NASA TECHNICAL NOTE

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TELEMETRY DATA FRAME READOUT SYSTEM

by Charles E. Cote

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Greenbelt, Md.

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ABSTRACT

A visual numeric oscilloscope screen display of conveniently formatted data bits provides a unique and practical means of monitoring large quantities of digital information. Ones and zeros are represented numerically by specific Lissajous patterns (0 and 1) generated by bit-to-bit gating of sinusoids. A complete system description for a 256-bit format display is provided, and accompanying diagrams provide the detailed design. Also included are sample photographs of oscilloscope displays which illustrate the features of this system.

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INTRODUCTION

The growing complexity of modern digital telemetry systems has produced a need for improved methods of monitoring large quantities of digital information during the design and testing phases of many programs. In particular, a problem area has existed where real-time system operation is concerned. With the exception of complex data handling equipment, devices used in present-day practice are inherently slow; and when they are used, data analysis is generally time consuming. Therefore, an instrument which provides a high data handling capability combined with a convenient display technique is highly desirable.

An instrument which satisfies the requirements for speed and versatility has been devised in conjunction with the Nimbus B, IRLS (Interrogation Recording and Location System) experiment design. This device provides a means of visually displaying, in numeric form, the ones and zeros contained in a serial pattern of binary bits formatted into a frame containing up to several hundred bits. The result of this innovation has been a great saving in both time and expense, since system operation can be quickly and accurately checked for bit errors or other malfunctions in discrete system components or in the RF link.

SYSTEM OPERATION

Basically, the operation of the system consists of forming a 256-bit oscilloscope raster display generated by bit-by-bit and line-by-line electron beam deflection. The beam scanning action is accomplished by use of 16-level staircase sweeping signals obtained from 4-bit D/A (Digital-to-Analog) converters (Figure 1). At each beam location the representation of either a one or zero is accomplished by generating a specific Lissajous pattern, either 1 or 0, formed by gating sinusoids which are superimposed on the staircase sweeping signals. Each pattern generated is determined by the state of an input data bit, where each bit serves as a gating signal to pass or inhibit a 90 degree sinusoidal component of the frequency. Waveshapes are shown in Figure 2 for pattern formations using 10kc sinusoids and a 1-kilobit data rate. As shown, 10 cycles of beam deflection occur for each bit presented, thus providing ample screen brightness for convenient readout.

