TOLL SYSTEMS

40.8-KILOBIT DATA TRANSMISSION SYSTEM

OSCILLOSCOPE TESTS

CONTENTS PAGE

1. GENERAL

1.01 This section contains reference information useful in evaluating conditions of circuits on a 40.8-kilobit data transmission circuit by means of monitoring tests using an oscilloscope. The data set 301B (4-phase), which generates discrete signals or tones when transmitting a repeated code, is used in these systems. These discrete frequencies lend themselves to waveform analysis by use of an oscilloscope.

1.02 Oscilloscope tests are made at monitoring points in the data transmission circuit and can be made on an in-service, standby, or out-of-service basis. The tests are made under the direction of the circuit control office.

1.03 Observation of good waveforms while performing oscilloscope tests is not in itself a test of the quality of the data transmission circuit tested. No indication of the margin of satisfactory operation is obtained. Comparison of oscillographs observed in the tests with those contained in this section will, however, aid in locating and isolating trouble conditions.

1.04 The illustrative information contained in this section supplements detailed descriptions for performing specific tests on 40.8-kilobit data transmission circuits contained in the 314-605-5XX series of sections.

Apparatus

1.05 The tests require the use of a high-gain oscilloscope having accurate calibration and stable triggering. The model 561A Tektronix oscilloscope, or equivalent, should be used. The oscilloscope should be equipped with a 2B67 or similar time-base plug-in unit,and a 3A1 dual-trace amplifier plug-in unit (or equivalent providing 0.01 volt/division sensitivity) should be used as a vertical amplifier. The more sensitive 2A63 (or similar) 1 mv/cm unit is required at all group connector points. The testing cords described in 2.04 and 2.05 should be fabricated locally. Jacks are required in the wideband service bay (WSB) as shown on the WSB drawings. A spectrum analyzer can also be used to observe the signal frequency spectrum and can be used at practically any unbalanced 75-ohm point in the circuit.

1.06 A carrier-frequency selective voltmeter, such as the 37B transmission measuring set (TMS), is also helpful in determining exact signal power by measuring the 30.6-kHz component of the idle code.

2. TEST PROCEDURE

2.01 When a circuit outage is reported, an attempt should be made to determine if the equipment at the customer location is the source of trouble. Request the customer to attempt to transmit a data tape, and monitor the circuit at the terminal repeater. When the tape is transmitted, the oscillograph will show a change to complex data signals from the idle code. If this change is not observed, tests of the business machine and/or the data set 301B will be required at the customer location.

2.02 Tests with the oscilloscope may be made on a balanced or an unbalanced basis. If the circuit is balanced (neither side grounded), the oscilloscope should be balanced. If the circuit is unbalanced (one side grounded), the oscilloscope should be unbalanced and care should be taken to avoid a reversal in the test connections which will short-circuit the line.

2.03 Tests at the data auxiliary set (DAS) 803( ) and at the WSB are made on a balanced basis and are described in Method 2. Tests at the WLR-1 or -2 repeater jacks are made on an unbalanced basis and are described in Method 1.

Precautions

2.04 When making oscilloscope tests at the WLR-1 repeater MON jack in a terminal office, care should be taken to connect the oscilloscope so that the "hot" lead and the ground lead of the test cord are not reversed between the tip and ring of the MON jack. Such a reversal will cause the circuit to be disabled and may interrupt service. It is recommended that a special test cord be locally fabricated of RG58- or RG59-type coaxial cable with an Amphenol 31-202 plug at one end and a 310 plug at the other end. The center conductor of the cable should be connected to the tip of the 310 plug.

2.05 When making tests at the WSB, the oscilloscope may be wired to jacks as shown on the WSB drawings (SD-50375-01, Fig. 8 or SD-73035-01, Fig. 14). For testing at the DAS, a special 3-conductor test cord should be fabricated; channel 1 should be connected to the tip lead, channel 2 should be connected to the ring lead, and ground should be connected to the sleeve lead. A 310 plug should be connected to the second end of the cord, which is connected to the DAS MON jack. Both channel 1 and channel 2 of the 3A1 dual-trace amplifier are used; the MODE switch is on ADDED and CH 1 INV. When connected in this manner, neither the tip lead nor the ring lead of the circuit is grounded. The gain controls of either channel may be used since they are effectively in series.

2.06 When comparison of observed oscillographs is made with oscillographs contained in this section, the same oscilloscope calibration should be used. Calibration information is given with each oscillograph.

A. Method 1, Unbalanced Measurements

STEP	PROCEDURE
1	Apply power to the oscilloscope and allow sufficient time for warmup. Calibrate the oscilloscope and adjust the dc balance as described in the manufacturer's instruction manual.

