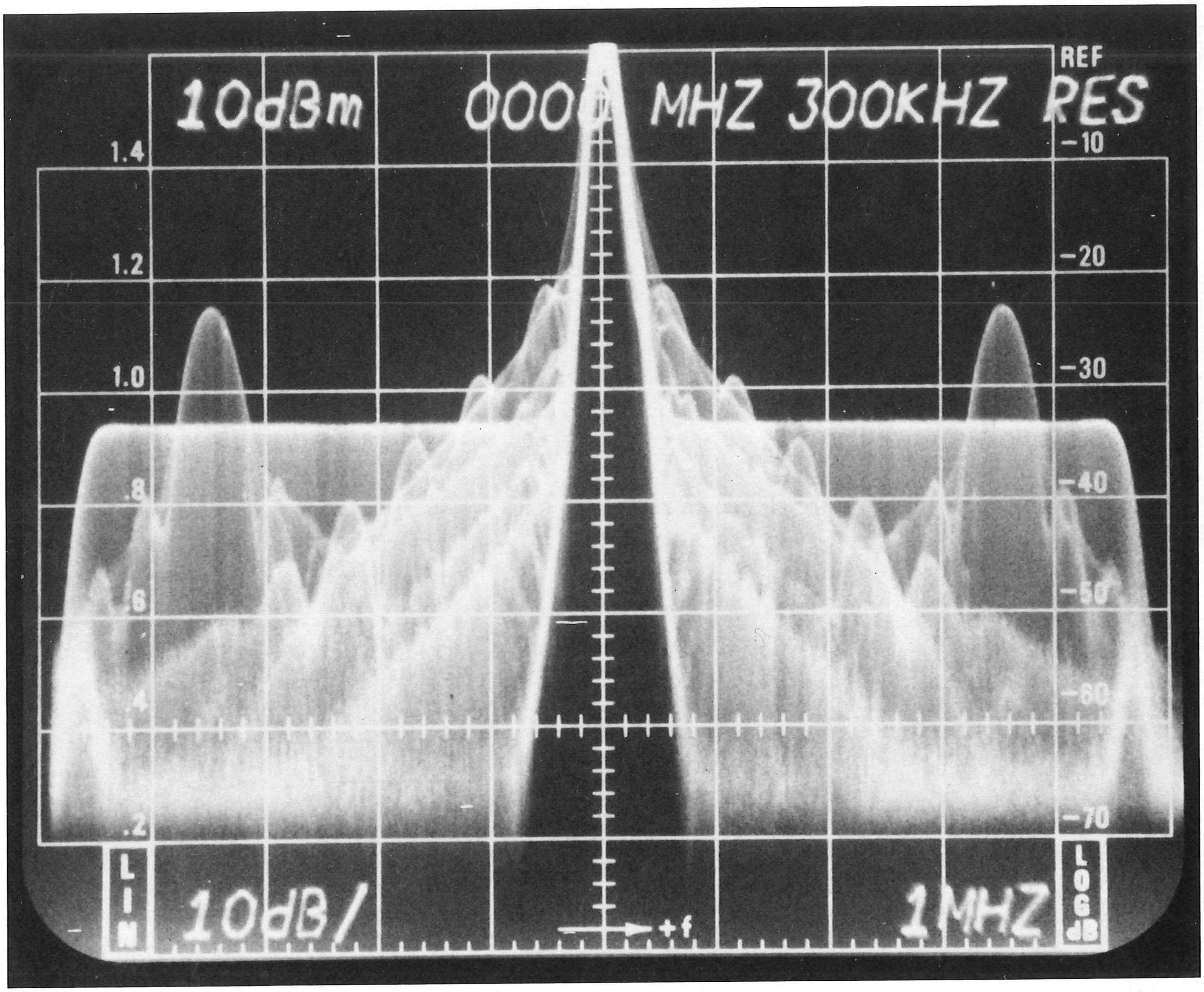
FREQUENCY RESPONSE TESTING USING THE SIN X/X TEST SIGNAL



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Introduction

A new test signal for frequency response testing is now available in the Tektronix 1900 Digital Generator. This test signal is called the sin x/x and is shown in both the time and frequency domain in Figures 1 and 2 respectively.