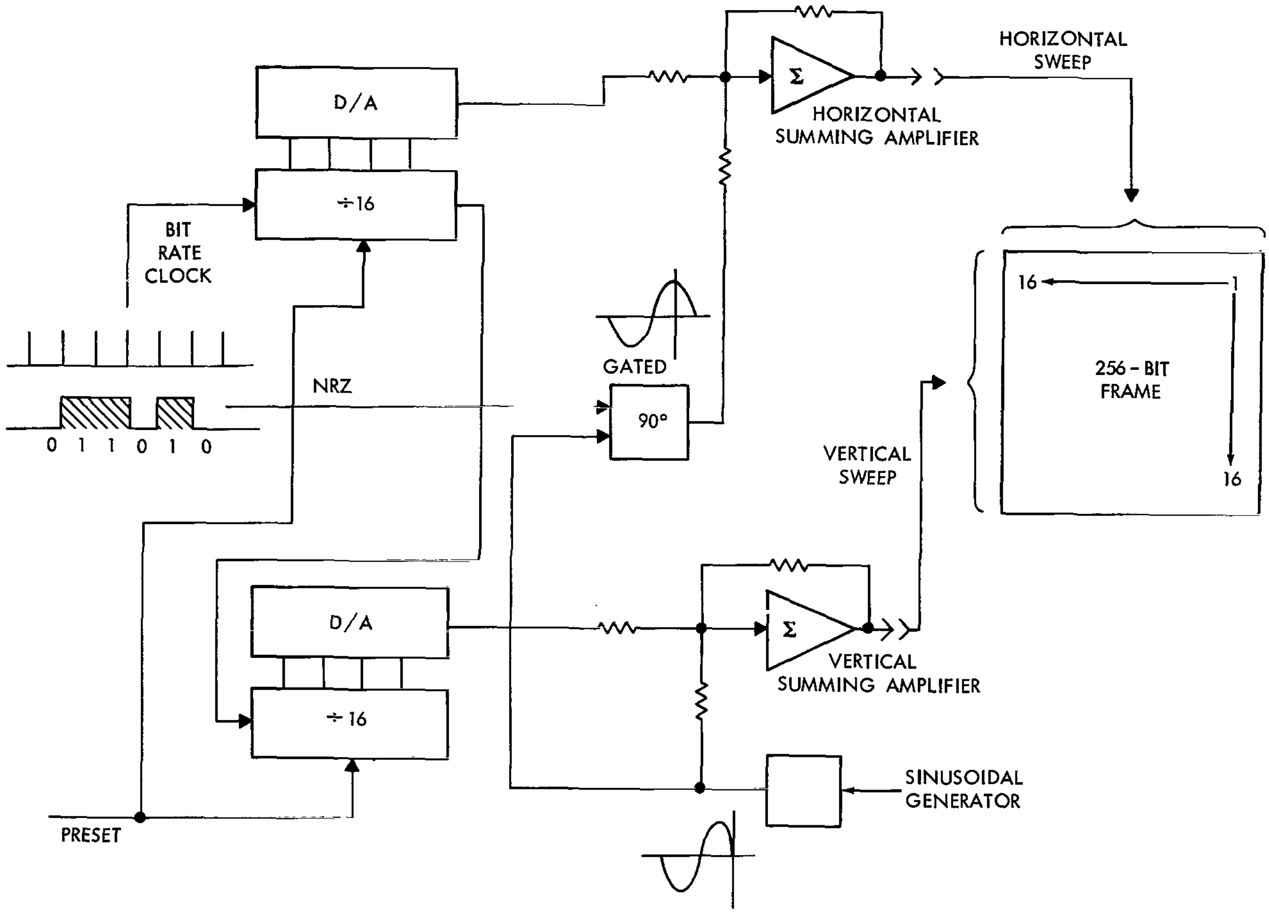


Figure 1 - Data from readout system block diagram.

DESIGN CONSIDERATIONS

Most of the commonly known D/A converter types may be used to provide the necessary staircase sweeping signals. The conversion accuracy should be maintained to better than $1/(2)\ (2^n)$, where n denotes the number of bits needed for a particular row or column size. For the 16×16 frame pattern described herein, an accuracy of ± 3 percent provides sufficient stabilization for recurring frame patterns to be displayed without causing ambiguities in bit or word locations due to items such as dc offsets and drifts.

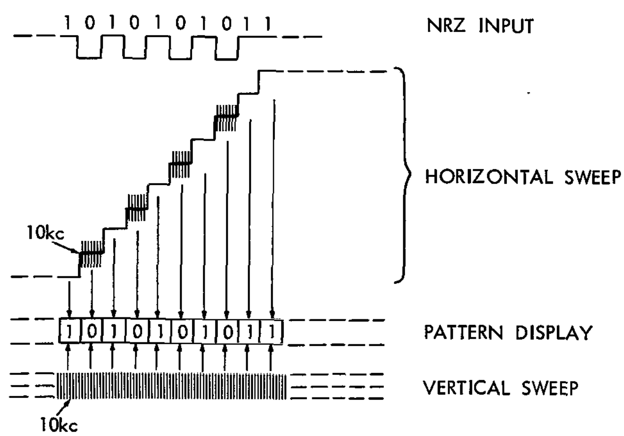


Figure 2 - Synchrogram of pattern formation for 10-kilocycle sinusoids and 1-kilobit data rate.

The magnitude of the least quantized interval of the D/A conversion and the amplitude of the superimposed sinusoids, determines the bit-to-bit and line-to-line spacing increments in the raster display. Therefore, the peak-to-peak amplitude of the sinusoids must be less than one-half the least quantized interval. This constraint is needed to prevent overlap of the data bits and thus retain adequate separation at the display output.

The horizontal and vertical summing amplifiers (Figure 1) serve to superimpose the sinusoidal components on the staircase signals. However, if dual trace oscilloscope amplifiers containing an add mode are available, the summing action can be accomplished without these external devices.

