2233887E-01
125.3397	219	0	39	-0.8588409E-01
185.3812	320	0	40	0.3210449E-01
2092.369	562	0	41	-0.1093750
705.3862	690	0	42	-0.2589111
869.4293	430	0	43	-0.6683350E-01
196.9959	651	0	44	0.4045105E-01
271.9697	1096	0	45	0.4821777E-01
1982.350	448	0	46	-0.4345703E-01
96.93374	319	0	47	0.4560089E-01
3047.676	368	0	48	-0.2880859E-01
7216.985	298	0	49	-0.1225586
6367.529	113	0	50	-1.529297

SNR=148

5003.825	287	0	1	-0.4086914
1146.772	621	0	2	0.8178711E-02
739.0062	801	0	3	0.1135254E-01
3715.315	296	0	4	-0.2475586
453.0964	713	0	5	0.3460693E-01
615.3016	826	0	6	0.4241943E-01
163.2728	837	0	7	0.4386902E-01
69.88459	348	0	8	-0.1634979E-01
100.6730	419	0	9	0.2519989E-01
195.6712	259	0	10	-0.2674103
382.5636	1461	0	11	0.1947021E-01
70.47127	213	0	12	0.2744293E-01
317.3933	528	0	13	-0.3024292E-01
116.7464	580	0	14	0.8964539E-02
2880.073	345	0	15	-0.3100586E-01
2368.094	367	0	16	-0.2004395
2120.817	439	0	17	-0.1228027
2172.856	779	0	18	-0.2133789
232.6406	987	0	19	0.3544617E-01
1012.245	922	0	20	0.4992676E-01
297.0164	298	0	21	-0.2983093
6081.109	967	0	22	0.3417969E-01
368.2046	551	0	23	0.2261353E-01
499.5285	1413	0	24	0.4513550E-01
2143.960	983	0	25	0.2636719E-01
1207.155	747	0	26	-0.3725586
753.9807	914	0	27	0.4113770E-01
2870.083	203	0	28	-0.4907227E-01
684.6075	587	0	29	-0.1589355
117.1880	280	0	30	0.3653717E-01
922.1492	503	0	31	-0.2675781
172.5676	789	0	32	0.6835938E-02
1257.983	342	0	33	-0.2126465
147.7612	358	0	34	0.1084900E-01
4872.777	194	0	35	-0.5859375E-02
3721.160	253	0	36	-0.1123047E-01
325.1910	262	0	37	-0.2966919
134.7065	680	0	38	0.4405212E-01
120.8177	229	0	39	-0.3810120E-01
170.5905	335	0	40	-0.2815247E-01
1854.753	577	0	41	0.4187012E-01
628.6064	729	0	42	0.3497314E-01
772.5860	427	0	43	0.3918457E-01
190.3668	666	0	44	0.1750183E-01
249.5860	1053	0	45	0.4966736E-01
1570.133	657	0	46	-0.7690430E-02
91.13358	332	0	47	0.1509094E-01
2755.628	400	0	48	-0.3911133
5931.199	552	0	49	0.8789063E-02
6006.536	126	0	50	-1.646484