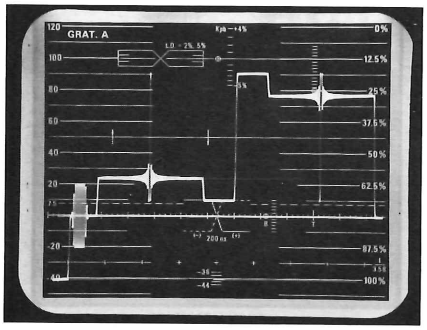

Figure 1. Sin x/x test signal displayed in the time domain.

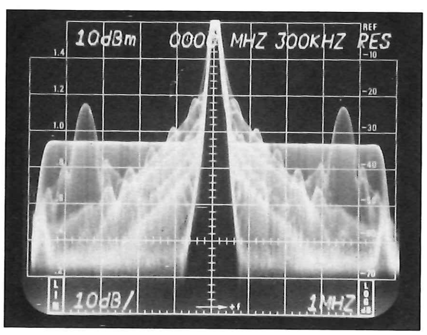

Figure 2. Sin x/x test signal displayed in the frequency domain.

The sin x/x, as generated by the 1900 Digital Generator, is a pulse whose spectrum contains all the harmonics of the horizontal scanning frequency up to 4.75 MHz. These harmonics are all of equal amplitude and energy with negligible energy above 4.75 MHz (See Figure 3).

As the sin x/x contains all the horizontal scanning frequency harmonics, it has much more video band information than the multiburst which has useful information at only six frequencies within the band. These properties, plus the fact that the sin x/x signal may be used as VIT signal, make this signal ideal for checking frequency response in television transmitters and other limited bandwidth devices and systems.

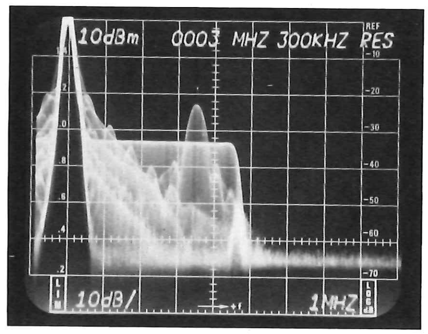

Figure 3. Sin x/x frequency domain display. Note the very steep roll off characteristic and absence of out-of-band energy (above 4.75 MHz).

Testing Methodology

Frequency response testing with the sin x/x signal is carried out with a spectrum analyzer. If the sin x/x is employed as a VIT signal, such as for in-service transmitter testing, a storage display will be required. The spectrum analyzer/mainframe combination used for this application note is a Tektronix 7L14/7613. Other suitable spectrum analyzers include the Tektronix 7L12 and 7L13 models.

Either of two testing methods may be employed: out-of-service testing where the sin x/x is used as a full field test signal or in-service testing where the sin x/x is used as a VIT signal. The equipment setup for each method is shown in Figures 4 and 5 respectively.

In figure 5, the Remote Control Unit is used to program the sin x/x VIT signal on the desired line and field. The 1480R Waveform Monitor is set to display the sin x/x VIT signal at 5 microseconds per division. The line strobe pulse from the 1480R is used to unblank the spectrum analyzer display for the sin x/x signal only.

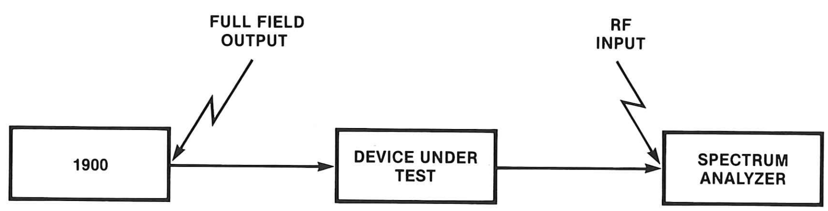

Figure 4. Setup for out-of-service testing.