STEP	PROCEDURE
2	Set the 2B67 time-base generator controls as follows:

CONTROL	SETTING
POSITION	As required for display on the oscilloscope
VARIABLE	CALIBRATED
TIME/DIV	20 μs (or as indicated)
TRIGGERING LEVEL	AUTO (or adjust for most stable display)
SLOPE	+
COUPLING	AC SLOW
SOURCE	INT

STEP	PROCEDURE
3	Set the 3A1 dual-trace amplifier controls as follows:

CONTROL	SETTING
CH 1	AC
VOLTS/DIV	2
VARIABLE	CALIB.
MODE	CH 1, NORM.
POSITION	Midrange

STEP	PROCEDURE
4	Connect the CH 1 input of the oscilloscope to the MON jack of the WLR-1 or -2 repeater (or other unbalanced point) using a special test cord (see 2.04). *Caution: The ring side of the circuit must be connected to the oscilloscope input ground.*
5	Adjust the oscilloscope POSITION and TRIGGER LEVEL controls, if required, to obtain a suitable display on the oscilloscope.
6	Study the display and compare it with the photographs in this section.
7	When the test is completed, disconnect the oscilloscope and remove power unless it is to be used again shortly. If power is not removed, turn the INTENSITY control fully counterclockwise.

B. Method 2, Balanced Measurements

STEP	PROCEDURE
1	Apply power to the oscilloscope and allow sufficient time for warmup. Calibrate the oscilloscope and adjust the dc balance as described in the manufacturer's instruction manual.
2	Set the 2B67 time-base generator controls as follows:

CONTROL	SETTING
POSITION	As required for display on the oscilloscope
VARIABLE	CALIBRATED
TIME/DIV	20 μs (or as indicated)
TRIGGERING LEVEL	AUTO (or adjust for most stable display)
SLOPE	+
COUPLING	AC SLOW
SOURCE	INT

STEP	PROCEDURE
3	Set the 3A1 dual-trace amplifier controls as follows:

CONTROL	SETTING
CH 1, CH 2	AC
VOLTS/DIV	1 (DAS 803A2), 2 (DAS 803A1), or 0.1 (WSB)
VARIABLE	CALIB.
MODE	ADDED, CH 1 INV
POSITION	Midrange

STEP	PROCEDURE
4	Connect CH 1 to the tip lead, CH 2 to the ring lead, and the oscilloscope ground to the sleeve lead of the circuit under test.
5	Adjust the oscilloscope POSITION and VOLTS/DIV controls, if necessary, to obtain a suitable display on the oscilloscope.
6	Study the oscilloscope display and compare it with the photographs in this section.
7	When the test is completed, disconnect the oscilloscope and remove power unless it is to be used again shortly. If power is not removed, turn the INTENSITY control fully counterclockwise.

3. OSCILLOSCOPE TESTS

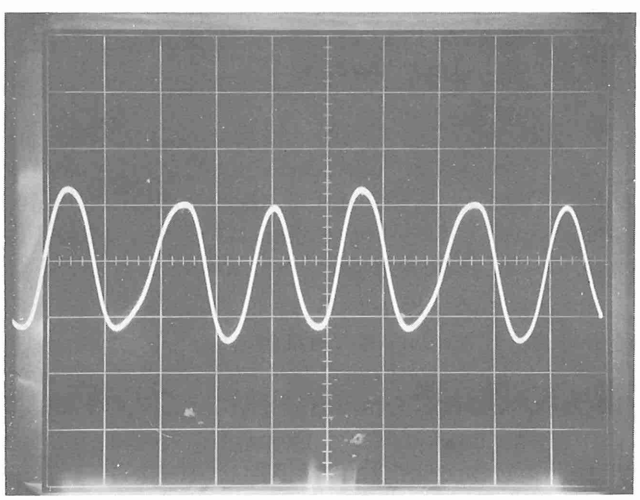
3.01 This section includes waveform photographs of the idle code, 63-bit word (transmitted by the 903B data test set), and 2047-bit word (transmitted by the 912A data test set). Photographs of oscilloscope displays were obtained at the DAS 803A2 (about 0 dBm), at the MON jack of WLR-1 or -2 repeaters (about +12 dBm), and at the WSB (about —10 dBm). If the DAS 803A1 is used, use a higher sensitivity (2 v/div).

A. Data Station Tests

3.02 Figure 1 shows the idle code waveform taken at the transmitting EQUIP jack of the DAS 803A2. The idle code (repeated 10-00 dibits) is transmitted as a 30.6-kHz carrier which has a low-level phase-modulation component producing a slight asymmetry in the waveform.

