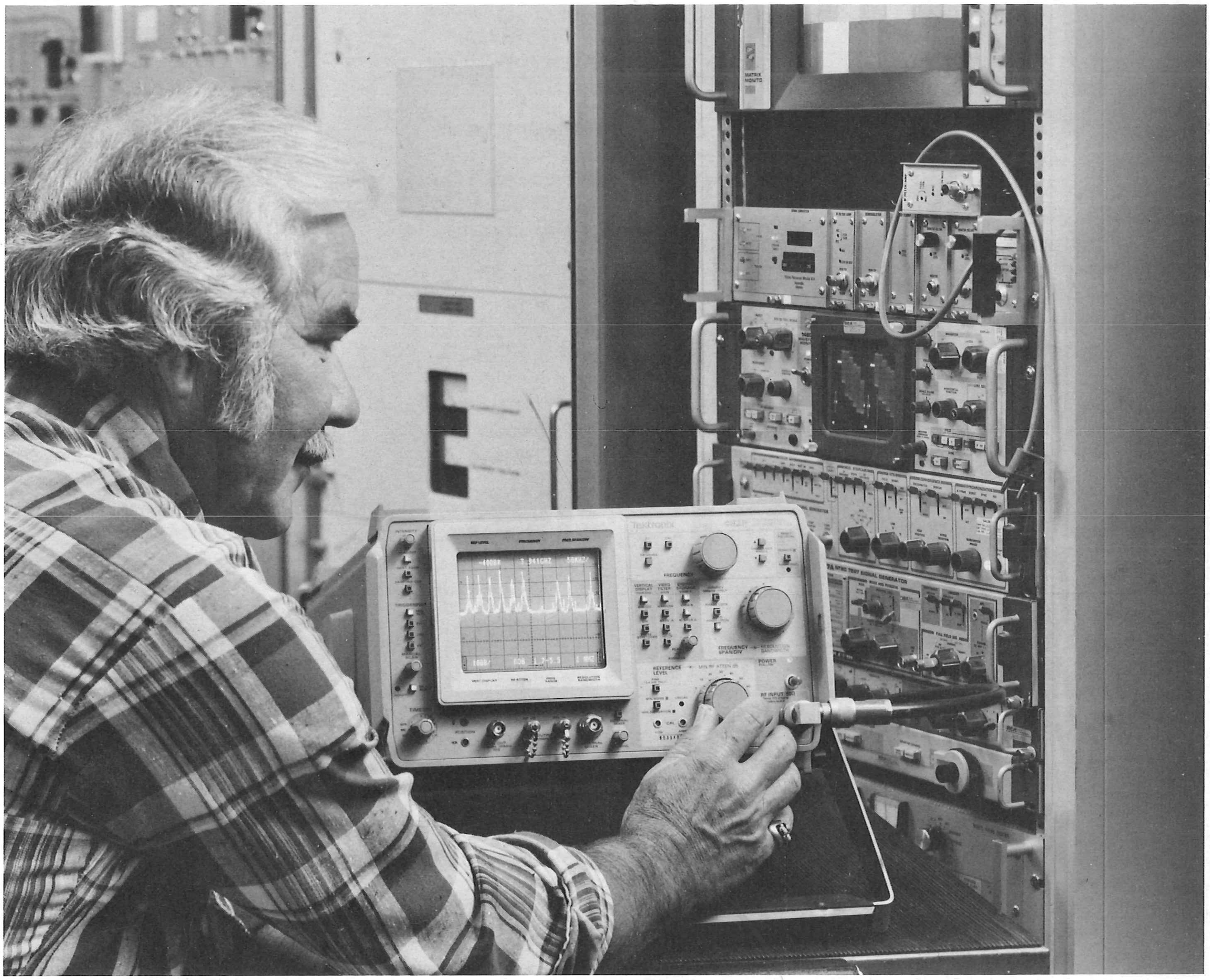
NO LOOSE ENDS — REVISED

THE TEKTRONIX PROOF-OF-PERFORMANCE PROGRAM FOR CATV



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Introduction

In today's competitive market, it is important that CATV systems provide their subscribers with high quality signals. FCC proof requirements and the installation of high capacity two-way systems have increased the necessity for proper adjustment and maintenance procedures.

Spectrum analyzers are the best all around measurement tools for CATV systems. The entire CATV spectrum can be viewed at a glance or one channel selected for close scrutiny. Very large and very small signals can be seen simultaneously. Maintenance is easier because the effects of any adjustment can be instantly noted. Quality test equipment is available today but many operators will not benefit from it due to a lack of proper measurement techniques.

This application note will help the reader to use the spectrum analyzer to measure many critical CATV parameters. Emphasis is placed on the proper technique which is vital for accuracy and repeatability. Each procedure includes an equipment list, a setup diagram, a step-by-step measurement sequence and photographs of the results, leaving "No Loose Ends".

1. Carrier Amplitude Measurements

Capability

Tektronix spectrum analyzers are capable of measuring signal levels accurately within the range of −42 dBmV to +79 dBmV. In addition, carriers with amplitude differences up to 80 dB can be displayed simultaneously on the screen in the 10 dB/DIV mode.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14 Plug-in.
2. Mainframe: Tek 7613 or any 7000 Series mainframe.
3. Minimum Loss Pad: Tek P/N 011-0112-00 (or 011-0118-00 Impedance Matching Pad).
4. F to BNC Adapter: Tek 013-0126-00.
5. Camera (optional): Tek C-5C or equivalent.
6. Preamplifier: Tek 7K11 plug-in (except when 7L14 is used).

Procedure

1. Verify the calibration of the spectrum analyzer using the internal calibrator. Also check vertical and horizontal position. (See analyzer manual.)
2. Set up the 7613 mainframe as follows:
   a. VERTICAL MODE: RIGHT (7L12) or LEFT (7L14)
   b. TRIGGER SOURCE: VERT MODE
   c. INTENSITY: 12 o'clock or as required for a usable display
   d. READOUT: 12 o'clock or as required to match trace intensity
   e. GRATICULE ILLUMINATION: Max clockwise
   f. MODE: NON-STORE
3. Set up the spectrum analyzer as follows:
   a. FREQUENCY: About 64 MHz Center mode (7L12)
   b. MODE: NORM
   c. SOURCE: FREE RUN
   d. TIME/DIV: 10 ms
   e. FINE: Both knobs centered
   f. LOG: 10 dB/DIV
   g. BASE LINE CLIPPER: Max counterclockwise
   h. CONTRAST: Max clockwise
   i. REFERENCE LEVEL: −30 dBm; RF ATTENUATION (outer ring): 10 dB (Adjust outer ring for 10 dB in window, and then adjust bar knob for −30 dBm); REF VAR: Calibrated
   j. VIDEO FILTER: Both buttons OUT
   k. VIDEO PROCESSOR: OFF
   l. AUTO PHASE LOCK: ON
   m. RESOLUTION: 300 kHz (outer ring)
   n. FREQUENCY SPAN/DIV: 2 MHz
4. Connect the subscriber tap to an F to BNC adapter. Connect the adapter to the Minimum Loss Pad and then to the spectrum analyzer's RF IN connector. See figure 1-1.
5. Using the FREQUENCY knob, center the channel 2 picture carrier over the first graticule line from the left.
6. Slowly turn the BASELINE CLIPPER clockwise to clip as much of the grass at the bottom of the screen as desired. Your display should look similar to that shown in figure 1-2.

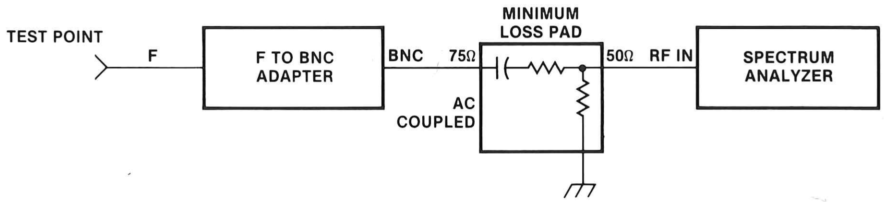


Figure 1-1. Equipment connection for amplitude measurements.

Note:
The photos in this application note were all taken with a Tektronix 7L14 Spectrum Analyzer in a 7613 Mainframe. Except for differences in the CRT readout, results obtained with a 7L12 Spectrum Analyzer will be the same. In some cases the 7L14's digital storage was turned on to show its advantages. These cases are noted in the text.

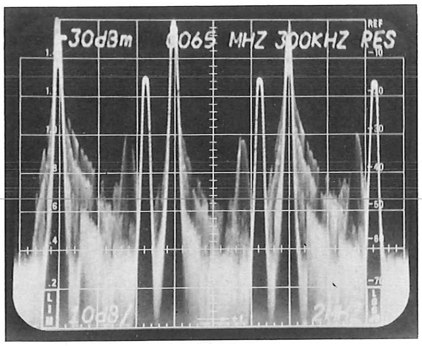


Figure 1-2. Channels 2, 3 and 4.

7. Picture and sound carrier amplitudes can now be measured on the 7L12. Since the reference level of the 7L12 is −30 dBm, an input signal must have an amplitude of −30 dBm to reach the top line (REF) of the graticule. Using the vertical scale factor of 10 dB/DIV, note the signal amplitude at the tip of each displayed carrier.

   If you are using the Tek Minimum Loss Pad 011-0112-00, the conversion to dBmV can be accomplished by adding 54.5 dB to every level read. If the Tek Impedance Matching Pad 011-0118-00 is used, the conversion to dBm can be accomplished by adding 60 dB to every level read.

   EXAMPLES: Picture carrier for channel 2 in figure 1-2 is:

   −30 dBm + 54.5 dB
   = 24.5 dBmV

   The sound carrier for channel 2 is:

   −45 dBm + 54.5 dB
   = 9.5 dBmV

   The difference between the picture and the sound carrier is:

   (−30 dBm) − (−45 dBm)
   = 15 dB

Hints, Notes and Precautions

1. The Tektronix Model 7K11 CATV Preamplifier automatically converts from 75 ohms and dBmV to 50 ohms and dBm making conversions unnecessary. It directly reads out the REF LEVEL in 7000 Series oscilloscopes.
2. The 7L14's digital storage capability makes carrier amplitude measurements easy. (See figure 1-3.) Position the PEAK/AVERAGE cursor at the bottom of the display so that the storage circuitry will capture the sync tip amplitude. Digital storage is especially valuable where slow speeds must be used.

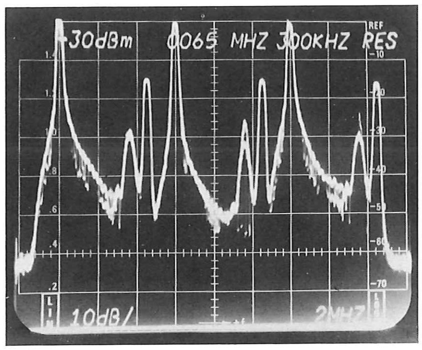


Figure 1-3. Amplitude measurements using the 7L14's digital storage.

3. In the preceding amplitude measurements, 10 dB of input RF attenuation was used to provide a good termination and thus improve accuracy. Depending on the levels being read, the input attenuation and IF gain can be adjusted to bring the largest carrier within the top division of the screen. This adjustment makes carrier signal measurements more convenient.
4. High sweep speeds can cause inaccurate amplitude readings.
5. The 2 dB/DIV mode gives highly accurate amplitude readings. Differences of 0.1 dB can easily be read. Absolute measurement accuracy is about ±1 dB.