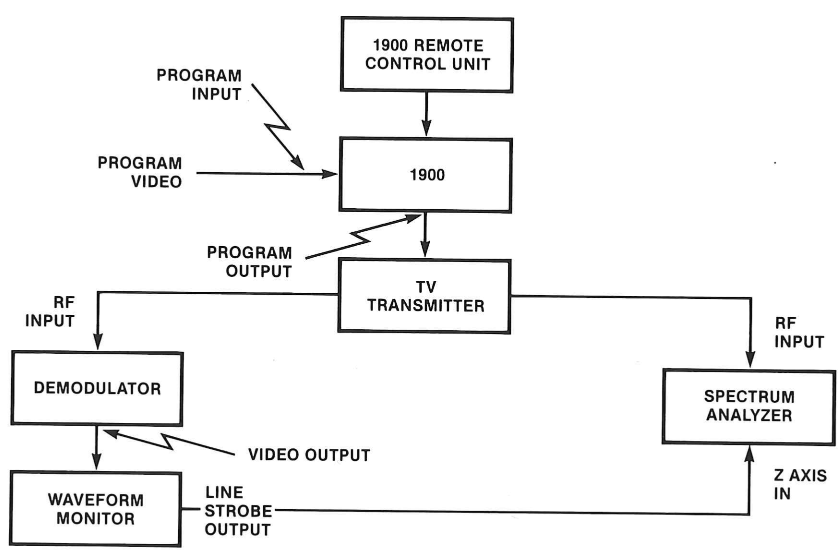

Figure 5. Setup for in-service testing at a television transmitter.

Correlation of the Sin x/x and the Multiburst

To further familiarize the user with the sin x/x signal, a frequency domain amplitude correlation with the more familiar multiburst is shown in Figures 6 through 15. Figures 6 and 7 are time domain displays of the multiburst and sin x/x signals respectively. Note that the multiburst signal contains equal amplitude and equal width frequency packets.* It is only when the multiburst signal meets these two criteria that the packets will be of equal energy content and give a flat amplitude response in the frequency domain.

NOTE: Do not attempt to correlate the sin x/x and multiburst signals in the frequency domain when the multiburst packets are not generated at equal amplitude and duration.

Figures 8 and 9 are frequency domain displays of the multiburst and sin x/x respectively. Note the flat amplitude response of both signals and the sweep-like display of the sin x/x signal. In Figure 9, the ruler flat portion of the display is the sin x/x signal. The steeply falling portion of the display between the 0 Hz marker (graticule center) and 1.25 MHz away from the 0 Hz marker is the luminance bar element of the sin x/x signal and the synchronizing signal information. The energy peak at 3.58 MHz is the color burst signal. Figures 10 and 11 are higher vertical resolution (2 dB per division) displays of Figures 8 and 9. Notice that the two signals correlate nearly perfectly across the entire video band.

* This multiburst signal was generated with a 1410 Series TSG6 Multiburst Generator with special PROMS installed. Tektronix part number for the PROMS is 160-0220-00 and 160-0222-00.

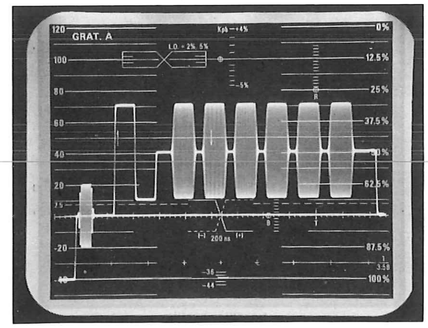

Figure 6. Multiburst signal displayed in the time domain.