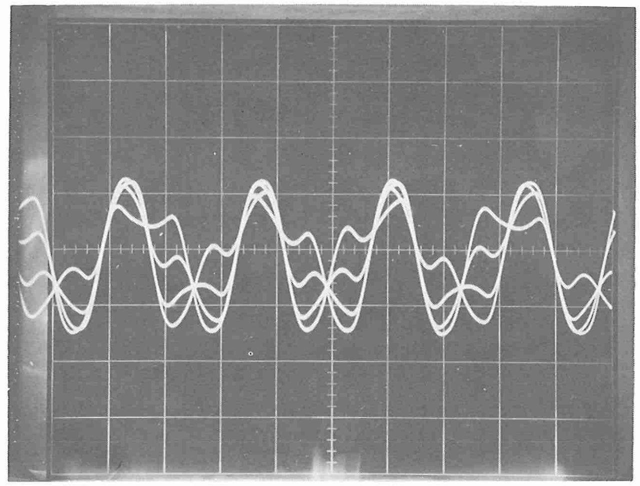
3.03 The waveform shown in Fig. 2 was taken in the same manner as that in Fig. 1 and shows the repeated 63-bit word generated by the 903 data test set. Due to the difficulty of interpreting such a waveform, the idle code (Fig. 1) should be used for isolating most troubles.

3.04 The waveform in Fig. 3 shows the 2087-bit word generated by the 912A data test set. Due to the difficulty of interpreting such a waveform, the idle code (Fig. 1) should be used for isolating most troubles.



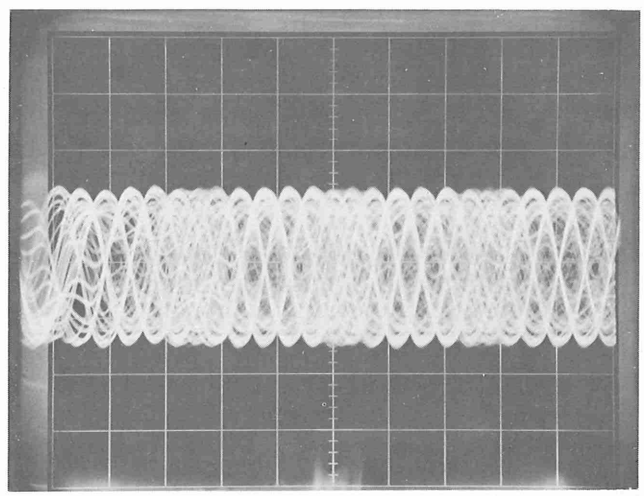
1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 1 — Idle Code Monitored at DAS 803A2 EQUIP Jack



1 v/cm, 20 μs/cm, no oscilloscope termination

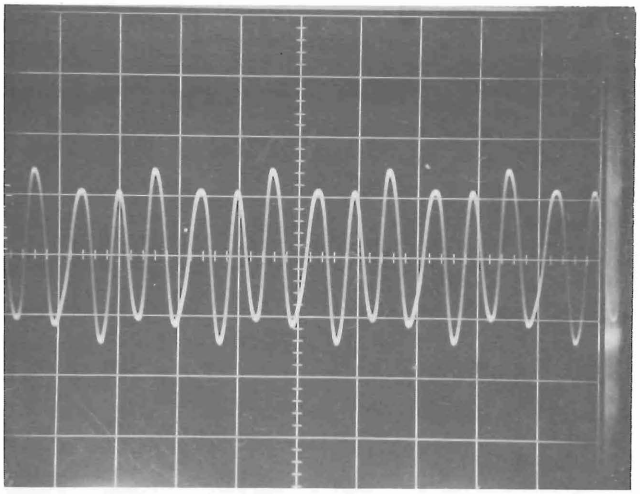
Fig. 2 — 63-Bit Word Monitored at DAS 803A2 EQUIP Jack



1 v/cm, 20 μs/cm, no oscilloscope termination

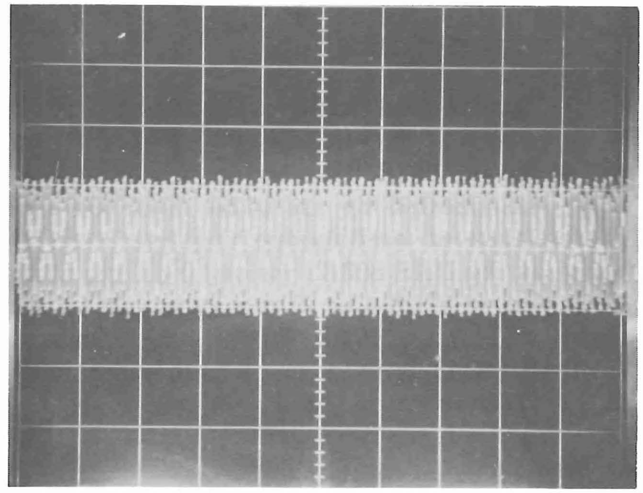
Fig. 3 — Waveform Generated by 912A Data Test Set

3.05 The idle code monitored, under normal operating conditions, at the transmitting terminal WLR-1 repeater MON jack, is shown in Fig. 4. The gain setting is dependent on whether the repeater is equipped with an amplifier or a shorting unit. The repeater at which this waveform was taken was equipped with an amplifier.