APPENDIX D

PHAES SHIFT MIGRATION PROGRAM

```
C         DELTA X=4 METER,DELTA T=4mSEC
          COMPLEX CP(256,64),XIMAGE(256,66),CWORK(64),TEM(64)
          COMPLEX ZKZ(256,64),CC,F,U(256,64),HK(256)
          DIMENSION H(256),C(256,64)
          REAL DT,DX,V,PI,XKX,W,TA,B,DIV,SKX
          NT=256
          NX=64
          DT=0.004
          DX=4.
          PI=3.14159265
          V=1000.
          DO 5 I=1,NT
          DO 5 J=1,NX
          CP(I,J)=0.
5         ZKZ(I,J)=0.

C         CP(32,32)=(1.,0.)

          DO 270 I=1,NX
          DO 270 J=1,NT
270       READ(101,*)CP(J,I)
```

```
      CALL FT2D(NT,NX,CP,1.,-1.,CWORK)

      DO 998 ITAU=1,NT

      DO 212 I=1,NT
      DO 212 J=1,NX
212   U(I,J)=CP(I,J)
      TA=ITAU*DT

      DO 333 IKX=1,NX

      XKX=((2.*PI*(IKX-1))/(NX*DX))
      IF(IKX.GT.NX/2) XKX=(2.*PI/DX-XKX)
      SKX=XKX*XKX
      XIMAGE(ITAU,IKX)=0.
      DO 444 IW=1,NT

      W=((2.*PI*(IW-1))/(NT*DT))
      IF(IW.GT.NT/2) W=(2.*PI/DT-W)

      IF(ITAU.GT.1) GO TO 111

      DIV=(W/V)**2

      IF(DIV.LT.SKX) GO TO 444

      B=SQRT(DIV-SKX)
      ZKZ(IW,IKX)=(0.,-1.)*B*V

111   IF(ZKZ(IW,IKX).EQ.0) GO TO 444

      CC=CEXP(ZKZ(IW,IKX)*TA)
      U(IW,IKX)=U(IW,IKX)*CC
      XIMAGE(ITAU,IKX)=XIMAGE(ITAU,IKX)+U(IW,IKX)

444   CONTINUE
333   CONTINUE

      DO 995 J=1,NX
995   TEM(J)=XIMAGE(ITAU,J)

      CALL FORK(NX,TEM,1.)

      DO 994 I=1,NX
994   XIMAGE(ITAU,I)=TEM(I)
998   TYPE*,ITAU

      XMAX=REAL(XIMAGE(1,1))
      WRITE(104,2)((REAL(XIMAGE(I,J)),I=1,NT),J=1,NX)
      DO 667 I=1,NT
      DO 666 J=1,NX
```

```
        C(I,J)=REAL(XIMAGE(I,J))
        T=REAL(XIMAGE(I,J))
        IF(XMAX.LT.T) XMAX=T
666     CONTINUE
667     CONTINUE

        TYPE*,XMAX
        WRITE(105,*) XMAX

        DO 631 I=1,NT
        DO 631 J=1,NX
631     C(I,J)=C(I,J)/XMAX

        DO 659 I=1,NX
        DO 658 J=1,NT,8
        WRITE(106,3)C(J,I),C(J+1,I),C(J+2,I),
     1  C(J+3,I),C(J+4,I),C(J+5,I),
     1  C(J+6,I),C(J+7,I)
  2     FORMAT(G)
  3     FORMAT(8(F10.7))
658     CONTINUE
659     CONTINUE

364     END

        SUBROUTINE FT2D(N1,N2,CP,SIGN1,SIGN2,CWORK)
        COMPLEX CP(N1,N2),CWORK(N2)
        INTEGER N1,N2
        REAL SIGN1,SIGN2
        DO 11 I2=1,N2
11      CALL FORK(N1,CP(1,I2),SIGN1)
        DO 22 I1=1,N1
        DO 23 I2=1,N2
23      CWORK(I2)=CP(I1,I2)
        CALL FORK(N2,CWORK,SIGN2)
        DO 24 I2=1,N2
24      CP(I1,I2)=CWORK(I2)
22      CONTINUE
        RETURN
        END

        SUBROUTINE FORK(LX,CX,SIGNI)
        COMPLEX CARG,CW,CEXP,CTEMP,CX(LX)
        J=1
        SC=SQRT(1./LX)
        DO 30 I=1,LX
        IF(I.GT.J) GO TO 10
        CTEMP=CX(J)*SC
        CX(J)=CX(I)*SC
        CX(I)=CTEMP
 10     M=LX/2
 20     IF(J.LE.M)GO TO 30
```

```
        J=J-M
        M=M/2
        IF(M.GT.1)GO TO 20
 30     J=J+M
        L=1
 40     ISTEP=2*L
        DO 50 M=1,L
        CARG=(0.,1.)*(3.14159265*SIGNI*(M-1))/L
        CW=CEXP(CARG)
        DO 50 I=M,LX,ISTEP
        CTEMP=CW*CX(I+L)
        CX(I+L)=CX(I)-CTEMP
 50     CX(I)=CX(I)+CTEMP
        L=ISTEP
        IF(L.LT.LX) GO TO 40
        RETURN
        END
```

PHASE SHIFT MODELING PROGRAM

```
C       DELTA X=4 METER,DELTA T=4mSEC
        COMPLEX CP(256,64),XIMAGE(256,64),CWORK(64),TEM(64)
        COMPLEX ZKZ(256,64),U(256,64)
        COMPLEX CC,F
        DIMENSION C(256,64)
        REAL DT,DX,V,PI,XKX,W,TA,B,DIV,SKX
        NT=256
        NX=64
        DT=0.004
        DX=4.
        DZ=4.
        PI=3.4159265
        V=1000.

        VTC=V*0.001

        DO 5 I=1,NT
        DO 5 J=1,NX
        XIMAGE(I,J)=0.
        U(I,J)=0.
 5      ZKZ(I,J)=0.
        XIMAGE(32,32)=(1.,0.)
 2      FORMAT(G)
```