APPLICATIONS

A sample photograph of a display illustrating a typical application is shown in Figure 3. A 256-bit data frame is scanned during its transmission from a remote PCM telemetry system containing complex logic circuitry. Thus, the entire system including the RF link is quickly analyzed for bit dropouts or other errors during real-time operation. As an additional embodiment of this mode, single bit error rates at various signal-to-noise ratios may be determined by using a storage type oscilloscope for data display. This enables repetitively scanned frame patterns to be superimposed one upon the other with bit errors being displayed as superimposed 1's over 0's at the error locations. The bit error rate is then determined when a suitable number of frames has been transmitted.

In addition to real-time applications, the display system is extremely useful as a convenient means of formatting large quantities of serial information such as would be obtained from a memory output or other digital component within a PCM system. Also, if any particular line of a frame is desired for display, oscilloscope tube masking or digital gating of the sweep counters will provide the desired result as depicted in Figure 4.

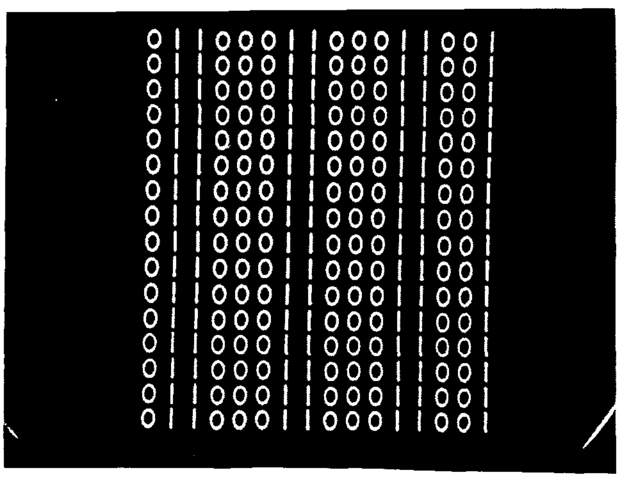


Figure 3 - Presentation of a complete 256-bit data frame.

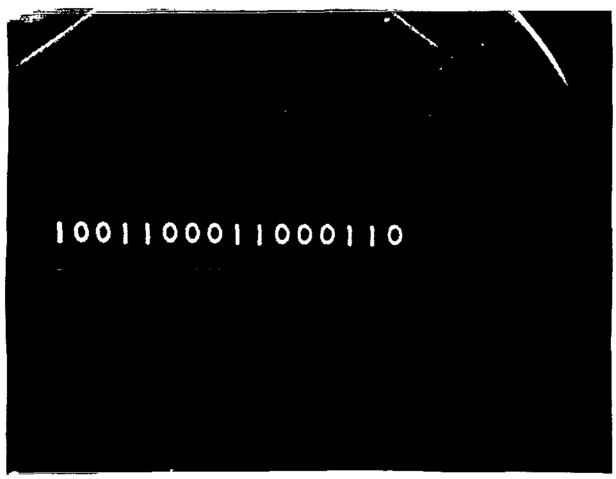


Figure 4 - Presentation of a particular line from a frame.

CONCLUSION

When compared to display techniques such as memory element arrays or pen-type recorders, a cathode ray tube readout system of this type offers many advantages. In many instances, the technique is less expensive even when considering the cost of an oscilloscope. Also, as was stated before, data rates and acquisition times often preclude the use of other devices. The numerical feature of the presentation offers an advantage in that separation of words and bits is readily apparent. This is not the case when analyzing data in forms such as NRZ (non-return-to-zero). Finally, the adaptability of the device to photographic recording techniques provides a means of quickly obtaining precise test records.