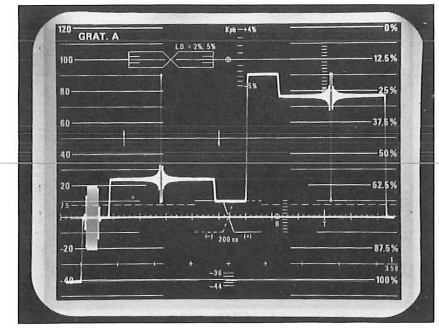

Figure 7. Sin x/x signal displayed in the time domain.

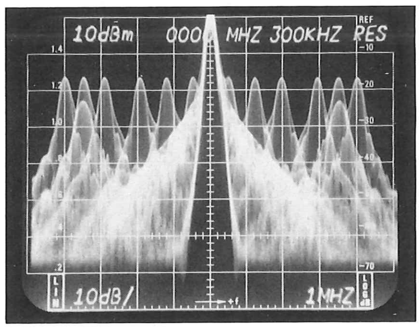

Figure 8. Multiburst signal displayed in the frequency domain.

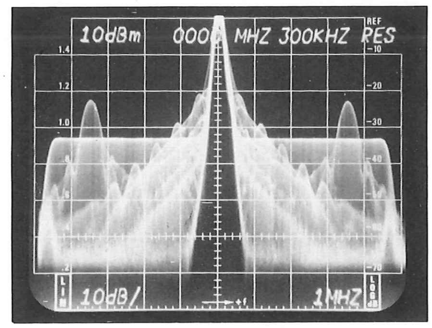

Figure 9. Sin x/x signal displayed in the frequency domain.

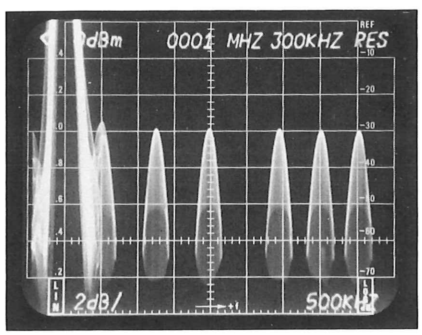

Figure 10. Multiburst signal displayed in the frequency domain at 2 dB per division.

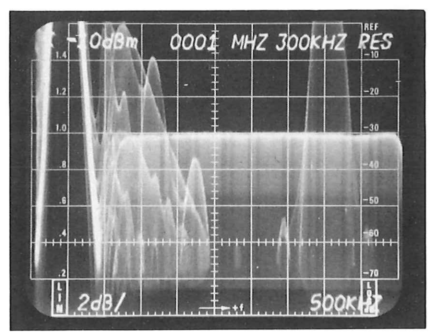

Figure 11. Sin x/x signal displayed in the frequency domain at 2 dB per division.

Figures 12 and 13 are the multiburst and sin x/x respectively after passing through a circuit with high frequency roll off. Notice the sin x/x pulse amplitude has been reduced by about 8 IRE at its peak and that the lobe amplitudes at the bottom of the positive going pulse and at the top of the negative going pulse are also reduced.

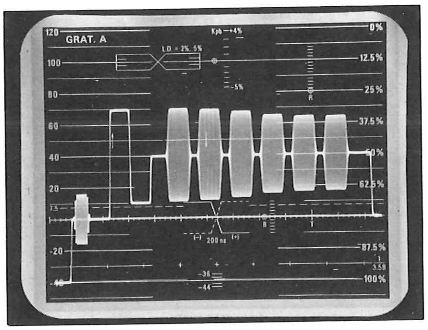

Figure 12. Time domain display of the multiburst signal exhibiting high frequency roll off.

