SIDEBAND ANALYSIS FOR TV

application note AX 2933-1

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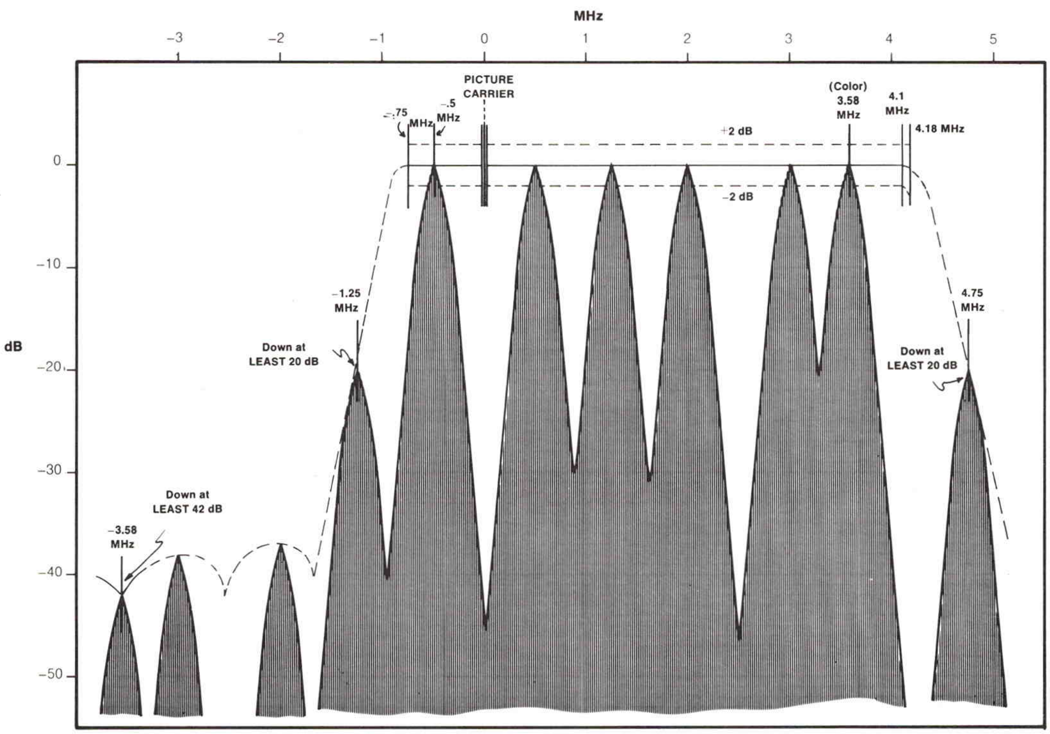

Figure 1. *Idealized Color Transmitter Response (Multiburst Superimposed)*

Presented herein are four techniques for sideband analysis, using the spectrum analyzer, all proven to yield excellent results. Some of the techniques are more applicable for **alignment**, and some work better for **measurements**. Any of the four can be used on any TV transmitter that operates up to 1.8 GHz. This includes UHF or VHF currently being used in the U.S.A. and every other known TV transmitting standard used in the world today.

Transmitter response specifications are defined by the FCC in §73.687. Figure 1 is a useful representation of a typical color television transmitter response. This is ideally what we would like the sideband analyzer to show. As a practical matter we can show the response curve, or with a multiburst, can show a representation of the curve with frequency domain "spikes". The relationship shown between the spikes and the response curve is valid as shown.

Background

Sideband Analysis is a basic response test performed on TV transmitters. Many stations, as a matter of preventive maintenance, perform sideband analysis daily before the beginning of the broadcast day. The results indicate the transmitter performance, tuning, vestigial sideband filter tuning, and overall response.