   To use this mode, first use the REFERENCE LEVEL controls to bring the input signals to within 10 dB of the REF LEVEL (top of screen). As you press the 2 dB/DIV button, the top 1.6 divisions of the screen are expanded to fill the 8 vertical divisions of the graticule. If the signal is too small to display in this mode, the beam will stop at the bottom graticule line. The INTENSITY and BASE LINE CLIPPER controls may need readjustment when using this mode.
6. As the spectrum of a TV channel is observed, the effect caused by the vertical interval will be seen rolling through the display. This effect is observed because each sweep takes a period of time. When the vertical interval is transmitted, the amplitude of its spectrum at the frequency the analyzer happens to be tuned to is displayed.

   The spectrum of the vertical interval is quite different than the rest of the signal. The carrier is held at full power for a duration of three lines which produces a bright bar at the sync tips. The chroma burst is omitted causing a gap in the chroma spectrum, and so on. These effects are both useful and annoying.
7. Accurate carrier amplitude and flatness measurements can be made only when all connections preceding the Minimum Loss Pad are maintained at an impedance of 75 ohms. This requirement deserves careful checking. In other cases, where measurements are made relative to carrier amplitude over narrow frequency ranges, the signal to be measured can be directly connected to the 50-ohm input to the analyzer.

2. Intermodulation

Capability

The spectrum analyzer is a valuable tool for intermodulation analysis, producing graphic, easy-to-understand results. It can be used at any point in the system to systematically locate the source of a beat problem, or to optimize equipment for a minimum beat condition. Depending on the subscriber tap level, it may be necessary to use a preamplifier to increase the sensitivity of an analyzer. Careful adjustment is indicated to ensure that spurious products are not generated in the preamplifier.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or any 7000 Series mainframe.
3. Preamplifier: Tek 7K11 (Optional. Not usable with 7L14.)
4. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00 or equivalent.
5. F to BNC Adapter: Tek 013-0126-00 or equivalent.

Procedure

1. Set up the equipment as illustrated in figure 2-1.
2. Select a frequency span of 0.5 MHz/DIV, 300 kHz resolution bandwidth and the 10 dB/DIV display mode. Tune in the channel to be tested.
3. Once a beat signal has been located, it can be measured by comparing the peak video carrier level to the peak beat level (figure 2-2).

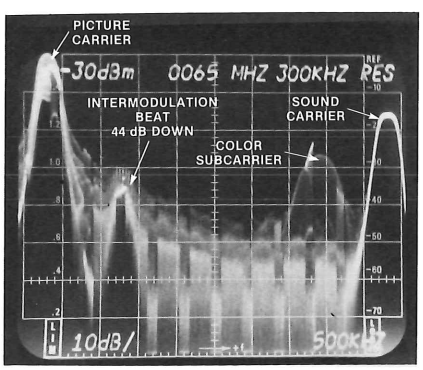


Figure 2-2. Intermodulation measurement.

4. Intermodulation and random beats also can be located below (to the left) of the picture carrier as shown in figure 2-3. When searching for beat signals, use the FREQUENCY control to slowly pan across the entire channel. To obtain satisfactory results, intermodulation measurements must be performed both slowly and carefully.
5. The sensitivity of the intermodulation measurements may be increased at low subscriber tap levels by using the 7K11 CATV Preamplifier with steps 1 through 5. See Hint #4.

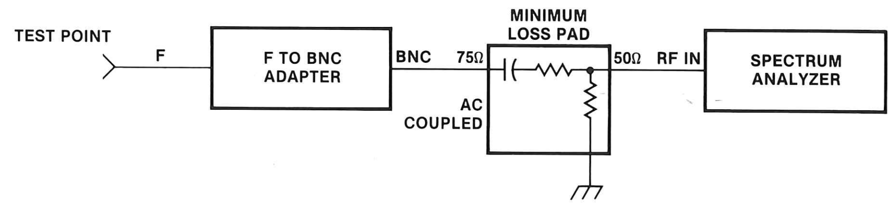


Figure 2-1. Equipment connection for intermodulation measurements.

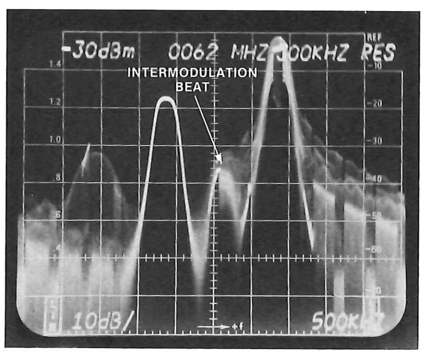


Figure 2-3. Intermodulation beat below the picture carrier.

Hints and Precautions

1. Select a flicker-free sweep rate to cause the video information to move across the screen without obscuring any of the beats.
2. Sometimes a beat can be detected although its level is below noise level. The noise around a beat contains a bump or hollow spot as shown in figure 2-4.
3. Vary the resolution bandwidth, sweep rate and video filters on the analyzer while adjusting the intensity and persistence to attain carriers that appear clear and distinct.
4. Verify that a beat is not a product of the preamplifier by decreasing its reference level by 3 dB. If the preamplifier is causing a problem, this 3 dB reduction in level will cause a reduction greater than 3 dB in the beat amplitude. For best results, protect the 7K11's input from overload with a bandpass filter.

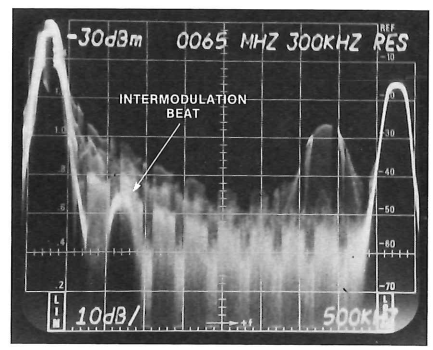


Figure 2-4. Low level intermodulation beat.

3. Composite Triple-Beat Measurements

Capability

In combination with other test equipment, the Tektronix 7L12 Spectrum Analyzer will make composite triple-beat measurements to 80 dB below the picture carrier. Triple-beats are caused by distortion in the distribution amplifier(s) which forms sums and differences from three different picture carriers. As the number of carriers increase, the number of triple-beats becomes very large. In a

35-channel system for instance, 353 beat signals fall on or near channel 11's picture carrier. Since there are so many triple-beat products, the sum of all the beats is measured instead of the individual amplitudes. This requires great care. Since CW carriers must be substituted for all the picture carriers in the system, the CATV system must be taken out of service to perform this measurement.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or any 7000 Series mainframe.
3. Preamplifier: Tek 7K11 (Except when 7L14 is used.)
4. Multiple Signal Generator: Matrix model SX-16 or equivalent.
5. Bandpass Filter: Tuneable or fixed for channel to be tested (normally channel 11).

   EXAMPLE: Wavetek 5200 Series or equivalent.
6. Adapters: As required.

Procedure

1. At the headend, disconnect the normal headend equipment. Connect the multiple signal generator to the distribution trunk. (A possible alternative is to disconnect all inputs to the headend processors and modulators and use their substitution carriers to provide a CW carrier at the frequency of each picture carrier.) Carefully verify the amplitude of each carrier.
2. Connect the test equipment shown in figure 3-1 at the test point in the distribution system. The bandpass filter must pass the picture carrier of the channel to be tested. Channel 11 is normally used for this measurement. The 7K11 Preamplifier is unnecessary when a tap level of +20 dBm or greater is available.

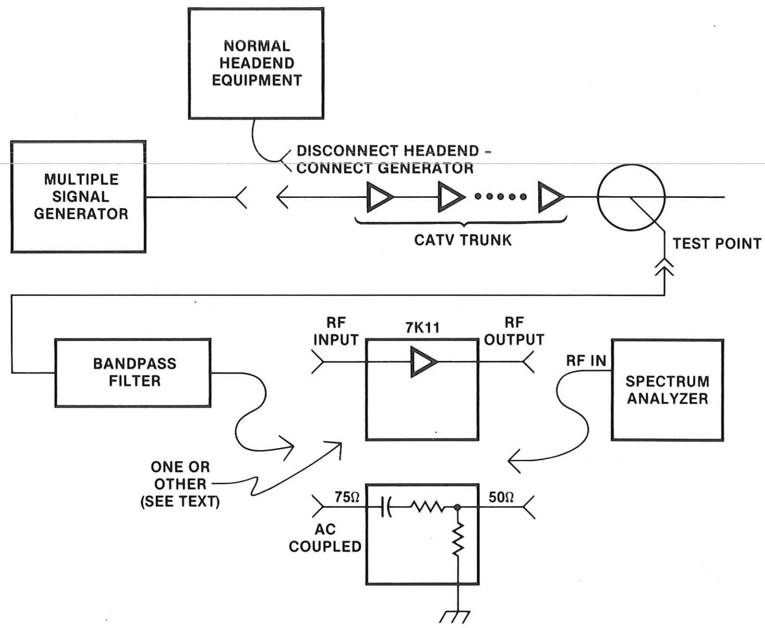


Figure 3-1. Equipment connection for composite triple-beat measurement.

3. On the spectrum analyzer, select a frequency span of 1 MHz/DIV and a resolution bandwidth of 300 kHz. Center the picture carrier and use the 7K11 REFERENCE LEVEL controls to bring the peak carrier to the reference level. Use REF VAR on the analyzer if the 7K11 is not used. If a variable bandpass filter is used, rock the tuning to maximize the signal level.
4. Narrow the FREQUENCY SPAN to 50 kHz/DIV and select the 30 kHz resolution bandwidth. Center the carrier on screen. Select a 300 Hz video filter and slow the sweep speed.
5. Change the 7K11 REFERENCE LEVEL control to lower the reference level by 10 dB. If the reference level of the 7K11 is less than 10 dBmV, increase the IF gain on the 7L12 by 10 dB. The carrier to be tested is now ten dB off the top of the screen. Have someone at the headend turn off this picture carrier.
6. The composite triple-beat will appear below where the carrier was (figure 3-2). Starting at the carrier amplitude (10 dB off screen), measure down to the middle of the triple-beat response. Since the composite triple-beat consists of multiple independent signals, the measurement on the spectrum analyzer screen will read low by 2.5 dB. Correct the measurement results by subtracting 2.5 dB from the measured value. For example, in figure 3-2 the composite triple-beat measures 66 dB below the carrier. The beat is actually 66 dB − 2.5 dB or 63.5 dB below the carrier.

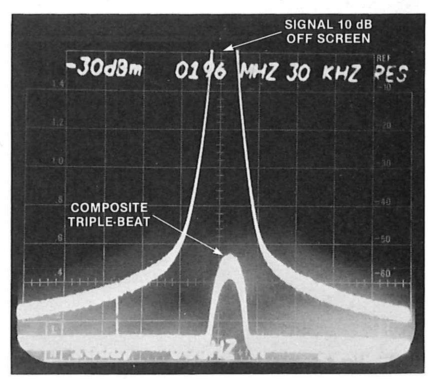


Figure 3-2. Composite triple-beat measurement (multiple exposure photograph).