C-12

```
      WRITE(100,2)((REAL(XIMAGE(I,J)),I=1,NT),J=1,NX)

      DO 125 K=1,NT
      DO 123 J=1,NX
123   TEM(J)=XIMAGE(K,J)
      CALL FORK(NX,TEM,-1.)
      DO 124 I=1,NX
124   XIMAGE(K,I)=TEM(I)
125   CONTINUE

      DO 555 IZ=1,NT

      DO 444 IW=1,NT
      W=((2.*PI*(IW-1))/(NT*DT))
      IF(IW.GT.NT/2) W=-1.*(2.*PI/DT-W)

      DO 333 IKX=1,NX
      XKX=((2.*PI*(IKX-1))/(NX*DX))
      IF(IKX.GT.NX/2) XKX=-1.*(2.*PI/DX-XKX)
      SKX=XKX*XKX
      IF(ABS(XKX).GT.ABS(W/V)) GO TO 333

120   IF(DZ.GT.VTC) GO TO 129
      ZOVTC2=(DZ/VTC)**2
126   SINE=SQRT(1.-ZOVTC2)
127   IF(ABS(V*XKX).GT.ABS(W*SINE)) GO TO 129
128   APR=1.
      GO TO 131
129   APR=0.

      IF(IZ.GT.1) GO TO 130

131   DIV=(W/V)**2
      B=SQRT(DIV-SKX)
      ZKZ(IW,IKX)=(0.,1.)*B

130   IF(ZKZ(IW,IKX).EQ.0) GO TO 333

      CC=CEXP(ZKZ(IW,IKX)*DZ)
      U(IW,IKX)=U(IW,IKX)*CC+APR*XIMAGE(NT+1-IZ,IKX)

333   CONTINUE
444   CONTINUE
555   TYPE*,IZ

      CALL FT2D(NT,NX,U,-1.,1.,CWORK)

      WRITE(101,2)((REAL(U(I,J)),I=1,NT),J=1,NX)
      XMAX=REAL(U(1,1))
      DO 667 I=1,NT
      DO 666 J=1,NX
      C(I,J)=REAL(U(I,J))
```

```
      T=REAL(U(I,J))
      IF(XMAX.LT.T) XMAX=T
666   CONTINUE
667   CONTINUE

      TYPE*,XMAX
      WRITE(102,*) XMAX

      DO 999 I=1,NT
      DO 999 J=1,NT
999   C(I,J)=C(I,J)/XMAX


      DO 659 I=1,NX
      DO 658 J=1,NT,8
      WRITE(103,3)C(J,I),C(J+1,I),C(J+2,I),
     1 C(J+3,I),C(J+4,I),C(J+5,I),
     1 C(J+6,I),C(J+7,I)
3     FORMAT(8(F10.7))
658   CONTINUE
659   CONTINUE

364   END

      SUBROUTINE FT2D(N1,N2,CP,SIGN1,SIGN2,CWORK)
      COMPLEX CP(N1,N2),CWORK(N2)
      INTEGER N1,N2
      REAL SIGN1,SIGN2
      DO 11 I2=1,N2
11    CALL FORK(N1,CP(1,I2),SIGN1)
      DO 22 I1=1,N1
      DO 23 I2=1,N2
23    CWORK(I2)=CP(I1,I2)
      CALL FORK(N2,CWORK,SIGN2)
      DO 24 I2=1,N2
24    CP(I1,I2)=CWORK(I2)
22    CONTINUE
      RETURN
      END

      SUBROUTINE FORK(LX,CX,SIGNI)
      COMPLEX CARG,CW,CEXP,CTEMP,CX(LX)
      J=1
      SC=SQRT(1./LX)
      DO 30 I=1,LX
      IF(I.GT.J) GO TO 10
      CTEMP=CX(J)*SC
      CX(J)=CX(I)*SC
      CX(I)=CTEMP
10    M=LX/2
20    IF(J.LE.M)GO TO 30
      J=J-M
```

```
         M=M/2
         IF(M.GT.1)GO TO 20
30       J=J+M
         L=1
40       ISTEP=2*L
         DO 50 M=1,L
         CARG=(0.,1.)*(3.14159265*SIGNI*(M-1))/L
         CW=CEXP(CARG)
         DO 50 I=M,LX,ISTEP
         CTEMP=CW*CX(I+L)
         CX(I+L)=CX(I)-CTEMP
50       CX(I)=CX(I)+CTEMP
         L=ISTEP
         IF(L.LT.LX) GO TO 40
         RETURN
         END
```