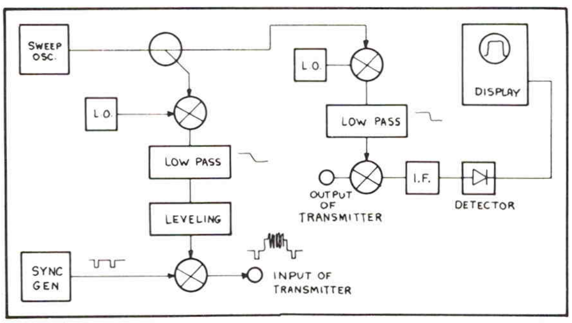

Figure 2. *Traditional Sideband Analyzer.*

The traditional sideband analyzer consists of a swept oscillator input (0-6 MHz) locked to a tracking display receiver as shown in Figure 2. Some sync information must be inserted to "trick" the transmitter into "thinking" it is passing a visual signal, as indicated.

We have developed less expensive, more flexible techniques to replace the traditional sideband analyzer. The displays may be unfamiliar at first, however, the measurement and alignment of TV transmitters is still the end result.

Advantages

Some of the advantages we have found with our new techniques follow:

1. The spectrum analyzer is a calibrated horizontal span device, making the use of markers unnecessary (however, the multiburst may be utilized to verify span accuracy if desired).
2. Within the scope of sideband analysis, we can attain higher versatility than possible with traditional units such as variable modulation levels, variable transmitter duty cycles, and independent analysis of the separate parts of the transmitting chain.
3. The spectrum analyzer may be used to check any channel **without** separate or special plug-ins, crystals, or demodulators. This is especially attractive for manufacturers and consultants where a variety of channels and situations may be encountered.
4. The displays of 2 dB/div and 10 dB/div are especially convenient and easy to understand.
5. Although a high quality spectrum analyzer could easily be justified with our new procedures, an analyzer has many more applications in TV and Broadcast stations, including measurement of such parameters as intermodulation distortions, signal to noise, hum, field intensity, modulation depth, and FM deviation.

Synopsis

The spectrum analyzer displays the sideband response in all four measurements. The TEKTRONIX 147A Test Generator produces a variety of test signals, including multiburst and full field noise signals.

Procedures 1 and 2 are the primary techniques to be used for sideband analysis. Using only the 147A and the spectrum analyzer, these two procedures are used to flatten the transmitter (between −.75 MHz and +4.1 MHz within ±1/4 dB), and then set the filter skirt shapes and lower 3.58 MHz trap.

Procedure 3 is an in-service test utilizing a single line of noise, available from the 147A or 1430 TEKTRONIX Test Sets. This test is particularly useful for mid-day tests, and evaluation of equipment while operating during icing conditions, after power failures, and during any period that air time must be maintained.

Procedure 4 is a non-synchronous version of traditional sideband analysis utilizing the spectrum analyzer and any generator capable of sweeping from approximately 0 to 6 MHz. It should be pointed out that presently the FCC rules do not recognize any sideband analysis techniques, other than tests using a sine wave oscillator (FCC §73.687). The implication is that the first proof of performance on a TV station must be performed with procedure 4. All subsequent tests may be performed using alternate procedures 1, 2 or 3.

#1 Full Field Noise Source Technique of Sideband Analysis

Capability

This technique is used to generate a display of the frequency response of a transmitter at 10 dB/div. This is particularly useful for seeing the vestigial sideband filter skirts down 50 dB or more, and for specific measurements of the lower −3.58 MHz notch filter, the lower −1.25 MHz rolloff point, and the upper +4.75 MHz rolloff point.

A wideband noise source is used as a signal source. The 147A or 1430 can be set up to provide full field flat noise across the video spectrum (0-6 MHz). The spectrum analyzer video filter will average the noise, such that the sideband response will be displayed. The advantages of this technique over the use of a tracking generator are cost, and no synchronization requirements. The primary disadvantages are that the noise source represents an appreciable amount of power that can, if improperly applied, overload the transmitter or the spectrum analyzer. (See Hints and Precautions.)