Hints and Precautions

1. The pilot carriers must be left on (if used) so that distribution system is at its normal operating amplitude.
2. It is best to check the measured results by raising the level of the carriers by 3 dB with respect to the pilot carriers. If the amplitude of the composite triple-beat rises by 9 dB, the measured composite triple-beat is valid. If it does not, check to make sure the correct signal was measured or verify that all the distribution amplifiers are operating properly.
3. Very low triple-beat levels can often be measured by raising the signal amplitudes in the distribution system until the measurement can be made. The normal amplitude of the composite triple-beat is the level measured minus three times the amount the system amplitudes were raised to make the measurement.
4. If a 7L14 is used, move the PEAK/AVERAGE cursor to the top of the screen and slow the sweep to 1 sec/DIV. The 7L14's digital storage makes the measurement much easier. Figure 3-3.

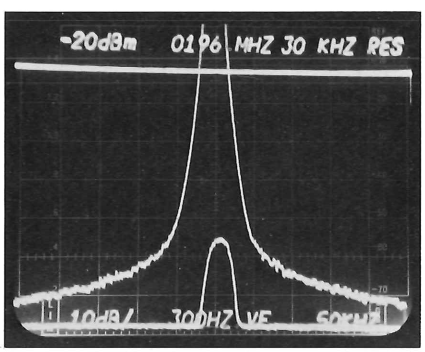


Figure 3-3. Composite triple-beat measurement using the 7L14's digital storage.

4. Frequency Measurements

Capability

The following procedure can be used to measure FCC specified visual and aural frequencies for CATV. Processors are available that (combined with a counter) enable carrier measurements to be completed quickly and easily. However, the zero-beat method listed here is more flexible and can be used to measure the frequencies of low-level signals or other signals such as pilots, random beats, and spurs that may not be within the range of a given signal processor.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or other 7000 Series mainframe.
3. Signal Generator: Stable CW source (must be easily tunable over small frequency changes).
4. Frequency Counter: Tek DC508A.
5. Two-way Hybrid Splitter (2): Jerrold 1596A or equivalent.
6. Attenuator: 75 ohm, 0 to 70 dB in 1 dB steps.
7. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00 or equivalent.
8. F to BNC Adapter: Tek 013-0126-00 or equivalent.

Procedure

1. Interconnect the equipment as illustrated in figure 4-1.
2. Set the spectrum analyzer controls to select:
   a. 55.25 MHz FREQUENCY (Channel two picture carrier)
   b. 200 kHz/DIV
   c. 300 kHz RESOLUTION BANDWIDTH
   d. 1 ms/DIV Sweep Speed
   e. 10 dB/DIV
3. Adjust the signal generator for a CW signal of 55.25 MHz. Increase the generator's output amplitude until the counter reads correctly.
4. Adjust the attenuator until the picture carrier and the generator appear at the same amplitude on the spectrum analyzer. It may be necessary to slightly readjust the frequency of the CW signal so that the two amplitudes can be easily compared.
5. Carefully adjust the frequency of the signal generator so the CW signal and the carrier slide together. A zero-beat pattern will be noted just as they cross over one another. (See figure 4-2). If necessary, rock the generator's amplitude slightly to maximize the depth of the null.

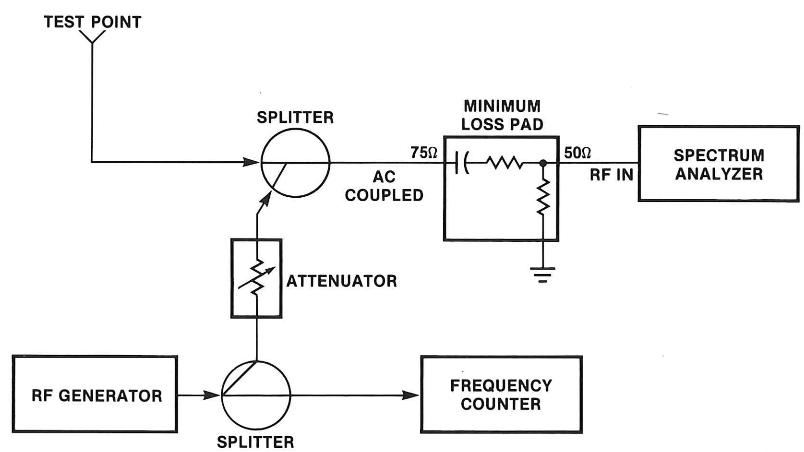


Figure 4-1. Equipment connection for frequency measurement.

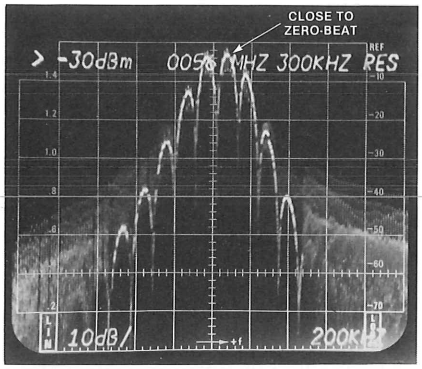


Figure 4-2. Frequency measurement.

6. Carefully trim the fine frequency adjustment on the signal generator to minimize the frequency of the beat (the fewest number of cycles per horizontal division). The frequency indicated on the frequency counter is the frequency of the channel two carrier.
7. The sound carrier is measured in the same manner. However, a series of frequency readings should be taken and averaged. This method may be tedious but is necessary for accuracy.

Hints and Precautions

1. A mechanical or electronic vernier should be incorporated in the signal generator as an aid in finding the zero-beat frequency. A standard utility CW generator can be used if your sweep generator is not equipped for stable operation.
2. For the aural measurement, also monitor the signal with a radio or TV set. Making the measurement during quiet periods simplifies the process and produces the most recognizable beats.
3. When the two signals are close together in frequency, finding the zero-beat point is sometimes facilitated by switching the analyzer to 0 Hz/DIV (or Zero Span). After changing the FREQUENCY SPAN control use the FINE TUNING controls to maximize the displayed signals.
4. Measurement error can be easily estimated when measuring in Zero Span. Note the period of the beat using the TRIGGERING controls and the TIME/DIV control as you would on an oscilloscope. The frequency difference between the CW signal and the carrier is the reciprocal of this period.
5. If you do not have a CW generator or counter that tunes high enough, it is often possible to use the second or third harmonic output of the generator. Multiply the counter reading by the harmonic number of the signal you are using.
6. A carefully matched 75 ohm system is not required for this measurement.
7. In theory, it is possible to zero beat a 15.75 kHz sideband instead of the carrier. In practice it is quite difficult and looks different than a carrier zero-beat. Figure 4-3 shows what such a zero-beat looks like. Note the lack of the bright line outlining the beat note.

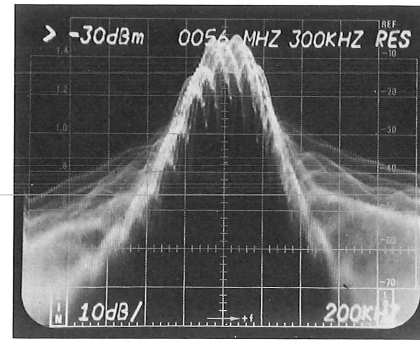


Figure 4-3. Near-zero-beat on 15.75 kHz sideband.

5. Co-channel Interference Measurements

Capability

Co-channel interference measurement capabilities of the 7L12 Spectrum Analyzer are graphically represented in figure 5-1. These curves are valid for a resolution setting of 3 kHz. The signal level at a normal subscriber tap (0 to + 5 dBmV) is sufficient for co-channel interference measurement. These measurements are limited to 60 dB below the carrier by information in the TV signal between the carrier and the first 15 kHz sideband.

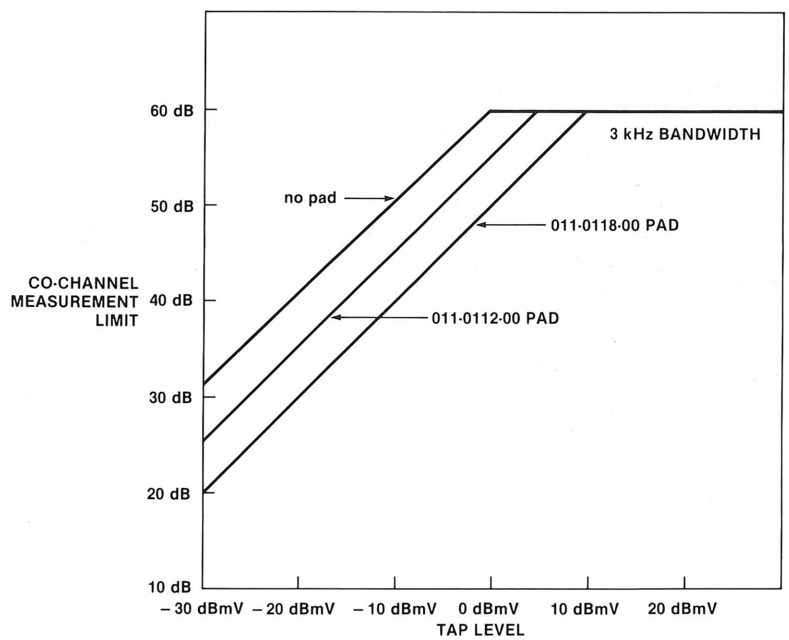


Figure 5-1. Co-channel measurement capability.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or any 7000 Series mainframe.
3. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00 or equivalent.
4. F to BNC Adapter: Tek 013-0126-00 or equivalent.

Procedure

1. Interconnect the equipment as illustrated in figure 5-2.
2. Select the channel to be tested with the analyzer's FREQUENCY control.
3. With the analyzer's FREQUENCY SPAN and the RESOLUTION controls locked together, decrease the frequency span to 5 kHz/DIV while keeping the trace centered. The display should look similar to figure 5-3 with video modulation (random spikes) running through the display. If co-channel interference is present, it will appear as an additional carrier offset 10 or 20 kHz from the picture carrier.
4. For maximum sensitivity, remove all of the spectrum analyzer's RF attenuation when the carrier is −30 dBm or less. Increase IF gain as necessary.

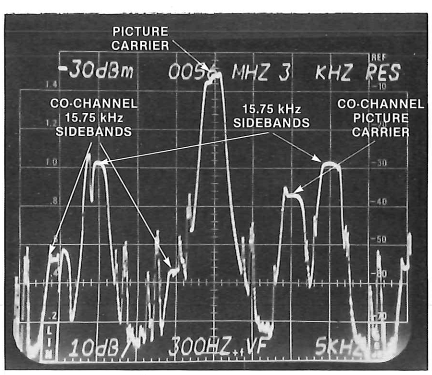


Figure 5-3. Co-channel signal with +10 kHz carrier offset.

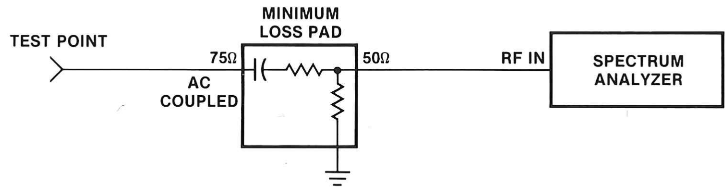


Figure 5-2. Equipment interconnection for co-channel measurements.

5. Using the 10 dB/DIV display mode, determine the co-channel signal amplitude by measuring the vertical separation between the amplitude of the picture carrier and the co-channel carrier.