STOLT OR F-K MIGRATION PROGRAM WITH LINEAR INTERPOLATION

```
         COMPLEX CP(256,64)
         DIMENSION C(256,64)
C        NX IS COLOUMN AND NT ROW
         NX=64
         NT=256
         VDTODX=1./4.

         DO 999 I=1,NT
         DO 999 J=1,NX
999      CP(I,J)=0.

C        CP(32,33)=1.
C        CP(32,9)=1.
C        CP(64,17)=1.
         CP(128,33)=(1.,0.)

C        WRITE(102,991)((REAL(CP(I,J)),I=1,NT),J=1,NX)
991      FORMAT(G)

         CALL STOLT(NT,NX,CP,VDTODX)
```

```
      XMAX=REAL(CP(1,1))
      DO 11 I=1,NT
      DO 11 J=1,NX
      T=REAL(CP(I,J))
      C(I,J)=T
11    IF(XMAX.LT.T) XMAX=T

      TYPE*,'XMAX=',XMAX

      DO 14 I=1,NX
      DO 13 J=1,NT,8
      WRITE(104,12)C(J,I),C(J+1,I),C(J+2,I),C(J+3,I),
     1 C(J+4,I),C(J+5,I),C(J+6,I),C(J+7,I)
12    FORMAT(8(F10.7))
13    CONTINUE
14    CONTINUE
      END

      SUBROUTINE STOLT(NT,NX,CP,VDTODX)
      COMPLEX CP(NT,NX),CBF(10000)
      INTEGER IKX,NX,NT,NTH,IKTAU,IOM
      REAL OM,VKX,WL,WH,AKTAU,PI,PIONTH,VDTODX
      PI=3.14149265
      NTH=NT/2
      PIONTH=PI/NTH
      CALL FT2D(NT,NX,CP,1.,-1.,CBF)
      DO 888 IKX=1,NX
      VKX=((IKX-1)*2.*PI*VDTODX)/NX
      IF(IKX.GT.NX/2)VKX=2.*PI*VDTODX-VKX
      CBF(1)=0.
      CBF(NT+1)=0.
      DO 887 IOM=1,NT
887   CBF(IOM)=CP(IOM,IKX)
      CP(1,IKX)=0.
      DO 886 IKTAU=2,NTH+1
      AKTAU=(IKTAU-1.01)*PIONTH
      OM=SQRT(AKTAU*AKTAU+VKX*VKX)
      IOM=1+OM/PIONTH
      IF(IOM.LT.NTH)GOTO 500
      CP(IKTAU,IKX)=0.
      GOTO 886
500   WL=IOM-OM/PIONTH
      WH=1.-WL

      CP(IKTAU,IKX)=WL*CBF(IOM)+WH*CBF(IOM+1)
      CP(NT-IKTAU+2,IKX)=WL*CBF(NT-IOM+2)+WH*CBF(NT-IOM+1)
886   CONTINUE
888   CONTINUE
      CALL FT2D(NT,NX,CP,-1.,1.,CBF)
      RETURN
      END
```

```
      SUBROUTINE FT2D(N1,N2,CP,SIGN1,SIGN2,CWORK)
      COMPLEX CP(N1,N2),CWORK(N2)
      INTEGER N1,N2
      REAL SIGN1,SIGN2
      DO 11 I2=1,N2
11    CALL FORK(N1,CP(1,I2),SIGN1)
      DO 22 I1=1,N1
      DO 23 I2=1,N2
23    CWORK(I2)=CP(I1,I2)
      CALL FORK(N2,CWORK,SIGN2)
      DO 24 I2=1,N2
24    CP(I1,I2)=CWORK(I2)
22    CONTINUE
      RETURN
      END

      SUBROUTINE FORK(LX,CX,SIGNI)
      COMPLEX CARG,CW,CEXP,CTEMP,CX(LX)
      J=1
      SC=SQRT(1./LX)
      DO 30 I=1,LX
      IF(I.GT.J) GO TO 10
      CTEMP=CX(J)*SC
      CX(J)=CX(I)*SC
      CX(I)=CTEMP
10    M=LX/2
20    IF(J.LE.M)GO TO 30
      J=J-M
      M=M/2
      IF(M.GT.1)GO TO 20
30    J=J+M
      L=1
40    ISTEP=2*L
      DO 50 M=1,L
      CARG=(0.,1.)*(3.14159265*SIGNI*(M-1))/L
      CW=CEXP(CARG)
      DO 50 I=M,LX,ISTEP
      CTEMP=CW*CX(I+L)
      CX(I+L)=CX(I)-CTEMP
50    CX(I)=CX(I)+CTEMP
      L=ISTEP
      IF(L.LT.LX) GO TO 40
      RETURN
      END
```

VITA

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