This is primarily a **measurement** technique, resolution around the picture carrier being limited. This technique used in conjunction with #2 will provide all the **measurement** and **alignment** functions normally required of a sideband analyzer.

Equipment Required

1. TEKTRONIX 7L12 or 7L13 Spectrum Analyzer
2. TEKTRONIX 7000 Series Mainframe
3. TEKTRONIX 147A NTSC Signal Generator or 1430 Random Noise Measuring Set

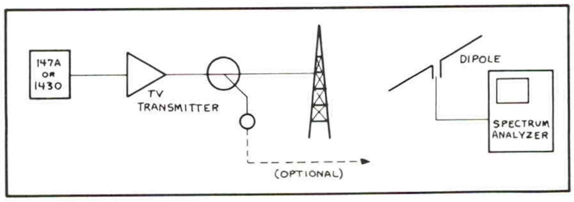

Figure 3. *Set-up Procedure #1*

Procedure

1. Setup the 147A or 1430 at the input of the transmitter. Many stations already have a 147A located in the transmitter loop that can be utilized. Set the controls for full field noise and dial in 20 dB of noise. (The 148 may be used on foreign standard systems.)

2. The 7L12 Spectrum Analyzer can be connected to either an R.F. testpoint, or a dipole of known response.

3. Using the 300 Hz filter, tune in the visual and aural carriers of the transmitter. The results will look similar to Figure 4 and 5.

4. Care should be taken to use the internal attenuator on the 7L12, so that the analyzer is not in an overload condition. Generally, a display similar to Figure 4 or 5 is correct, whereas a raised baseline 10 MHz or more away from the picture carrier is almost a sure indication of a overload condition. (See Hints and Precautions.)

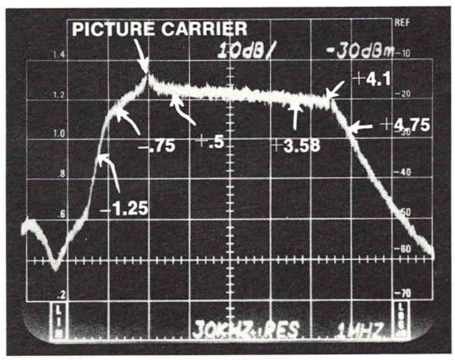

Figure 4. *Sideband Response Using Noise (1 MHz/DIV).*

Procedure Hints

The Z axis input on the Tektronix 7613 requires about 10 volts to turn off the intensity axis entirely. To facilitate fine control of the Z axis, it is recommended that a buffer amplifier such as a 7A15 vertical be used in the mainframe. Also, the signal available for Z axis modulation from either a Tektronix 147A or 529 must be inverted by the buffer.

The vertical amplifier can be connected from the rear panel VERT SIG OUT to the Z AXIS with a BNC cable. The VERT SIG OUT is selected by pushing the LEFT TRIGGER SOURCE.

The Z axis keying source is then obtained by either connecting a test probe into the program panel of a 147A or 1430 on the line jumper corresponding to the noise line selected. The key source may also be obtained from the VIDEO output of a modified 529 waveform monitor. Modify the monitor by disconnecting R198.

The line intensify action can be tested by selecting the LEFT VERT MODE of the mainframe and observing the intensify pulse on the oscilloscope display. By adjusting the VERTICAL GAIN and POSITION controls of the buffer (7A15) it should be possible to obtain an intense bar corresponding to the line containing the half line of noise.

Then connect the RF of the TV transmitter to the spectrum analyzer plug-in and select the RIGHT VERT MODE. By using storage and adjusting the INTENSITY, a display of the sideband response should appear as shown in Figure 10 or 10a (enclosed). Figure 10a is normally the resultant display and shows the sideband response outline.

Final flatness checks in-service should be performed with the same procedure using MULTIBURST.