Hints and Precautions

1. The use of video filters and slow-sweep speeds coupled with CRT or digital storage produces very clean traces (figure 5-4). The digital storage capability of the 7L14 is very effective in the co-channel interference measurement. Slow the sweep, use a video filter and position the PEAK/AVERAGE cursor at the top of the screen so the entire display is in the AVERAGE mode.
2. Additional carriers may be observed from strong co-channel stations. These carriers are the 15 kHz sidebands caused by the horizontal sync pulses on the co-channel signal. This can be seen at the first graticule line from the left in figure 5-3.
3. Co-channel carriers can occur on either side of the picture carrier and as far away as 20 kHz depending on station offset as illustrated in figures 5-4 and 5-5.
4. Since the measurement relies on amplitudes relative to the carrier and are over a narrow frequency range, the 75 to 50 ohm matching pads can be omitted for increased sensitivity.

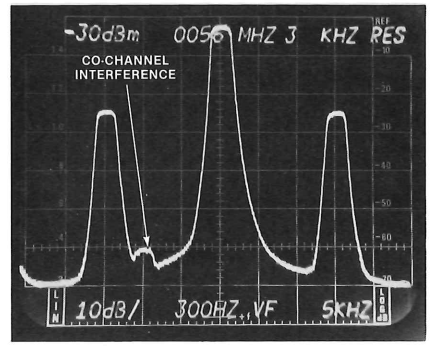


Figure 5-4. Low level interference measurements can be made by using storage, slow sweeps and video filtering.

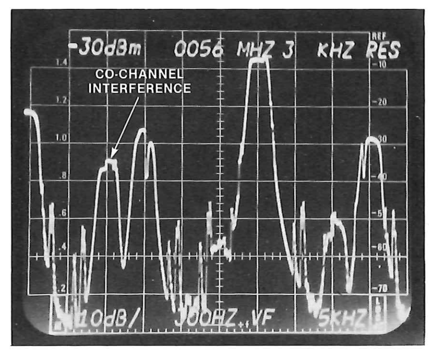


Figure 5-5. Co-channel interference with total offset of 20 kHz. This is caused by the desired signal being offset +10 kHz and the interfering signal −10 kHz.

6. Headend Frequency Response Measurements

Capability

Headend components such as processors and modulators can be tested rapidly and accurately using a spectrum analyzer and a sweep generator. Resolution of ¼ dB is possible, and the out-of-service time is minimized.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Storage Mainframe: Tek 7613.
3. Sweep Generator(s) or Signal Generator(s): Must be tunable over the input frequency range of all processors and from 100 kHz to 5 MHz.
4. Fixed Attenuator: 75 ohm, 10 dB.
5. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00 or equivalent.
6. F to BNC Adapter: Tek 013-0126-00 or equivalent.
7. Directional Couplers (2): 8 dB.
8. Terminator: 75 ohm.
9. Sideband Adapter: Tek 1405 (optional).

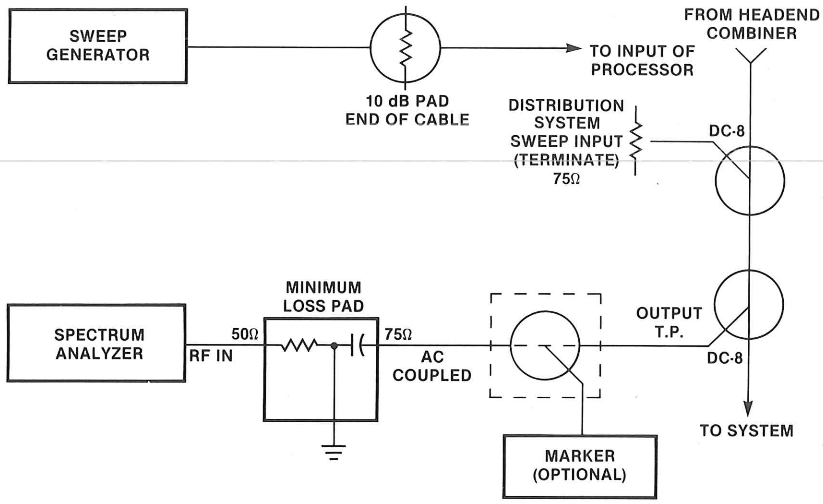


Figure 6-1. Equipment connection for headend frequency response measurements.

Procedure for Processors

1. The headend output feed should include two test points, each developed by a directional coupler inserted in the directions indicated in figure 6-1. These couplers provide system access for the headend tests. Set up the equipment as shown in the figure.
2. Connect a cable of sufficient length to reach all the processor inputs to the sweep generator. Connect a 10 dB pad between the cable and the processor input to reduce reflections in the cable and insure a proper impedance match.
3. Connect the spectrum analyzer through the Minimum Loss Pad to the output test point.
4. Select a channel to be swept and tune it to center screen with the spectrum analyzer's FREQUENCY control. Also select a FREQUENCY SPAN of 1 MHz/DIV and set the RESOLUTION to 30 kHz.
5. Use the analyzer's REFERENCE LEVEL controls to bring the peak of the picture carrier within the top two horizontal graticule lines of the display. Carefully adjust the analyzer's FREQUENCY control to bring the picture carrier to the second vertical graticule line from the left.
6. Switch to 2 dB/DIV.
7. Set the processor to manual mode or disable its AGC by some other means. Use the manual gain control to reset the picture carrier to its former amplitude.
8. Disconnect the antenna cable from the processor and connect a cable from the sweep or signal generator in its place. Note that the input signal must be connected at a point that precedes all bandpass filters or any device that will alter the frequency response of the processor.
9. Determine the input frequency of the processor. Using the CW mode of the sweep generator, (input frequency may be different than output frequency) adjust the sweep generator amplitude and frequency until a signal is displayed on the spectrum analyzer at the same frequency and amplitude as the picture carrier.
10. Once the sweep generator level has been established, the spectrum analyzer can be switched to high persistence, and by manually rocking the generator frequency about the picture frequency, a picture of the exact response will be stored in the display as in figure 6-2.
11. Reconnect the antenna to the processor and photograph the display.

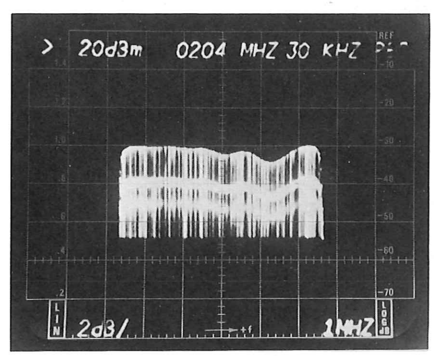


Figure 6-2. Swept heterodyne processor response.

Hints and Precautions

1. Once the foregoing technique has been mastered, it can be performed in approximately 30 seconds of off-air time per channel.
2. The signal insertion step (9) may impose a number of variables such as cross channel conversions, AGC and AFC circuits, and automatic signal sense circuits. Each case may require a slight modification to the approach but can be successfully accommodated with the foregoing procedure.
3. When the 7L14 is used, the same procedure is followed except that MAX HOLD is used to store the swept display. Position the PEAK/AVERAGE cursor at the bottom of the screen and turn MAX HOLD on just before sweeping the processor (figure 6-3). Turn off MAX HOLD to clear the screen.

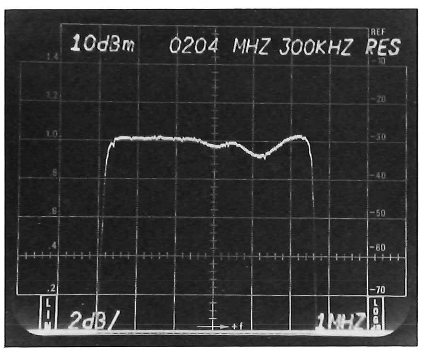


Figure 6-3. Digital storage display of processor response.

Procedure for Modulators

1. Disconnect the video source from the modulator and connect a signal from the (100 kHz to 5 MHz) sweep generator in its place. Adjust the generator's amplitude control for an output signal of 300 mV RMS or less.
2. Connect the spectrum analyzer to the output test point through the Minimum Loss Pad (figure 6-1).
3. Determine the output frequency of the modulator and tune the analyzer's FREQUENCY control to that channel. Set analyzer FREQUENCY SPAN to 1 MHz/DIV, RESOLUTION to 30 kHz and select 10 dB/DIV. Adjust the analyzer's FREQUENCY control to center the picture carrier over the fourth vertical graticule line from the left. The peak picture carrier should be near the top of the display. Adjust the BASELINE CLIPPER to blank the bottom division.
4. Switch the mainframe to high persistence or storage. Sweep (or manually rock) the generator's output frequency over its 100 kHz to 5 MHz range. A picture of the modulator's response will be developed on the display screen (figure 6-4).
5. Check the modulator's response with respect to figure 6-5.
6. Turn off the analyzer's storage. Select 2 dB/DIV and 500 kHz/DIV. With the generator tuned to a frequency of about 1 MHz, increase the analyzer's IF gain until the generator's signal appears on the screen. Turn on the analyzer's storage and sweep the generator's frequency again. Verify this response (figure 6-6) with respect to figure 6-5.

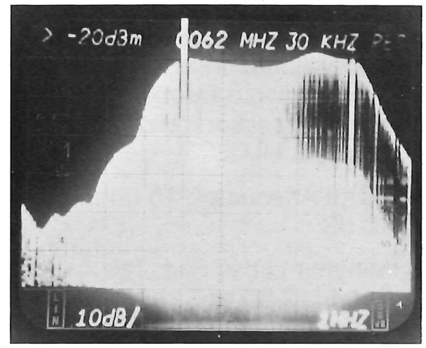


Figure 6-4. Swept modulator response.

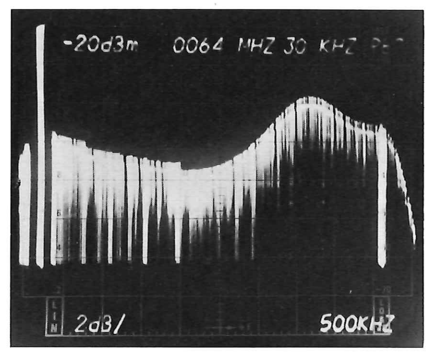


Figure 6-6. 2 dB/DIV swept modulator response.

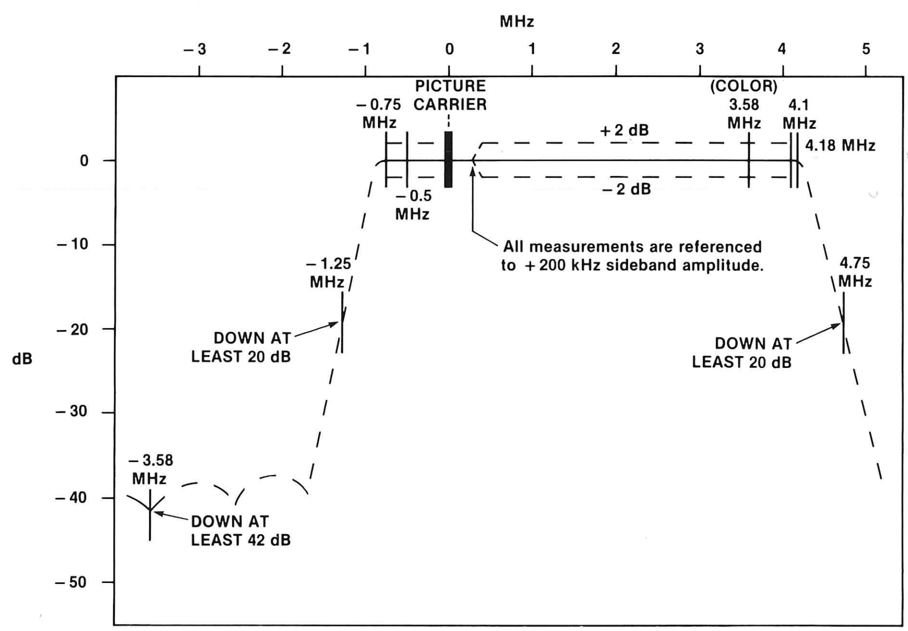


Figure 6-5. Idealized NTSC color transmitter response.