2 v/cm, 50 μs/cm, no oscilloscope termination

Fig. 4 — Idle Code Monitored at MON Jack of Transmitting WLR-1 Repeater

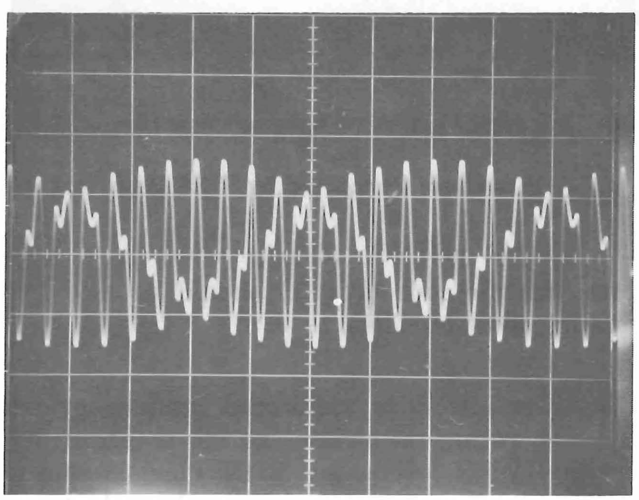


2 v/cm, 2 ms/cm, no oscilloscope termination

Fig. 6 — Data (Magnetic Tape) Monitored at MON Jack (AMPL 2) of Receiving WLR-1 Repeater

3.06 A repeated 11-11 pattern monitored at the WLR-1 repeater is shown in Fig. 5. This signal causes high-level sidebands which can interfere with L carrier channels and should be transmitted only for very short periods.

3.07 A complex waveform produced by transmission from a customer magnetic data tape and monitored at the receiving WLR-1 repeater is shown in Fig. 6. The waveform consists of a phase-shifted line signal with no steady tones. Readjust the TIME/DIV control to obtain the best presentation.



2 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 5 — Waveform Generated by Repeated 11-11 Pattern Monitored at WLR-1 Repeater

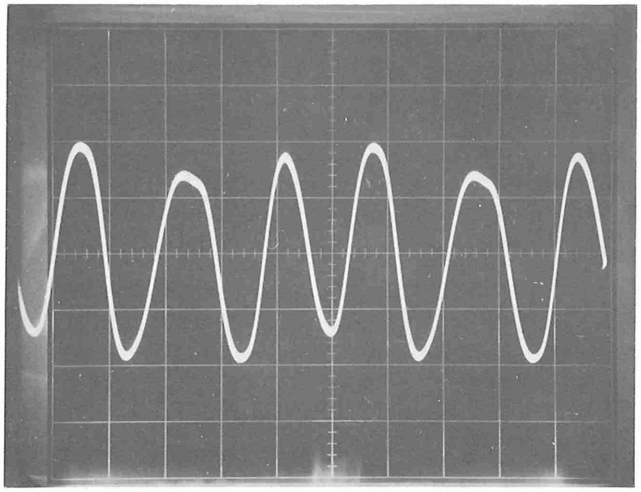
3.08 The oscillographs shown are single-channel presentations. If a dual-trace preamplifier is available, both the transmitting side (AMPL 1 MON jack) and the receiving side (AMPL 2 MON jack) can be monitored at the same time. Apply the signal from the transmitting side (AMPL 1) to channel 1 (CHAN 1) of the preamplifier, and lock the internal trigger of the oscilloscope on this channel.

B. Wideband Service Bay Tests

3.09 Tests at the WSB are normally made on a bridging, balanced basis at the MON jacks. Figures 7, 8, and 9 show the idle code, 63-bit word (903A data test set), and 2047-bit word (912A data test set) monitored at the WSB.