#4 Sideband Analysis Using A Non.Synchronous Sweep

Capability

This procedure satisfies the FCC initial proof of performance requirement for using a sinewave source [FCC §76.687 (4)]. This technique is also particularly useful for checking response close to the picture carrier, the limit being 300 Hz for the 7L12 Spectrum Analyzer. One can usually expect to see about 10 kHz from the picture carrier with the typical sweep generator.

This procedure can also utilize a leveled CW generator **manually** tuned from 0 to 6 MHz with quite usable results.

Equipment Required

1. TEKTRONIX 7L12 or 7L13 Spectrum Analyzer
2. TEKTRONIX 7613 Variable Persistence or 7313 Storage Mainframe
3. Wavetek 1801A38 Sweep Generator with 15 kHz modulator

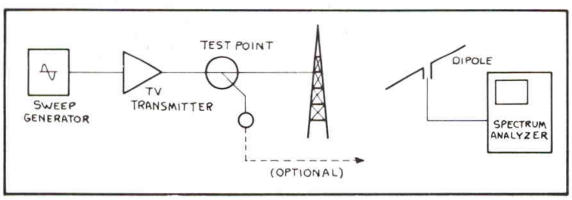

Figure 12. *Set-up Procedure #4.*

Procedure

1. Set up the sweep generator at the transmitter input. Use the +57 dBmV output setting (1/2 volt) and the 15 kHz Square wave modulation. The pin diode attenuator used in the Wavetek 1801A38 makes it possible to attain a symmetry similar to standard video, with the 15 kHz bringing the total envelope to 1 V p-p.

2. The 7L12 (or 7L13) Spectrum Analyzer can be connected to either an R.F. test point, or a dipole of known response, (for remote monitoring or antenna characteristic measurements).

3. Using a 30 kHz RESOLUTION BW, the spectrum analyzer is tuned to the output frequency of the transmitter.

4. Either 1 MHz or 2 MHz per division can be selected and the channel can be centered as desired. For convenience, we have centered the picture carrier always on the 4th graticule line from the left when using 1 MHz per division.

5. The sweep generator should be swept slowly (3-5 sec/MHz) from 0 to 6 MHz, while using a fast sweep rate. The fastest sweep rate that can be used on the analyzer can be determined by observing sweep rate error on the picture and sound carriers.

6. The results will be similar to those observed in Figures 13 and 14.

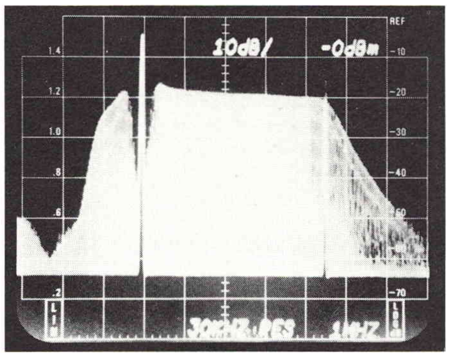

Figure 13. *Non-Synchronous Sideband Analysis Using A Sweep Generator (1 MHz/DIV).*

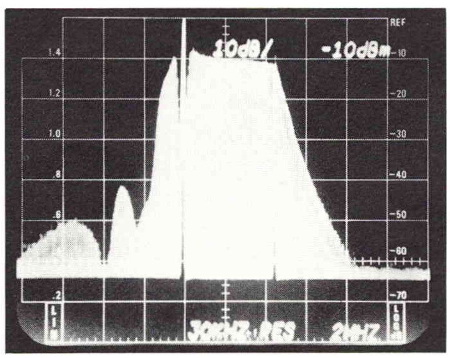

Figure 14. *Non-Synchronous Sideband Analysis Using A Sweep Generator (2 MHz/DIV).*

#3 In-Service Sideband Analysis Using The Vertical Interval

Capability

These procedures can be used while the transmitter is in-service, causing no visible picture impairment. Many times during icing and other less desirable conditions, it would be nice to verify the performance of the transmission line, filters and antenna.

Procedure #3 can do just that. Noise and Multiburst signals can be inserted in the VIT interval, and sideband analysis can be performed.