Alternative Procedure for Modulators

In the procedure above, the modulator being measured is operating without sync. The procedure is slow and any adjustments required are often tedious. The Tektronix 1405 Sideband Adapter supplies standard video signals to the modulator and allows rapid and accurate measurements. The 1405 also provides verification of modulator performance as the video parameters are varied.

1. Connect the test set up shown in figure 6-7.
2. Connect the RF IN on the 7L12 to the output test point via a Minimum Loss Pad and an F to BNC Adapter.
3. Adjust FREQUENCY control on the analyzer to bring the modulator output signal (picture carrier) to center screen. Select 10 dB/DIV, FREQUENCY SPAN of 1 MHz/DIV and RESOLUTION BANDWIDTH of 300 kHz. Readjust the FREQUENCY control to bring the picture carrier to the fourth vertical graticule line from the left.
4. Set the AMPLITUDE control on the 1405 to 100 percent and the APL LEVEL to 50 percent. Turn the 1405 SYNC to ON and deselect all the markers. Connect the 1405 output to the modulator input.
5. If necessary, check the percentage of modulation using the 1405 as a source:
   a. Adjust the analyzer's FREQUENCY controls to bring the picture carrier to center screen.
   b. Select Zero Span (SPAN control fully CCW)
   c. Set AUTO PHASE LOCK to OFF
   d. Adjust FREQUENCY control to maximize response
   e. Select LIN Mode
   f. Adjust IF gain and REF VAR controls to bring sync tips to top graticule line.

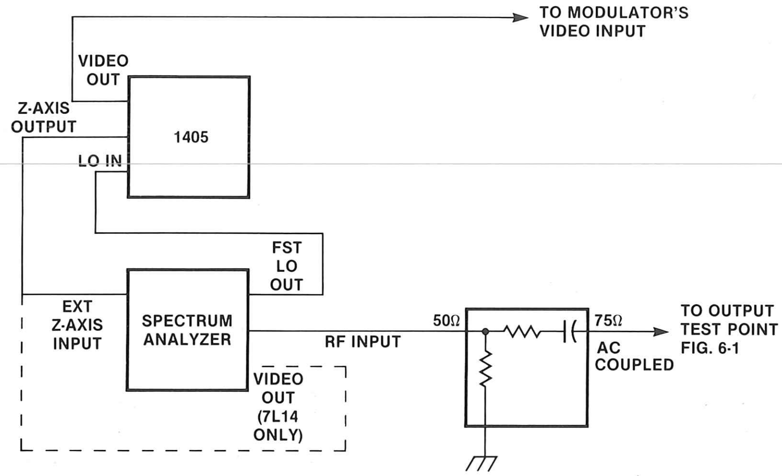


Figure 6-7. Equipment connection for testing modulators using the 1405.

   g. Disconnect the cable between the 1405 z-axis output and the mainframe
   h. Set 1405 APL LEVEL to 100 percent, AMPLITUDE control to 0 IRE
   i. Adjust the modulator's VIDEO GAIN to bring peak white to 12.5 percent of sync tip or 1 division from base line (figure 6-8)
   j. Reconnect the z-axis output to the mainframe. Set the analyzer AUTO PHASE LOCK to ON, the FREQUENCY SPAN to 1 MHz and select 10 dB LOG Mode.

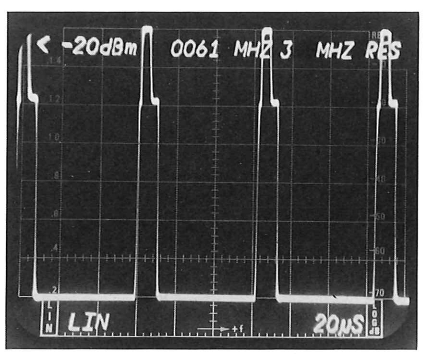


Figure 6-8. Adjusting percentage of modulation using 1405.

6. On the 1405, reset APL LEVEL to 50 percent; tune the TRANSMITTER FREQUENCY control to the channel of interest. As this control is adjusted, a spurious signal will move past the picture carrier. Continue to turn the control to bring the two signals together until the display floor suddenly rises. This display condition indicates that the video sweep from the 1405 and the sweep from the analyzer are in synchronism and that the response of the modulator is being displayed.
7. Rock the FINE control on the 1405 to maximize the response. Set RESOLUTION BANDWIDTH to 30 kHz and again rock the FINE control for maximum response amplitude. Select a video filter to smooth the response (figure 6-9).

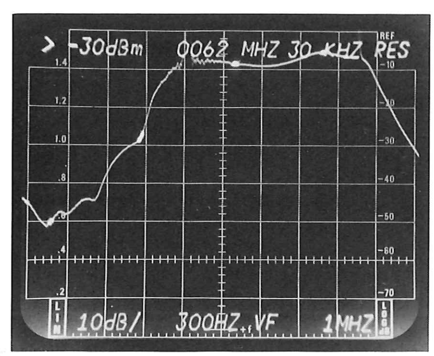


Figure 6-9. Swept modulator response using 1405. Markers are at 1.25 MHz, 3.58 MHz and 4.75 MHz.

8. On the 1405, turn on the 1.25, 3.58 and 4.75 MHz markers. Adjust the INTENSITY and WIDTH controls for pleasing markers. Verify that the lower 3.58 MHz sideband and channel edge amplitudes are within specified limits (figure 6-5).
9. On the analyzer, select 2 dB/DIV. Adjust the IF gain as required to bring the displayed waveforms on screen. On the 1405, turn off the 1.25 and 4.75 MHz markers leaving on the 3.58 MHz marker. Turn on the 0.75 and the 4.18 MHz markers. Adjust INTENSITY and WIDTH as necessary. Check for overall flatness. Verify sideband amplitudes at 3.58 MHz and channel edge amplitudes are within specified limits (figure 6-10).

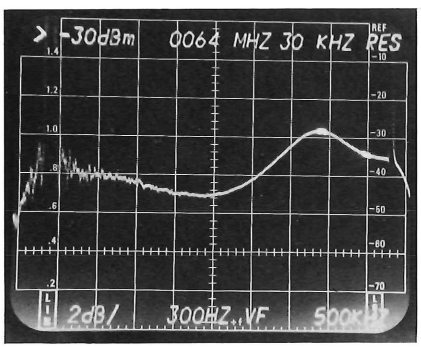


Figure 6-10. 2 dB/DIV swept modulator response using 1405. Markers are at 3.58 MHz and 4.18 MHz.

Hints and Precautions

1. The 7L14's digital storage capabilities work very well for the frequency response measurements. Note that the 7L14's Max Hold feature can be used to build up a swept display.
2. To use the 7L14 with the 1405, the z-axis output of the 1405 is connected to the VIDEO OUT on the 7L14 (using a Tek 175-1175-00 cable). The displayed waveform will show a downward deflection at the marker frequency as shown in figure 6-11. Position the PEAK/AVERAGE cursor to the top of the display screen.

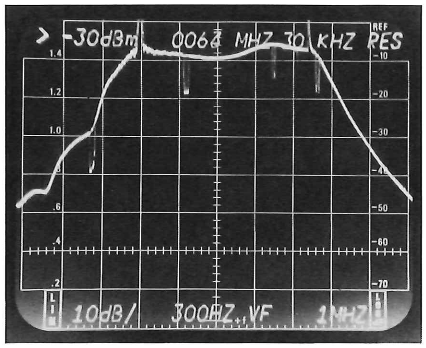


Figure 6-11. Swept response with markers on 7L14 display.

7. Distribution System Frequency Response Measurements

Capability

Frequency response measurements can be performed directly from the antenna input to the subscriber terminals. However, separating the headend measurements from the distribution system measurements is recommended. Separate measurements are more convenient and help to isolate response problems. The results of the two measurements are then combined algebraically to verify that total system response is as specified by the FCC.

The following procedures use a sweep generator to provide input signals over a specific frequency range. When carefully performed, these procedures constitute one of the most accurate methods of measuring the frequency response of CATV system components. Resolution of ± ¼ dB and accuracy of about ± ½ dB are possible.

While this measurement technique interferes with normal CATV signals, the ease and speed with which it can be accomplished (only one or two sweeps at each test point) cause an interference interval of about one to two seconds per test point.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe Oscilloscope: Tek 7613.
3. Sweep Generator: Slow sweep and single sweep capability very helpful. Frequency coverage to include all CATV channels.
4. Fixed Attenuator: 75 ohm, 10 dB.
5. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00.
6. F to BNC Adapter: Tek 013-0126-00.
7. Directional Couplers (2): 8 or 10 dB.

Procedure

1. Set up the equipment as illustrated in figure 7-1.
2. The sweep generator should be connected to a 10 dB pad mounted directly on the directional coupler.
3. Connect the spectrum analyzer to the test point on the second directional coupler.
4. Set the sweep generator for a CW output signal and tune it to about 50 MHz. Adjust the analyzer's FREQUENCY SPAN for 5 MHz/DIV, RESOLUTION to 300 kHz, and FREQUENCY controls to center the low band channels in the display (refer to number 1 in Hints and Procedures). Adjust the sweep generator output amplitude so that it is about equal to the channel 2 picture carrier amplitude.
5. Set the sweep generator for a wideband sweep (0 to top system frequency) with a slow sweep speed. The sweep frequency should change at about a 2 MHz per second rate.
6. Adjust the analyzer's REFERENCE LEVEL control to bring the sweeper signal to within the top division of the screen. Set the analyzer to 2 dB/DIV.
7. Start the sweep generator's sweep. Increase the scope persistence or use storage mode to hold the display.
8. As the low band is completed, rapidly photograph the resultant display. Adjust the analyzer's controls to the mid-band channels and then the high-band channels and repeat the measurement (steps 4 - 7). One or more sweeps may be necessary to photograph the entire spectrum.

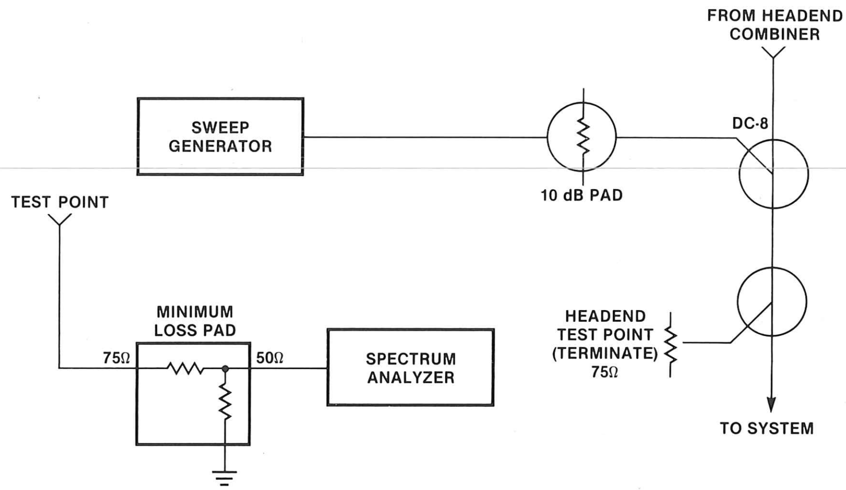


Figure 7-1. Equipment connection for distribution system frequency response measurement.