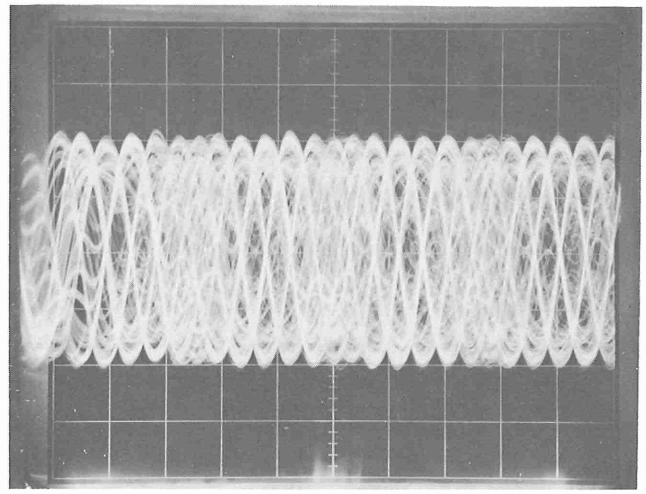
C. Wideband Modem (LWM-1) Tests

3.10 Data signals monitored at an LWM-1 wideband modem have been converted from the 10- to 51-kHz band to the 60- to 104-kHz group band of the L carrier. Figure 10 shows the idle code as monitored at the CH BK ALT jack on the LMX-2 transmitting bay. The thick trace in this oscillograph is caused by carrier leak. This presentation will be disturbed if the voice coordina-



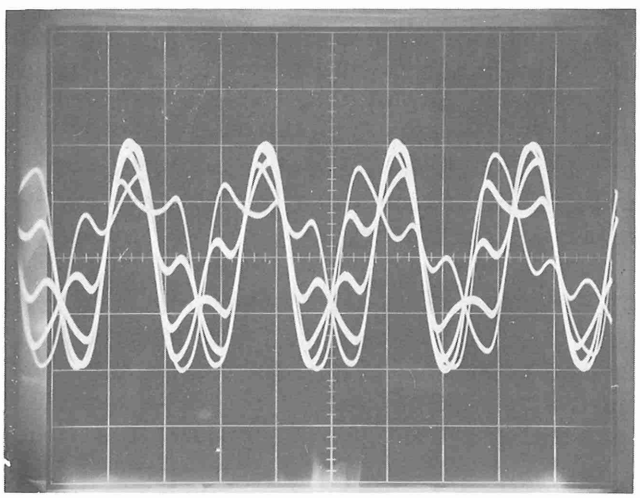
0.1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 7 — Idle Code Monitored at WSB



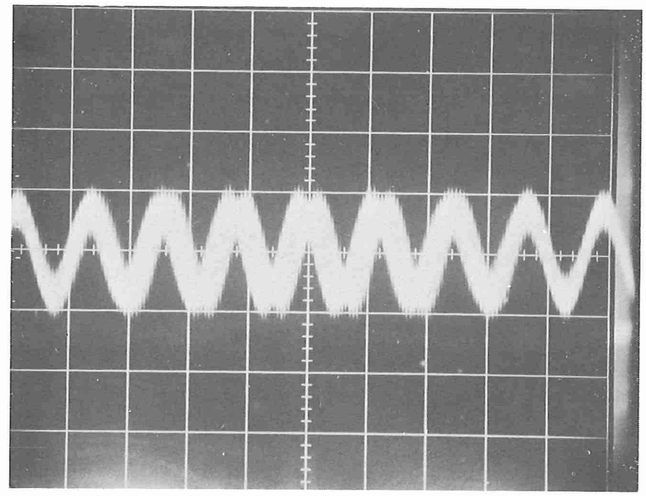
0.1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 9 — 2047-Bit Word Monitored at WSB



0.1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 8 — 63-Bit Word Monitored at WSB



2 mv/cm, 10 μs/cm, 135-ohm oscilloscope termination

Fig. 10 — Idle Code Monitored at CH BK ALT Jack at LWM-1 Location

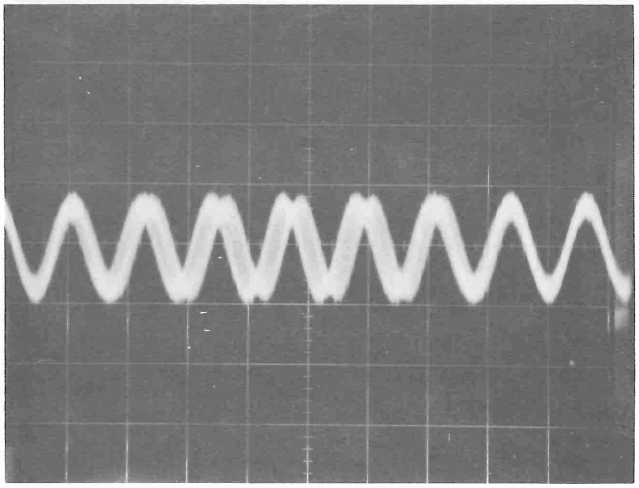
tion channel is used. The waveform contains the 82.6-kHz carrier and sideband on each side.