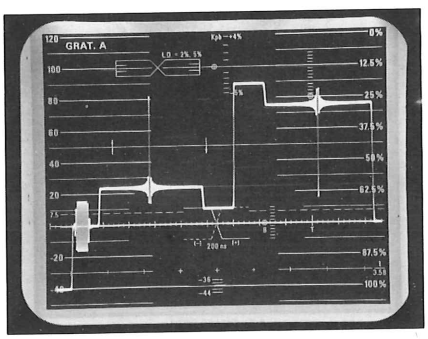

Figure 13. Time domain display of the sin x/x signal exhibiting high frequency roll off.

Figures 14 and 15 are high resolution frequency domain displays of 12 and 13. Note that the correlation between multiburst and sin x/x is excellent. This will always be the case in linear systems where frequency response does not vary as a function of signal amplitude.

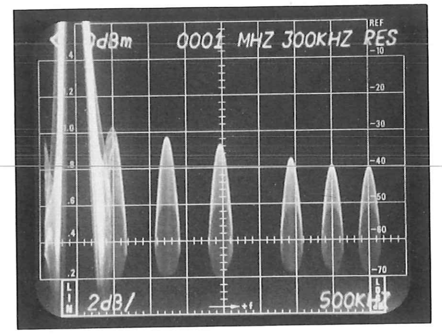

Figure 14. Frequency domain 2 dB per division display of the multiburst signal exhibiting high frequency roll off.

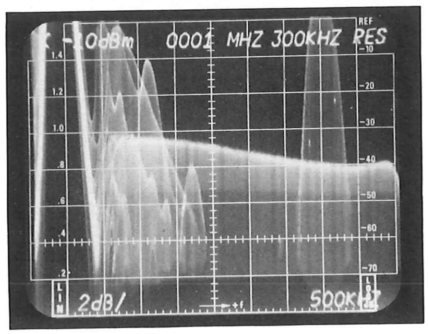

Figure 15. Frequency domain 2 dB per division display of the sin x/x signal exhibiting high frequency roll off.

Transmitter Frequency Response Testing

One application of the sin x/x signal is in-service frequency response testing of television transmitters. The advantages of this method of testing where the measurements are made at the designated channel frequencies are:

1. The shape of the vestigial sideband may be determined while the transmitter is in-service.
2. Amplitude errors introduced by a less than measurement grade demodulator are eliminated. The signal is not subjected to errors introduced in the RF to baseband conversion process when using a spectrum analyzer.

For this particular test, the sin x/x signal was inserted on line 18 of field 2 in place of the usual composite signal (see section 73.676 of the FCC rules for details on substitution of VIT signals on line 18 of field 2).

The equipment setup is that of Figure 5 with the demodulator video output fed to the waveform monitor input. The waveform monitor is set to view line 18 of field 2 at 5 microseconds per division. The spectrum analyzer RF input is taken from the point of interest within the transmitter system. A storage oscilloscope display is required.

Figures 16 and 17 show the sin x/x signal at 1 MHz and 500 kHz per division respectively. Figures 18 and 19 are higher vertical resolution displays of Figures 16 and 17.

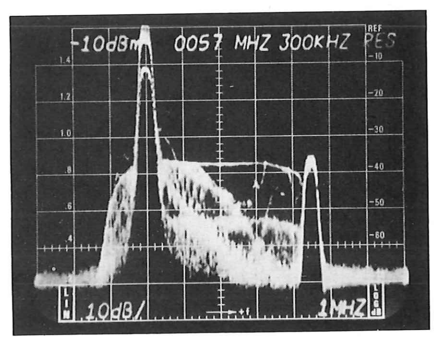

Figure 16. Sin x/x signal modulated on to the vision carrier (10 dB per division and 1 MHz per division).

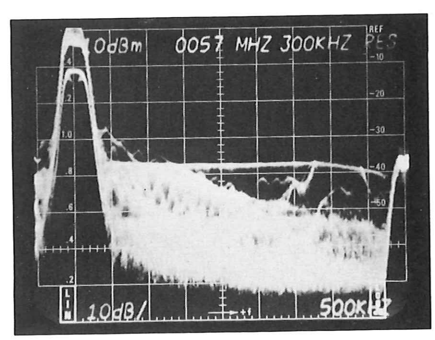

Figure 17. Sin x/x signal modulated on to the vision carrier (10 dB per division and 500 kHz per division).