Hints and Procedures

1. Adopt a consistent spectrum analyzer tuning method for the various photographs. For instance, for the low band, tune channel 2 to the second graticule line from the left; for the high band, tune channel 7 to the first line from the left. This makes it easy to compare the photographs taken at different points in the system.
2. When a Tektronix 7L14 is used, the same procedure is followed except that the MAX HOLD control is used to store the sweep information. Turn MAX HOLD off before retuning the analyzer and turn it on to make the measurement.
3. System AGC frequencies will be shown on the response photos as a notch. The slow sweep speed avoids the need for special filters.
4. Multiple serrations are caused by reflections in the interconnecting cables. If similar serrations appear in the display, or when in doubt, exchange the cables and insert 10 dB attenuators at the cable extremities to damp reflections.
5. If a generator with slow sweep is not available, tuning a generator manually will often suffice.

8. Carrier-To-Noise Measurement

Capability

The flexibility of the spectrum analyzer makes it a good instrument to measure carrier-to-noise (C/N) ratios. However, as in all measurements concerning noise, the process is complicated by various correction factors and bandwidth changes. A pair of charts is included to simplify the measurement procedure. These charts also compensate for the fact that a logarithmic display will show noise 2.5 dB lower in amplitude than it actually is.

If a tap level greater than 20 dBmV is available, the spectrum analyzer can make 55 dB C/N measurements directly (omitting a Minimum Loss Pad since the measurement is over a narrow frequency range). The following procedure describes how to make the C/N ratio tests required by the FCC on all local signals. A method of measuring first the headend and then the distribution trunk is described in the Hints and Precautions section.

A Tektronix 7K11 CATV Preamplifier can be used for situations where a high tap level is not available. Using this preamp, 52 dB C/N ratios can be made with a tap level of 0 dBmV.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. CATV Preamplifier: Tek 7K11 (Except when 7L14 is used.)
3. Mainframe: Tek 7613 or any 7000 Series mainframe.
4. Bandpass Filter: 6 MHz to 10 MHz bandwidth; centered to pass the channel under test.
5. Attenuator: 75 ohm, 1 dB steps, 0 to 10 dB range (useful to maximize the measurement range if the 7K11 is not used).

Procedure

1. Set up the equipment as illustrated in figure 8-1.
2. Carefully calibrate the 7L12 and (if used) the 7K11. Refer to the instruction manual(s).
3. Select the 1 MHz/DIV FREQUENCY SPAN and the 300 kHz RESOLUTION BANDWIDTH. Make sure all video filters are off.
4. Center the channel carrier to be measured on the display. Use the REFERENCE LEVEL controls on the 7K11 and the analyzer (or the 0 dB to 10 dB attenuator) to bring the sync tips of the carrier signal to the top graticule line of the display.
5. Switch the processor AGC to manual. Adjust the processor's GAIN control to bring the sync back to the same level. Disconnect the antenna from the processor and terminate the processor's input. (If preamplifiers and/or bandpass filters are used, they must be left in the system. In general, disconnect the antenna lead from the first device it connects to and terminate that device.)
6. Turn on a 300 Hz video filter and slow the sweep speed.
7. Determine the number of dB between the top of the screen and the noise level (figure 8-2).
8. Remove the signal from the analyzer. Note how many dB the noise level falls as the noise signal is removed from the analyzer (figure 8-2).

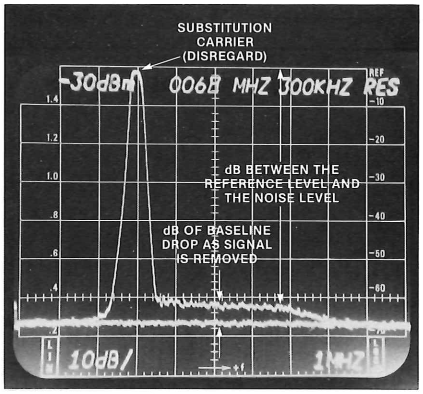


Figure 8-2. Measuring noise levels (multiple exposure photo).

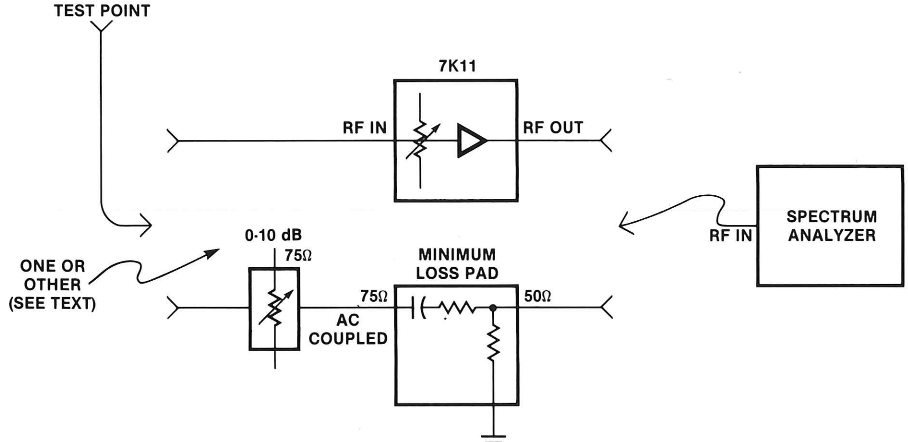


Figure 8-1. Equipment connection for carrier-to-noise measurement.

9. Refer to figure 8-3. Using the number of dB the noise fell as the signal was removed, determine how many dB to add to the C/N measurement in step 7. This correction compensates for the analyzer's own noise when the difference between the measured noise and the analyzer's noise is less than 10 dB.

10. Add the correction factor obtained in step 9 to the C/N measured in step 7. Referring to figure 8-4, use the corrected C/N value from the spectrum analyzer to find the C/N for a 4 MHz system.

EXAMPLE: Figure 8-2 shows an uncorrected C/N of 63 dB and a noise fall of 5 dB when the signal is removed from the analyzer.

Referring to figure 8-3, 5 dB along the x-axis crosses the correction curve at 1.7 dB. Therefore 1.7 dB must be added to the measurement:

$$C/N = 63\text{ dB} + 1.7\text{ dB}$$
$$= 64.7\text{ dB or } 65\text{ dB}$$

Referring to figure 8-4, 65 dB along the x-axis crosses the noise conversion curve at 50.3 dB. Therefore the 4 MHz C/N is actually 50.3 dB.

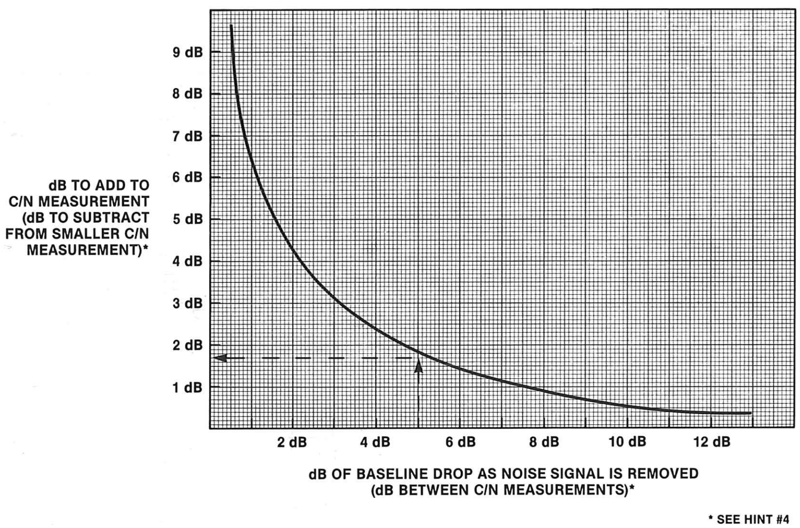


Figure 8-3. Analyzer noise floor correction chart.

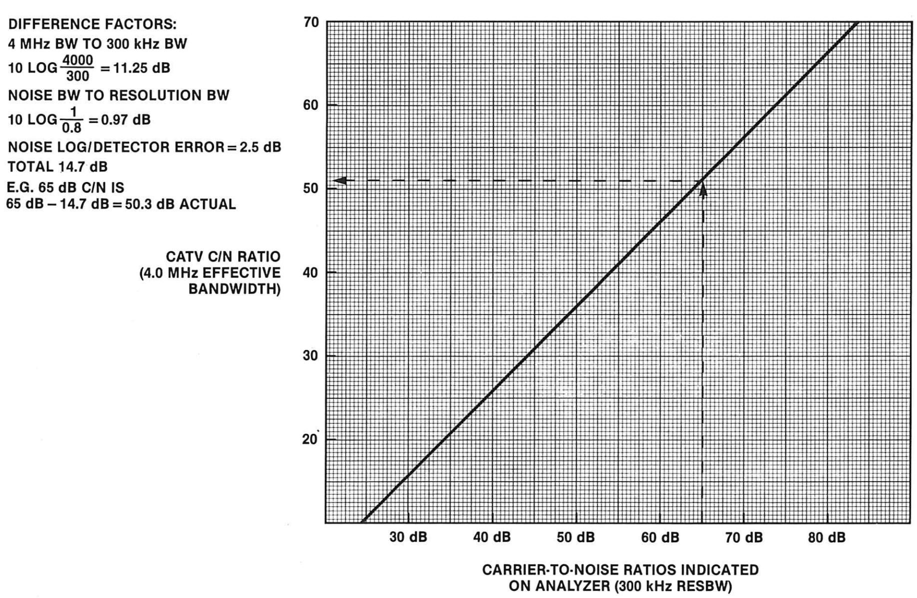


Figure 8-4. Analyzer bandwidth and log error conversion chart.

Hints and Precautions

1. In wideband systems, the total input power can saturate the analyzer's front end especially if a preamplifier is used. A bandpass filter should be used to protect the analyzer's inputs.
2. Measuring high C/N ratios requires a high tap level. If the analyzer's input is protected with a bandpass filter (so only in band noise is measured) the carrier can be moved 10 dB off the top of the screen by removing RF attenuation after step 6. Proceed as before, but add 10 dB to the C/N measured in step 7.
3. The C/N of the distribution system can be determined by performing steps 1 through 4 as given. Skip to step 6. In step 7, measure from the top of the screen to the noise floor of an unoccupied adjacent channel. For example, 2 divisions to the left of the picture carrier in figure 8-4.
4. If the C/N of the headend and the distribution system have been measured separately, the two measurements can be combined with the help of figure 8-3. Note the difference in dB between the two C/N measurements. Move along the x-axis to the corresponding (difference) value in dB. Move up to the curve and subtract this value from the smaller of the two C/N measurements.

EXAMPLE: If the headend C/N is 53 dB and the distribution system C/N is 58 dB, the difference is 5 dB. Enter figure 8-3 at 5 dB and find the correction factor at 1.7 dB. The combined C/N is then 53 dB − 1.7 dB ≅ 51 dB.

If one C/N value is 10 dB or more smaller than the other, for all practical purposes the smaller value is the combined headend and distribution system C/N.