ACKNOWLEDGEMENT

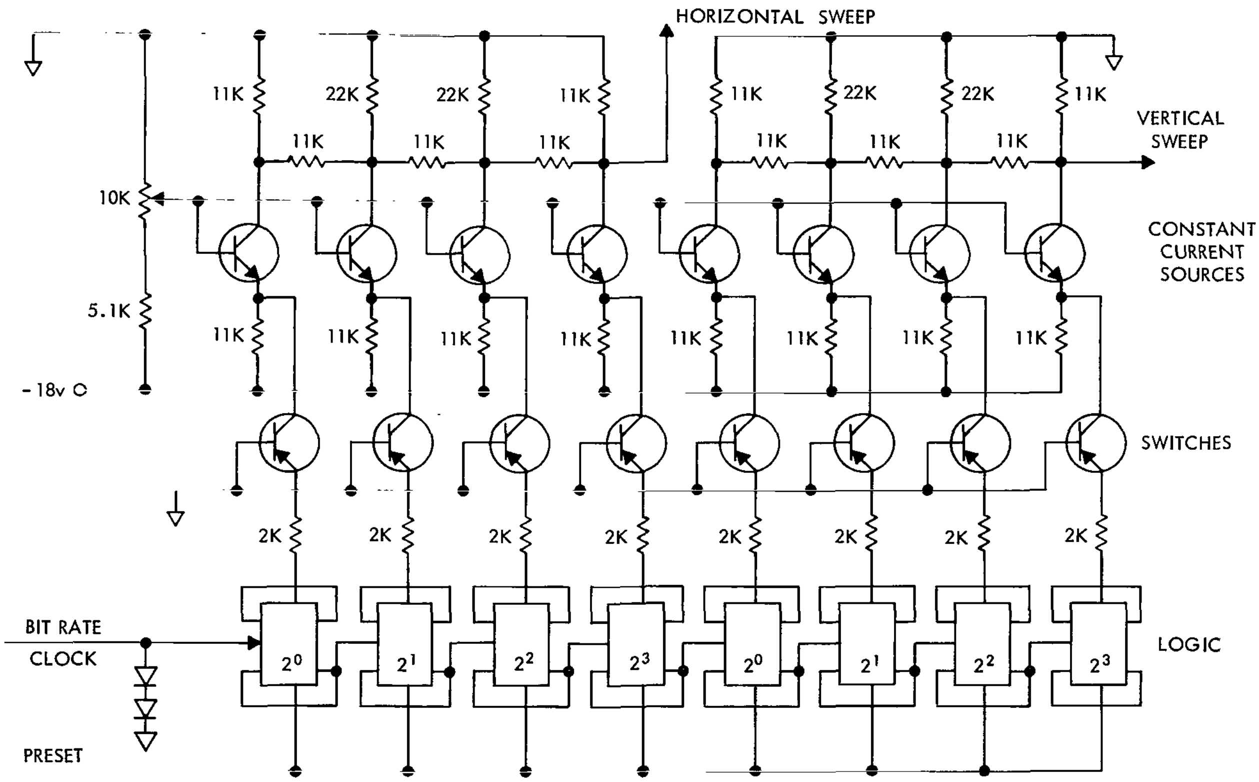
The author expresses his appreciation to Mr. John R. Cressey for his assistance during the design of the Telemetry Data Frame Readout System.

(Manuscript received September 29, 1965)

Appendix A

Detailed System Design

The Telemetry Data Frame Readout System detailed design is shown in Figures A1, A2, and A3.



NOTES:
NPN - 2N930
PNP - 2N995
LOGIC - TI SERIES 511
DIODES - 1N645

Figure A1 - D/A sweep circuits.