The displays take approximately 30 seconds to build up on the screen of a storage oscilloscope, making this primarily a **measurement** technique.

Theory of Measurement

The spectrum analyzer sweeps a complete TV channel and would display all frequency information including effects due to sync, color subcarrier and picture content. In addition, any test signals inserted during the vertical interval would be displayed simultaneously. Normally, it would be almost impossible to separate the test signals from the different random picture components with the naked eye.

Procedures devised to separate signals could involve either of two approaches. The analyzer input could be turned "on" only during the test signal interval, or the analyzer could be left running normally and the display intensity could be keyed "on" during a particular test signal. We chose to use the latter method in procedure #3.

Equipment Required

1. TEKTRONIX 7L12 or 7L13 Spectrum Analyzer
2. TEKTRONIX 7613 Variable Persistence or 7313 Storage Mainframe
3. TEKTRONIX 147A NTSC Signal Generator
4. Line trigger 529, 147A or 1430
5. TEKTRONIX 7A15 or other 7A-series amplifier.

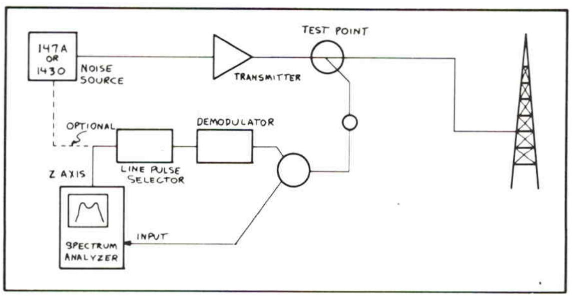

Figure 9. *Set-up Procedure #3*

Procedure

1. Set up the 147A or 1430 at the input to the transmitter. Set the controls for noise insertion on 1/2 line and the dial should indicate 20 dB.

2. The 7L12 (or 7L13) Spectrum Analyzer can be connected to either an R.F. test point, or a dipole of known response.

3. A means must be provided to supply a pulse to the Z (intensity) axis of the spectrum analyzer during the noise **line** selected. This pulse can be obtained from the 529 video output jack located on the rear panel. When the spectrum analyzer is used in the same location as the noise inserter (147A or 1430), a pulse can be obtained from the program panel for any line desired.

4. Using storage, a picture of the sideband response will be slowly 'painted' upon the screen similar to Figure 10.

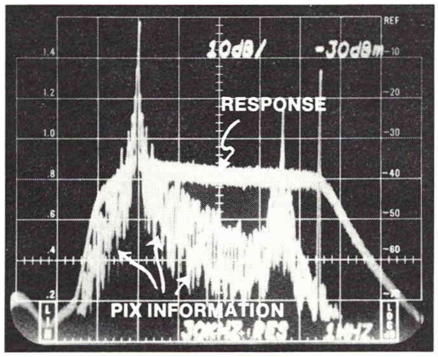

Figure 10. *In-Service VIT Sideband Analysis Using Noise*

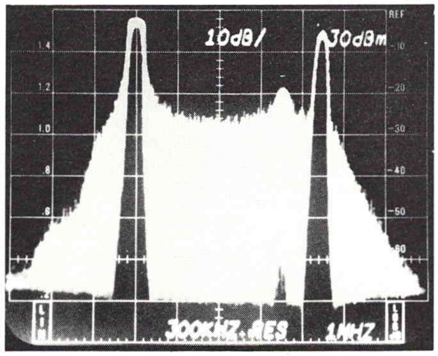

Figure 10a. *In-Service VIT Sideband Analysis Using Noise*

5. As an alternate, the multiburst **line** can be selected to energize the Z axis and a picture of the R.F. response can be obtained as in Figure 11. This picture closely matches the sideband response of a transmitter.