5. The 2.5 dB correction is due to differences between the RMS and AVERAGE amplitudes of CW and noise signals. If one has a noise signal and a CW signal with the same RMS amplitude, the AVERAGE amplitude at the noise signal will be 2.5 dB less than the amplitude of the noise signal. A 0.8 dB correction is included since the 300 kHz resolution bandwidth filter typically has a noise bandwidth of 240 kHz.

Alternate Signal-To-Noise Measurement

Capability

The Tektronix 1430 and 147 Noise Test Sets are capable of measuring signal-to-noise (S/N) ratios from 20 dB in 1 dB increments. The actual performance is dependent upon the performance of the demodulator and the customer tap level. The test sets are capable of easy and consistent measurements.

Equipment Required

1. Test Set: 1430 or 147A.
2. Demodulator: Tek 1450-1/TDC1/TDC2 or equivalent.
3. 1480 Waveform Monitor: or Oscilloscope with delayed sweep.
4. BNC Terminator: 75 ohm, Tek 011-0055-00.
5. Low Pass Filter: 4.2 MHz (only with 147A), Tek 015-0212-00.

Procedure

1. Connect the equipment as illustrated in figure 8-5.
2. Use a 4.2 MHz low-pass filter with a 147A. The filter is built into the 1430.
3. Tune the demodulator to the desired channel and fine tune for the least 4.5 MHz intercarrier as indicated on the waveform monitor.
4. Calibrate the waveform monitor for 1 volt or 140 IRE units.
5. Set the video output level on the demodulator such that the sync of the incoming signal is exactly 40 IRE units.
6. Select the line containing the calibrated noise generator on the waveform monitor. The noise can be programmed onto an unused line such as line 17, field 1.
7. Match the calibrated noise generator level to the incoming noise and read the noise directly from the dials. This is the S/N ratio (figure 8-6 and 8-7).
8. The signal-to-noise ratio as requested by the FCC in 376.605(9) is actually the carrier-to-noise ratio which can be obtained by adding 4 dB to the reading obtained in step 7.

EXAMPLE: For a reading of 41 dB S/N on the 147A or 1430, add 4 dB to obtain a 45 dB signal-to-noise ratio (C/N) to satisfy 376.605(9).

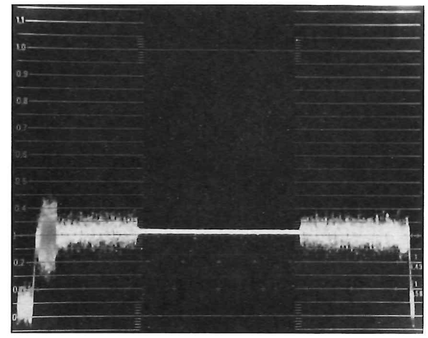


Figure 8-6. Match level with input signal.

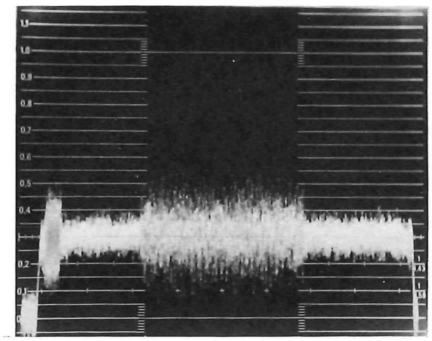


Figure 8-7. Adjust noise amplitude until the center area is indistinguishable from the rest of the line.

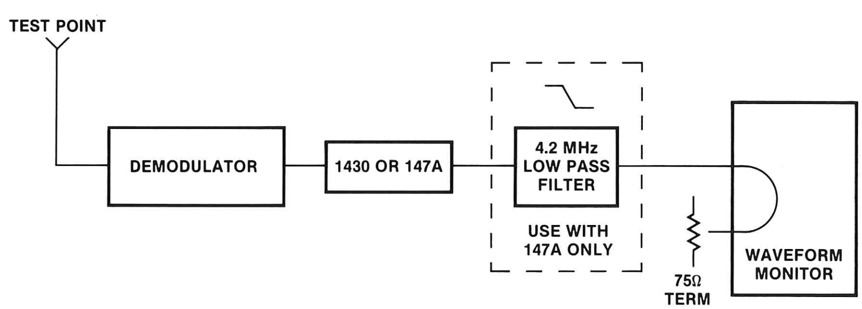


Figure 8-5. Equipment connection for alternative noise measurement.

9. Low Frequency Disturbance and Hum Measurement

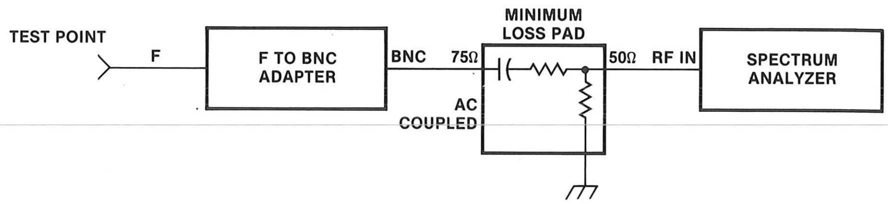


Figure 9-1. Equipment connection for hum measurements.

Capability

Low frequency disturbance and hum is defined as the peak-to-peak variation of the sync tip amplitude over the period of one frame (from one vertical interval to the next). These conditions can be caused by power supply hum, poor clamping, or DC restoration circuits. The spectrum analyzer is used in its Zero Span mode as a receiver. LF disturbance and hum as small as 1 percent can be measured with this procedure.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or any 7000 Series mainframe.
3. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00 or equivalent. (May be omitted for added sensitivity without loss of measurement accuracy.)

Procedure

1. Set up the equipment as illustrated in figure 9-1.
2. Select 2 dB/DIV. Check vertical position.
3. Select a channel to be tested with the spectrum analyzer FREQUENCY control.
4. Unlock the FREQUENCY SPAN/RESOLUTION BANDWIDTH controls. Leave the resolution bandwidth in 300 kHz. Center the picture carrier on screen and narrow the span until Zero Span is reached. Adjust the REFERENCE LEVEL until the signal is near the top of the screen.
5. Select LIN (Linear) mode and use the REF VAR control to position the sync tips of the carrier to the reference level. Set the TIME/DIV control to 20 ms/DIV and select line trigger (figure 9-2).

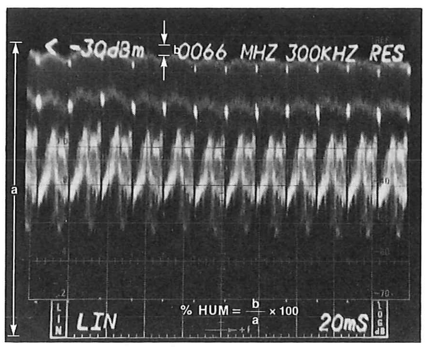


Figure 9-2. Measurement of hum and low frequency disturbance.

6. Low frequency disturbance and hum is the peak-to-peak variation of the sync-tip-level expressed as a percentage of the maximum sync top amplitude. Each minor graticule division then represents 2.5 percent of low frequency disturbance and hum modulation.

Hints and Precautions

1. To get an idea of CATV distribution system hum contribution, use the foregoing procedure to measure the hum on a pilot carrier.
2. Picture related disturbances and hum related disturbances are at slightly different frequencies. Observe the sync tip amplitude carefully over a seventeen second period to make sure that the worst case combination has been noted.
3. Digital storage capabilities of the Tektronix 7L14 makes the measurement of the hum component easy. During the vertical interval the television signal is largely unaffected by picture content. This interval also contains long, high power pulses that can be accentuated with a video filter. Set up the 7L14 analyzer as per steps 3, 4, and 5. Turn on digital storage. Position the cursor at the bottom of the screen. Turn on the video filter. Press MAX HOLD and wait until the display builds up. The result (figure 9-3) is the hum on that carrier.

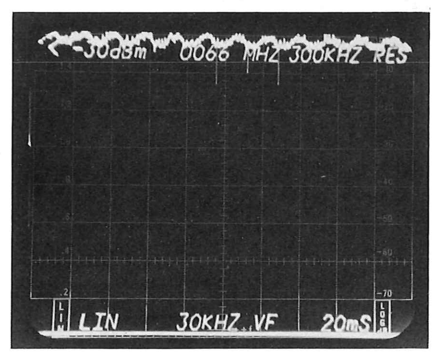


Figure 9-3. Measurement of hum with 7L14.

10. Terminal Isolation Measurements

Capability

The terminal isolation measurement test presented here can verify terminal isolation up to 70 dB over a frequency range from 100 kHz to 1800 MHz depending on the signal source used.

Equipment Required

1. Spectrum Analyzer: Tek 7L12 or 7L14.
2. Mainframe: Tek 7613 or any other 7000 Series mainframe.
3. Sweep Generator: To cover the desired frequency range.
4. Minimum Loss Pad: Tek 011-0112-00 or 011-0118-00.
5. F to BNC Adapter: Tek 013-0126-00.

Procedure

1. Set up the equipment as illustrated in figure 10-1 at one location for calibration.
2. Set the spectrum analyzer's REFERENCE LEVEL to −20 dBm, SPAN/DIV to 50 MHz, RESOLUTION to 3 MHz, and FREQUENCY to 250 MHz.
3. Connect (subscriber) point A to point B (figure 10-1).
4. Set the sweep generator for a CW output signal of about 250 MHz. Adjust generator amplitude so that the signal just touches the top line of the display.
5. Set the 7613 mainframe to STORE mode and adjust the sweep generator for a slow sweep. Experiment with the sweep generator's SWEEP TIME, the spectrum analyzer's TIME/DIV and BASELINE CLIPPER controls and the mainframe's storage controls until a display similar to figure 10-2 is obtained. If this display is more than 1 dB unflat, you might want to photograph this condition.

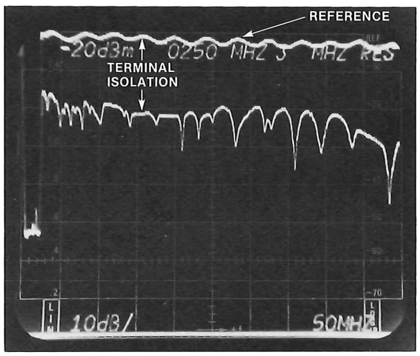


Figure 10-2. Subscriber terminal isolation measurement.

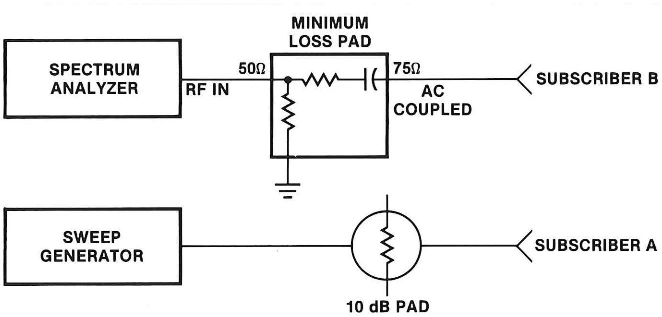


Figure 10-1. Equipment connection for subscriber isolation measurement.

6. Without altering any controls, move the sweep generator output to subscriber terminal A and connect the spectrum analyzer input to subscriber terminal B.
7. Repeat adjustments as in step 5 to achieve display similar to figure 10-2.
8. The terminal isolation is the difference in dB (at 10 dB/DIV) between the trace in step 5 (terminals A and B connected together) and the trace in step 7.
9. Other frequency ranges can be tested with the same procedure.