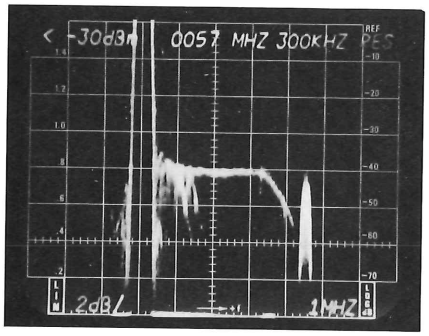

Figure 18. A 2 dB per division display of Figure 16.

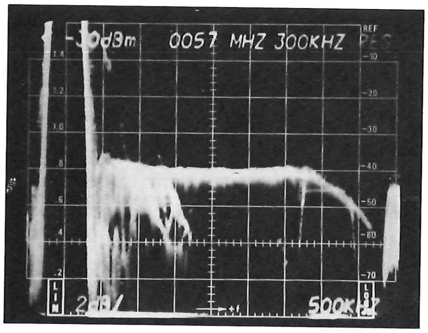

Figure 19. A 2 dB per division display of Figure 17.

The demodulated multiburst is shown in Figures 20 and 21. When compared with the demodulated sin x/x signal in Figure 22, there is amplitude correlation within 0.2 dB (referenced to 500 kHz) across the video band. The slight response differences between the sin x/x signal at the designated channel frequency (Figure 19) and the demodulated sin x/x signal (Figure 22) are due to the frequency response characteristics of the television demodulator.

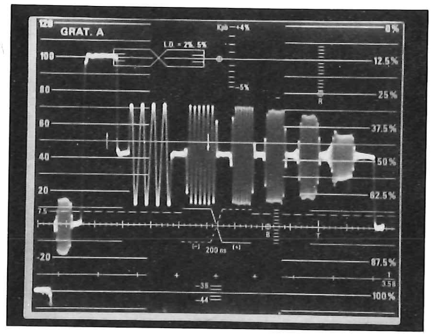

Figure 20. Demodulated multiburst test signal.

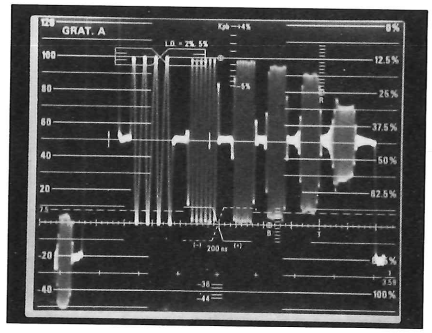

Figure 21. Demodulated multiburst test signal expanded to fill the 0 to 100 IRE range.

Amplitude Non-Linearity

When amplitude non-linearity exists in the device under test, the positive and negative going sin x/x pulse will suffer different kinds of distortion. The result of this will be a divergence of the two spectra as shown in Figure 23.

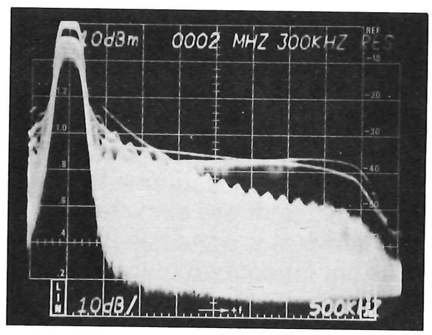

Figure 23. Sin x/x signal after passing through a non-linear system.