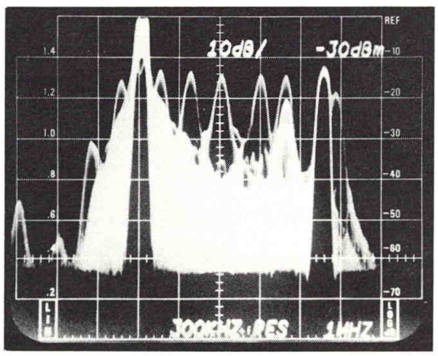

Figure 11. *In-Service VIT Sideband Analysis Using Multiburst*

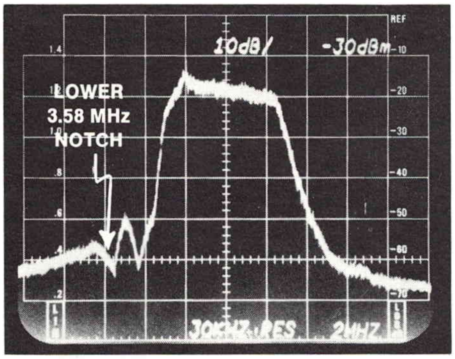

Figure 5. *Sideband Response Using Noise (2 MHz/DIV).*

5. The lower sideband color notch location can be identified by alternately switching in a multiburst signal to identify the position. Then using the full field noise source, the notch should be measured or adjusted to be 42 dB or more below the average working part of the vestigial sideband filter as indicated in Figure 5.

6. Critical points on the filter curve of −1.25 MHz, −.75 MHz, +.5 MHz, +3.58 MHz, +4.1 MHz and +4.75 MHz can be easily identified and measured in the 1 MHz/div, 10 dB/div mode on the spectrum analyzer as indicated in Figure 4.

7. If discrepancies are noted at −3.58 MHz, −1.25 MHz, or +4.75 MHz, the displays obtained in the procedure (#1) should be used for alignment of the transmitter.

8. If minor flatness discrepancies are noted between −.75 MHz and +4.1 MHz, then use procedure #2 which follows.

#2 Using The Multiburst For Flatness Adjustments.

Capability

This procedure is used primarily to align for flatness between the lower −.75 MHz and upper +4.75 MHz. The spectrum analyzer is used in the 2 dB/div mode such that resolution of ±1/4 dB is practical.

The multiburst signal is normally composed of six distinct frequencies, .5 MHz, 1.5 MHz, 2 MHz, 3 MHz, 3.58 MHz, and 4.2 MHz. These are sent in rapid succession for use in determining frequency response with a standard oscilloscope. Multiburst can, however, also be displayed in the frequency domain on a spectrum analyzer for use in studying the sideband response characteristics of a transmitter. While the multiburst does not represent every frequency between 0 and 6 MHz, an excellent representation of the transmitter response can be obtained by first flattening the transmitter using the multiburst, then verify overall response using the noise technique (#1).

Some may wish to use the multiburst as a marker. The Tektronix generators can be readjusted so that the 1.5 MHz burst is 1.25 MHz, and the 4.2 MHz burst is 4.1 MHz. The .5 MHz may also be adjusted to .75 MHz. All of these changes will help identify the critical points on the response curve (per Figure 1) although the calibrated span of the spectrum analyzer makes the use of markers unnecessary.

Equipment Required

1. TEKTRONIX 7L12 or 7L13 Spectrum Analyzer
2. TEKTRONIX 7000 Series Mainframe
3. TEKTRONIX 147A NTSC Signal Generator

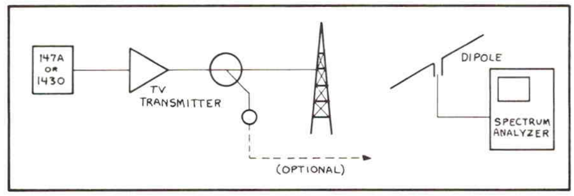

Figure 6. *Set-up Procedure #2*

Procedure

1. Setup the 147A at the input of the transmitter. Many stations already have a 147A located in the transmitter loop that can be utilized. Set the controls for a full field multiburst signal. (The 148 may be utilized on foreign standard systems.)