D. Intermediate Group Connector Tests

3.11 Oscilloscope tests can be made at all intermediate offices equipped with group (L-to-L) connectors. An oscilloscope sensitivity of 2 mv/cm is required. The tests must be made at the —42 dBm level (—50 dBm data level) side of the group connector. This point is the CH BK ALT jack on the LMX-2 transmitting bay. Figure 11 shows the idle code monitored at this point. An unbalanced oscilloscope may be used if short cords are used.

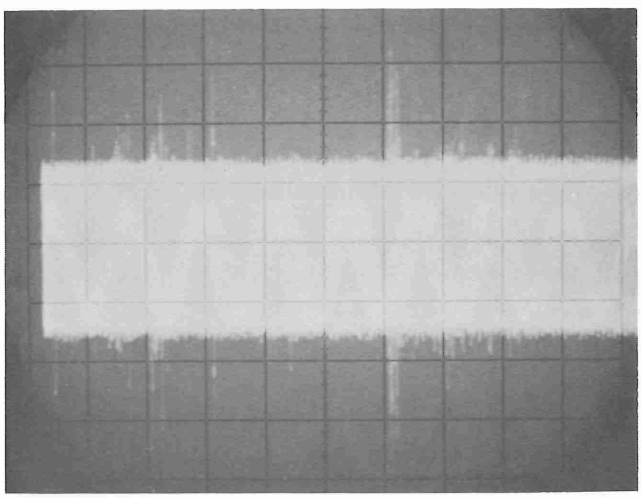
E. Waveforms Showing Trouble Conditions

3.12 The waveforms showing trouble conditions contained in this section are at group-band frequencies taken at group connector (L-to-L) points and at 10- to 51-kHz band at WLR repeater points. The trouble indications are somewhat similar to those obtained at other points. Figure 12 shows impulse noise spikes riding an idle code



2 mv/cm, 10 μs/cm, 135-ohm oscilloscope termination

Fig. 11 — Idle Code Monitored at Group Connector

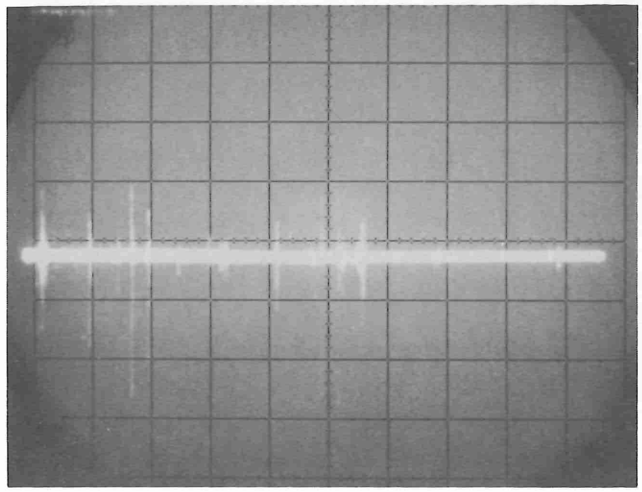


2 mv/cm, 1 ms/cm, 135-ohm oscilloscope termination

Fig. 12 — Impulse Noise on Idle Code at Group-Band Frequencies

waveform. These impulses were caused by a trouble condition in a TH radio system. A slow sweep speed helps in locating these types of trouble.

3.13 The waveform shown in Fig. 13 was taken under the same conditions as Fig. 12 except that the circuit has been terminated with no signal being transmitted. The impulse count under this condition was 240 per minute at 35 dBrn, as measured using a 6G wideband noise measuring set.

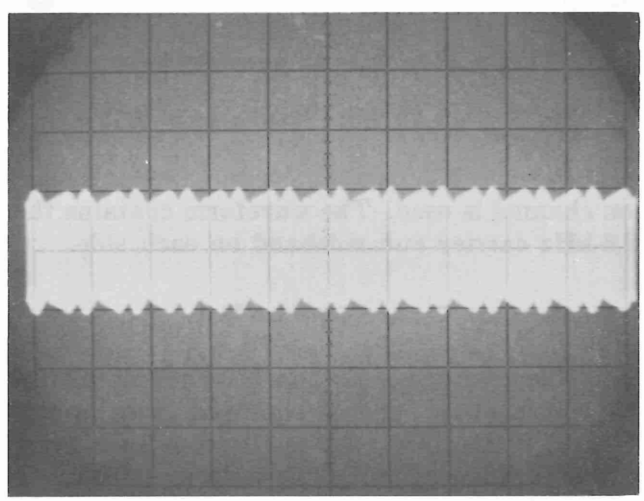


2 mv/cm, 1 ms/cm, 135-ohm oscilloscope termination

Fig. 13 — Impulse Noise with Circuit Terminated (No Signal)