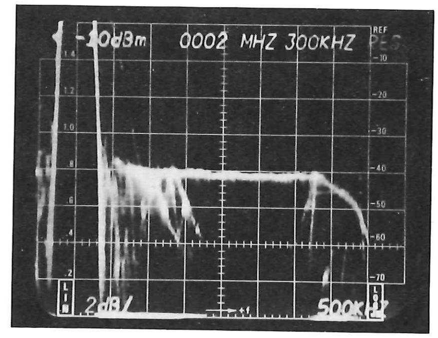

Figure 22. Demodulated sin x/x signal displayed at 2 dB per division.

This indicates that the frequency response of the device under test is different at different signal levels. When this occurs, determination of the actual frequency response characteristic can become difficult and the results subject to question.

If possible, the device under test should be adjusted to minimize non-linearity before using the sin x/x signal. Where this is not practical, the user should attempt to correlate results obtained with the sin x/x signal by employing alternate methods of frequency response testing. Two such methods of testing would be swept frequency and multiburst testing.

A requirement to do in-service testing would likely dictate use of the multiburst test signal. If testing is out-of-service, either a multiburst or swept frequency signal would be appropriate. In either case, the frequency response characteristic of the device under test should be noted for both full and reduced amplitude test signals to allow determination of the effects of non-linearity on the results. Full and reduced amplitude multiburst and sweep signals as provided by Tektronix 1410 Series Generators are shown in Figures 24 through 27.

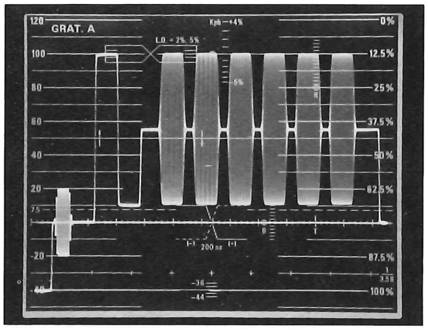

Figure 24. Full amplitude multiburst test signal.

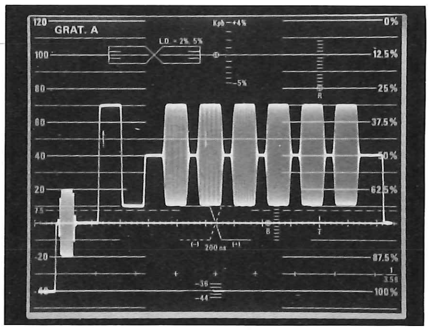

Figure 25. Reduced amplitude multiburst test signal.

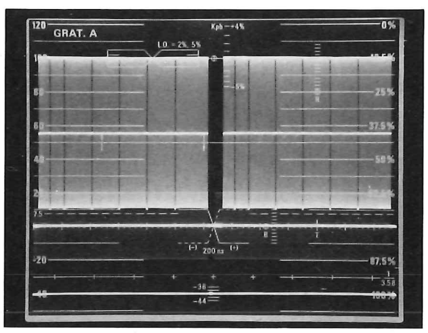

Figure 26. Full amplitude sweep signal with markers.

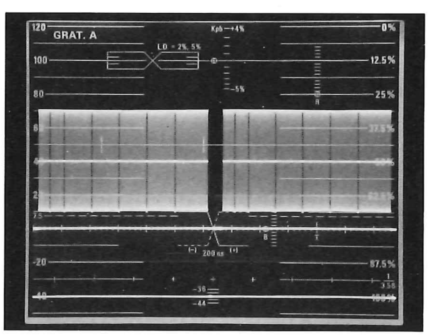

Figure 27. Reduced amplitude sweep signal with markers.

Summary

This application note has attempted to illustrate an easy means for doing frequency response testing using the sin x/x signal and a spectrum analyzer. The advantages of this method of testing are:

1. Continuous frequency coverage from 15 kHz to 4.75 MHz.
2. Sin x/x signal may be used as a VIT signal.
3. Elimination of the demodulator as a source of amplitude response error when testing TV transmitters.
4. Provision of an easily recognizable indication of amplitude non-linearity, thus alerting the user to verify results with alternate testing methods.

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