2. The 7L12 Spectrum Analyzer can be connected to either an R.F. test point or a dipole of known response.

3. Using a 30 kHz RESOLUTION and 1 MHz or 2 MHz per division, tune in the picture and sound carriers. Slow down the SWEEP until scan loss is eliminated. The display will look similar to Figures 7 and 8.

4. Using 2 dB/div on the Spectrum Analyzer, tune the transmitter for maximum flatness from −.75 to +4.1 MHz.

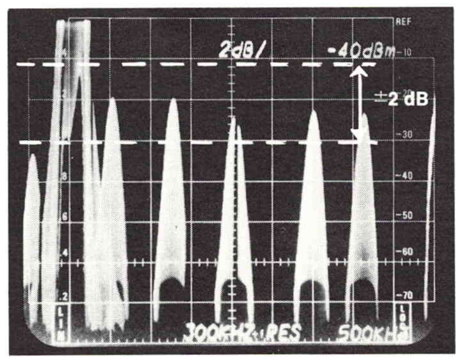

Figure 7. *Sideband Response Using Multiburst (2 dB/DIV)*

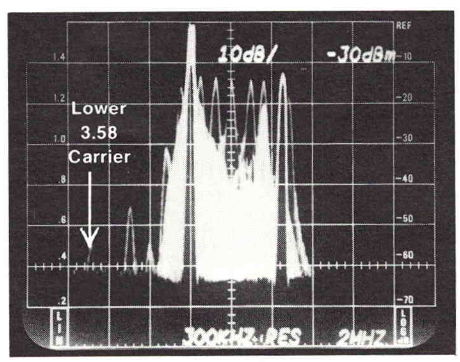

Figure 8. *Sideband Response Using Multiburst (10 dB/DIV)*

5. A modulation depth of up to 100% can be selected with the front panel controls on the 147A to verify transmitter performance under different load conditions.

Hints And Precautions

CAUTION

1. You are working with an expensive, high powered R.F. Transmitter. Take appropriate precautions to insure that operating parameters are not exceeded.

2. A sideband analyzer can cause adjacent channel interference when the TV transmitter is out of alignment, and should be handled carefully until proper alignment is attained.

3. Flat, white noise used for frequency response represents a lot of power. Most transmitters can be overloaded quite easily. Care should be exercised, not to exceed output power or final plate current ratings.

4. A high power R.F. transmitter can easily overload the mixer in the spectrum analyzer. R.F. test points should be "padded down" to 0 dBm **before** connecting the spectrum analyzer to the test point. An overload generally appears as an erratic display similar to Figure 16. Insert attenuation with the internal or external pads until the display appears similar to Figure 15 and remains stable.

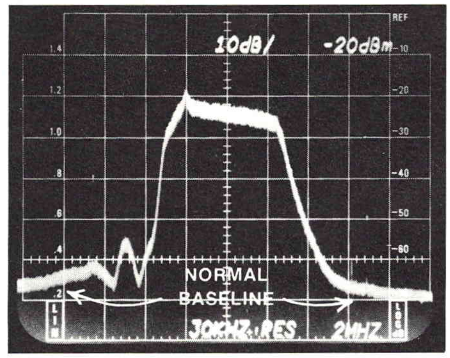

Figure 15. *Normal Display*

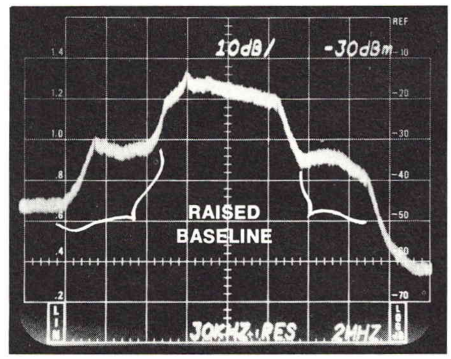

Figure 16. *Overload Display*

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