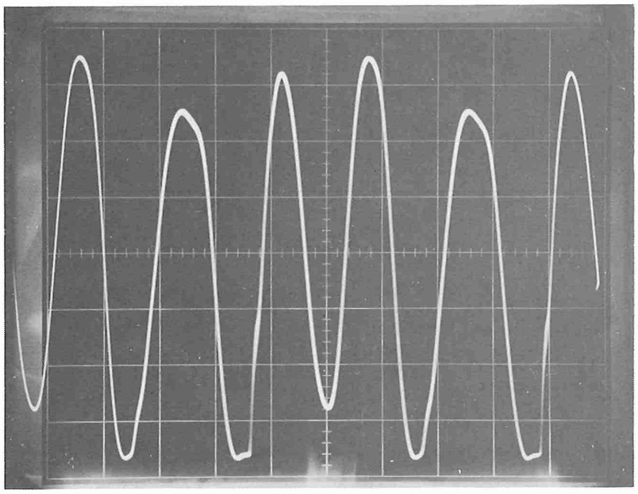
3.14 Low-frequency interference is shown in Fig. 14. Modulation of the waveform envelope can be seen. This kind of noise interference reduces the amount of distortion that can be tolerated from other sources, thus reducing the operating margin.

3.15 Figures 15, 16, and 17 show idle code and test word waveforms taken under signal overload conditions. These waveforms were obtained at the MON jack of a WLR-1 repeater arranged for fixed-gain operation. Note the



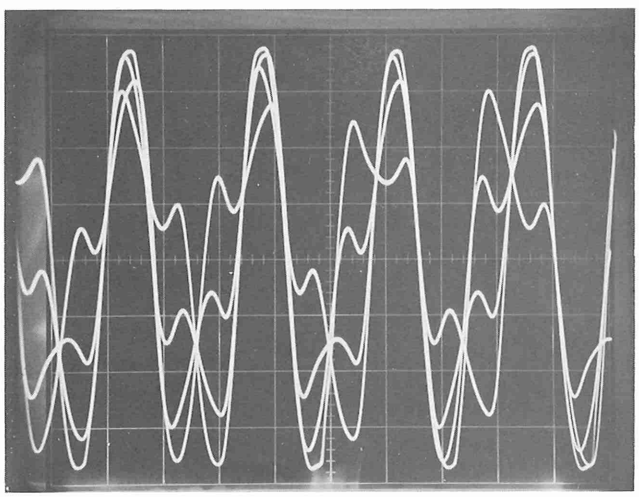
2 mv/cm, 1 ms/cm, 135-ohm oscilloscope termination

Fig. 14 — Low-Frequency Noise



1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 15 — Idle Code with Signal Overload Monitored at WLR-1 Repeater



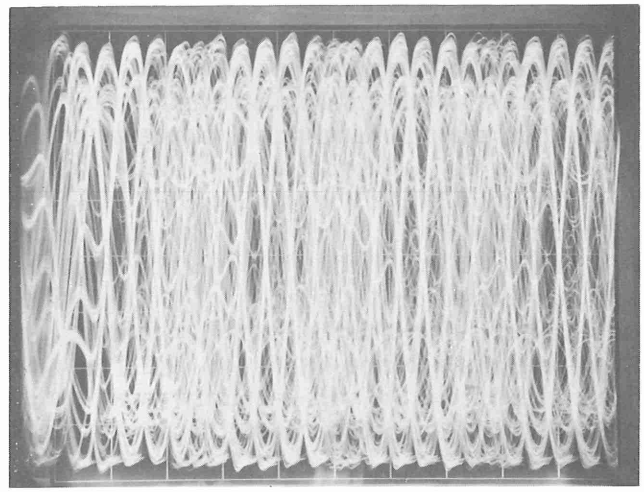
1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 16 — 63-Bit Word with Signal Overload Monitored at WLR-1 Repeater

distorted (clipped) waveform. These waveforms show only a slight overload condition. Notice that only one polarity is distorted.

4. EVALUATION OF OSCILLOGRAPHS

4.01 The usefulness of oscilloscope tests is dependent on the oscilloscope operator's ability to analyze the waveforms observed and to compare them with photographs of oscillographs made under normal operating conditions.



1 v/cm, 20 μs/cm, no oscilloscope termination

Fig. 17 — 2047-Bit Word with Signal Overload Monitored at WLR-1 Repeater

The oscilloscope operator should look for the following characteristics:

DESIRED CHARACTERISTIC	TROUBLE CHARACTERISTIC
(a) Clear, narrow traces	Thick, indistinct traces
(b) Steady traces*	Breakups in traces
(c) Signal amplitudes comparable to those shown in this section	Low-signal amplitudes
(d) Absence of noise impulses	Presence of noise impulses
(e) Undistorted peaks	Flattened peaks (overload)

* Except for "roll" produced by carrier offset in LMX and N2WM-1 systems.