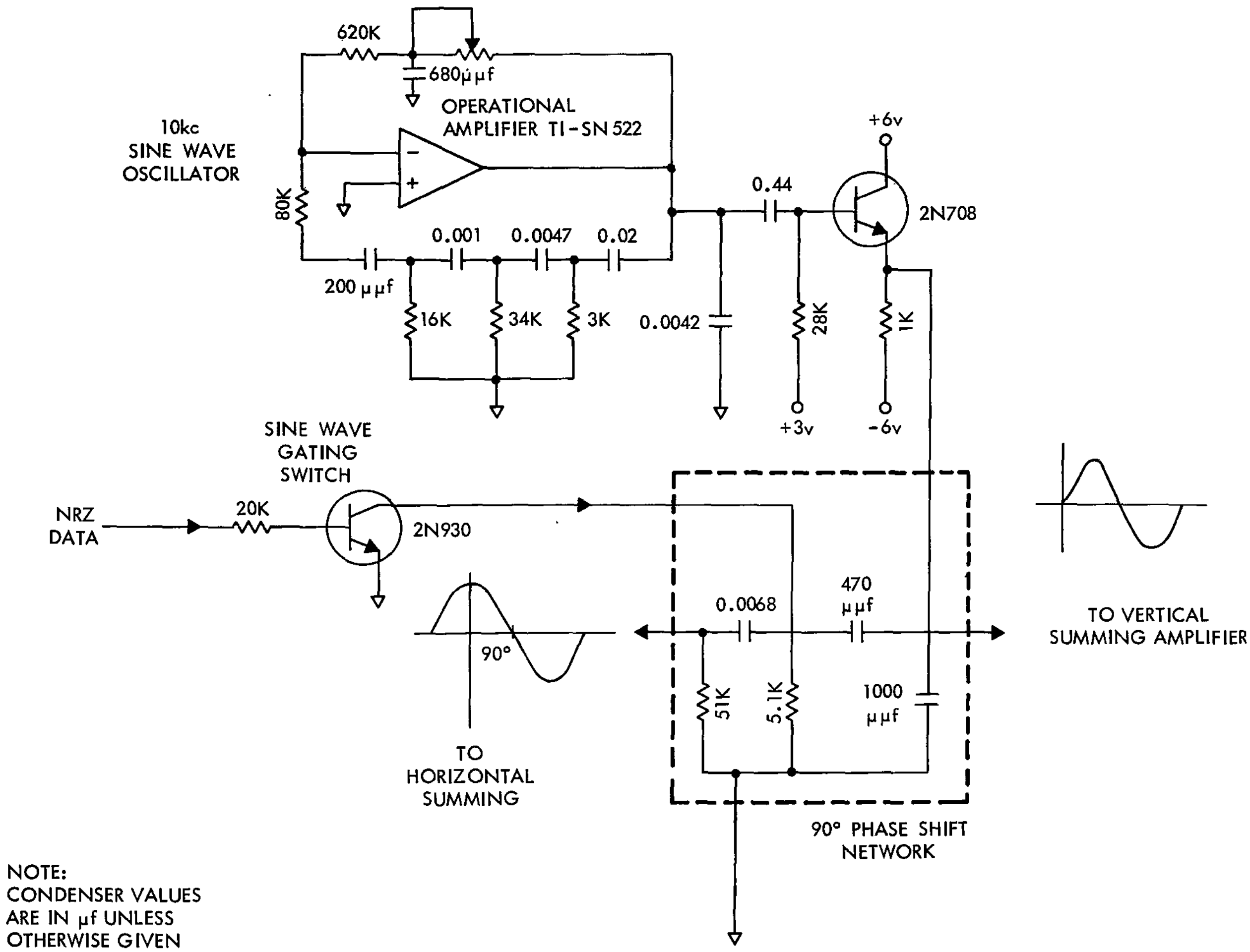


Figure A2 - Oscillator and phase shift network.

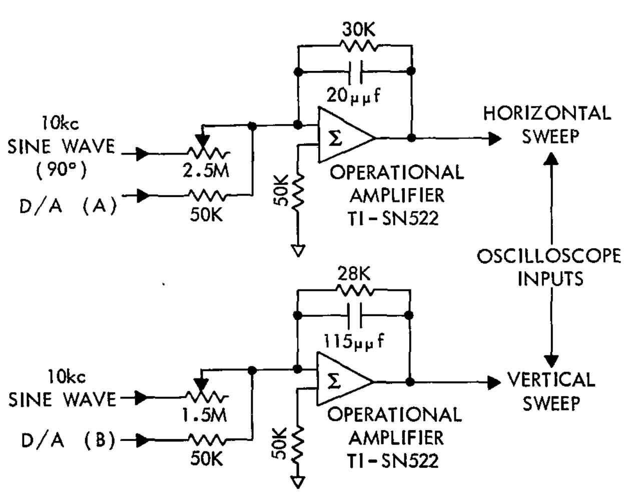


Figure A3 - Summing networks with operational amplifiers.

NASA-Langley, 1966 G-701-P

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