4.02 Data signals are complex and rather difficult to analyze. It is best to use a rather low sweep rate (long TIME/DIV setting) on the oscilloscope and to examine the envelope (top and bottom) of the waveform for signal breakups, noise hits, amplitude hits, low-frequency modulation, etc, that may affect transmission. A faster sweep rate (about 20 μsec/div) should be used to examine the waveform for overload distortion.

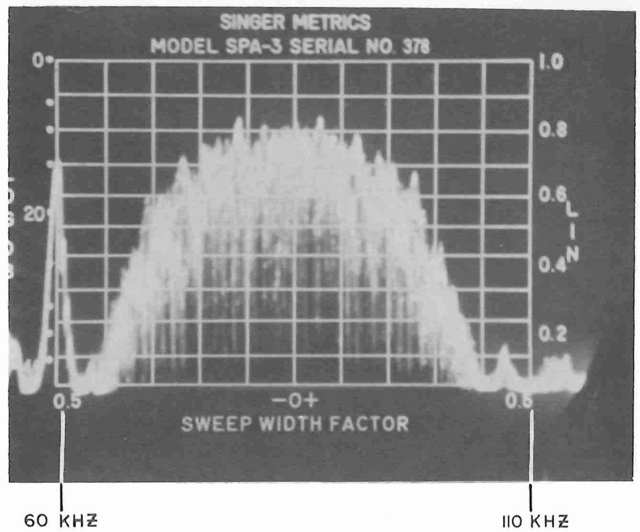
4.03 The receiving side of a data transmission circuit is normally used to return parity check signals to the end originating the transmission. This parity check signal appears on the oscilloscope as a short burst of data signals separated by relatively long periods of either the idle code or repeated 11 dibits. When monitoring on this side of the circuit, the burst of data signals may cause erratic triggering of the oscilloscope sweep; this is not a trouble condition. If an actual disturbance exists on the receiving side of the circuit, it will normally cause transmission to be stopped because the parity check will fail.

5. TESTS USING A SPECTRUM ANALYZER

5.01 The waveforms included in this part were obtained using a Singer Metric Model SPA-3 spectrum analyzer. The use of an instrument of this type permits a more comprehensive analysis of the frequency spectrum. The instrument is tunable to any part of the multiplex spectrum.

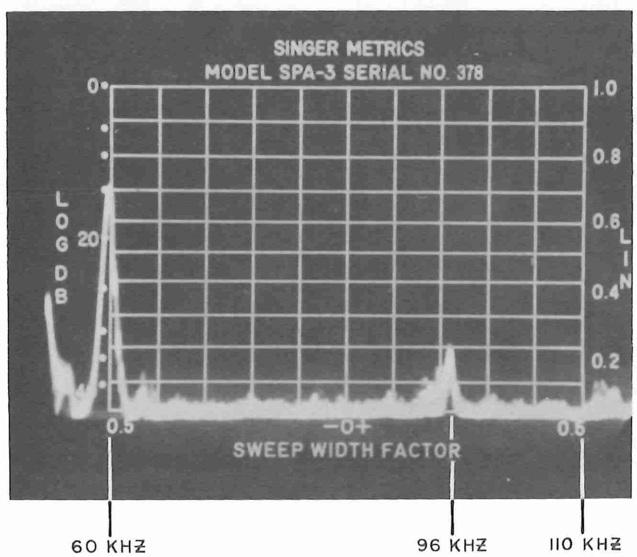
5.02 Figure 18 is an example of a spectrum analyzer presentation of random data signals in the group-band frequencies (60 to 108 kHz) under normal conditions. The waveform shows a symmetrical spectrum centered on an 82.6-kHz carrier. This 63-bit random word signal was transmitted from a 903B data test set.

5.03 The waveform shown in Fig. 19 was made under the same conditions as that shown in Fig. 18, except that the signal has been removed and the transmitting end of the circuit terminated. The waveform shows low-amplitude noise and tones with a 96-kHz tone introduced by the multiplex system. This tone should be at least 30 dB below the data signal level (see Section AA 636.603).



5 kHz/cm, 0 dB = —8 dBm0

Fig. 18 — Spectrum of 63-Bit Random Word



5 kHz/cm, 0 dB = —8 dBm0
(Note spurious tone at 96 kHz.)

Fig. 19 — Spectrum at Group-Band Point with Data Signal Blocked