   NOTE: For clarity this photo was taken using the 7L14's digital storage. Similar results (if not as photogenic) will be obtained using the 7613's CRT storage.

Hints and Precautions

1. Both traces can be recorded on the same photograph. Set the BASE LINE CLIPPER for a clip level one to two divisions down from the top of the screen for step 5. Lower the BASE LINE CLIPPER to the fourth or fifth division from the top for step 7. Turn down the CRT READOUT until the measurements are finished. Then turn it up just enough to show the numbers for the photograph.
2. The digital storage of the 7L14 makes the terminal isolation measurement much easier. Move the PEAK/AVERAGE cursor to the bottom of the screen. Turn SAVE A OFF, and MAX HOLD ON and perform step 5. After the reference trace is obtained turn SAVE A ON, and turn MAX HOLD OFF and then back ON. Perform step 7. The display now has the two traces and the terminal isolation is the difference between them.

Pressing B-SAVE A provides a third trace that is the difference between the A display and the B display and which directly displays the measurement results. Figure 10-3 shows the display when a digital storage spectrum analyzer is used. (See 7L14 manual for selecting the offset of the B-SAVE A trace.)

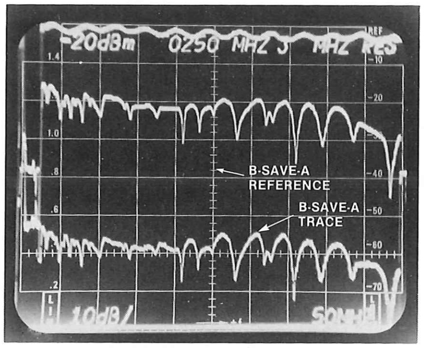


Figure 10-3. Direct measurement of isolation using B-SAVE-A feature.

11. Leakage Measurement Tests

The Tektronix 7L12, when used with the Tektronix 7K11, can be used to make wideband leakage measurements. These measurements satisfy FCC requirements and are easy to interpret. In most situations, leakage can be determined by measuring channels in use on the CATV systems but not occupied by local stations.

Equipment Required

1. Spectrum Analyzer: Tek 7L12.
2. Mainframe (if required): Tek 7613 or any 7000 Series.
3. Preamplifier Plug-in: Tek 7K11. (Except when 7L14 is used.)
4. Antenna: Homemade.
5. Camera (optional): Tek C-5C or equivalent.

Procedure

1. Set up the equipment as illustrated in figure 11-1.
2. Carefully calibrate the 7L12 and then the 7L12-7K11 combination (refer to instrument instruction manuals).
3. Connect the cable from the test antenna to the 7K11.
4. Position an appropriate dipole antenna 10 feet away from the point on the cable to be measured (100 feet away if below 54 MHz or above 216 MHz) and at least 10 feet away from the ground.
5. Using a resolution bandwidth of 300 kHz, measure the sync tip amplitude of any non-local CATV channels that appear on the analyzer's screen. Rotate the antenna from a horizontal position to a vertical position. The desired value is the maximum amplitude for any antenna angle. The 7K11's readout shows the reference level directly in dBmV.
6. Plot the measured values on a copy of figure 11-2. The measured values must be increased by the loss of the balun and the cable before being plotted.

   EXAMPLE: The measured leakage signal amplitude is −53 dBmV. Balun and cable loss together are 2 dB. Plot −51 dBmV on figure 11-2.
7. If all the points plotted are below the curve the FCC requirements are being met.

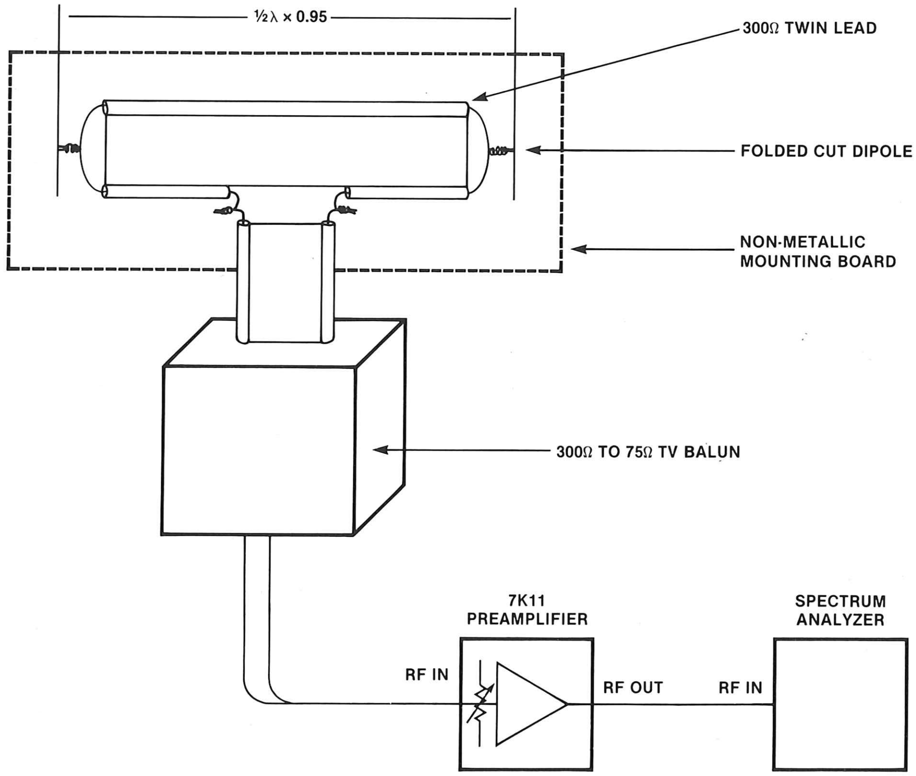


Figure 11-1. Details of homemade antenna and equipment connection for leakage measurements.

Hints and Precautions

1. Construction of homemade dipoles using 300 ohm TV twin lead is illustrated in figure 11-1. The length of the dipoles (in inches) for various frequencies are listed in figure 11-3. Each dipole should be mounted on its own (non-metallic) board as illustrated by dashed lines in figure 11-1. The loss of the balun is one half the loss of two baluns with their 300 ohm terminals connected together. Measure the loss of the cable by normal methods.
2. If radiation and amplitude measurements are made at the same location, the spectrum of the two can be compared to locate the frequency of the CATV only channels.
3. Storage can be used to hold the maximum value of each signal as the antenna is rotated.
4. Single frequency dipole antennas usually have a limited bandwidth. Do not make measurements beyond a channel or two on either side of the channel the antenna is cut for. Measure the dipole antenna to verify that its return-loss is maximum at the design frequency. Adjust its length as necessary.
5. For highest accuracy use a non-metallic tripod to mount the dipole antenna.
6. Because of the nature of radiation and the many variables affecting its measurement, we recommend that any leakage encountered be corrected so that no indication of leakage can be measured. This is far better than certifying a marginal leakage condition.

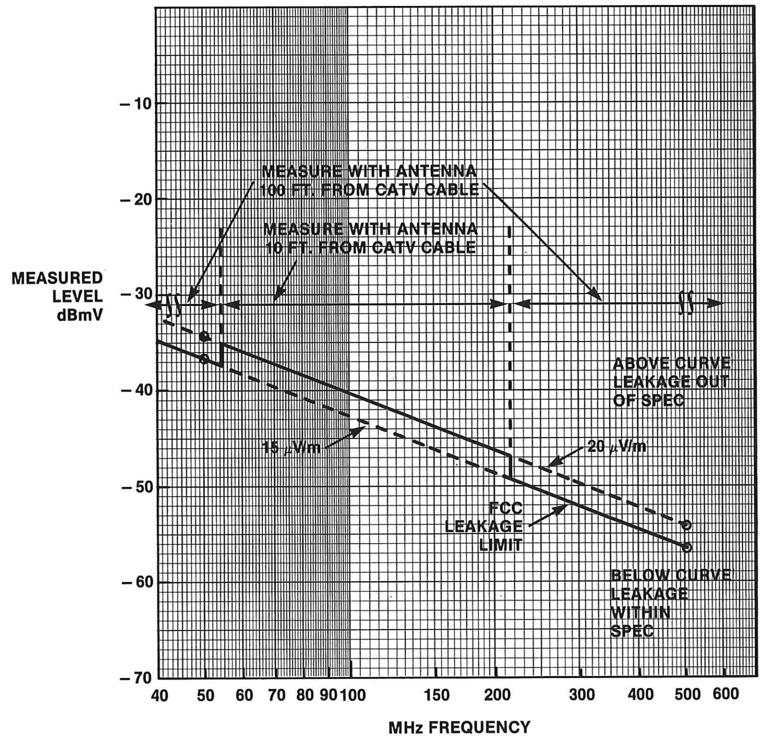


Figure 11-2. FCC leakage specifications as measured with a ½λ dipole.

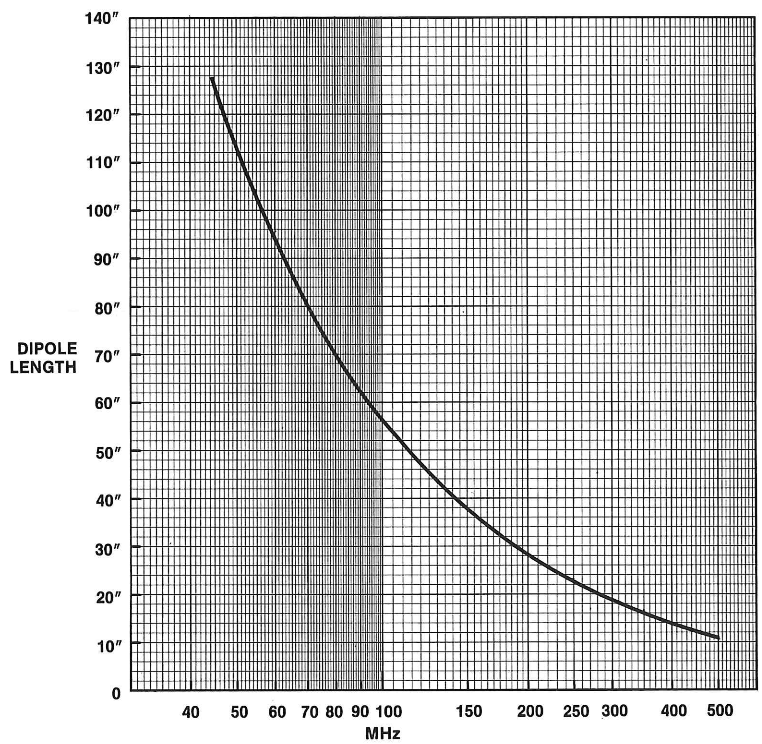


Figure 11-3. ½λ dipole length vs. frequency.

12. Measurements With The Spectrum Analyzer

Measurements made with a spectrum analyzer are somewhat different than those made with an oscilloscope. Once these differences are understood however, most measurements can be made easily and rapidly.

Changing the REFERENCE LEVEL of the analyzer effectively selects a range of measurement. The actual reference level is the top graticule line on the display (figure 12-1). In all cases, waveform amplitude measurements made with a spectrum analyzer are referred to the top graticule line. Amplitude is measured by counting down from this reference in increments determined by the vertical dB/DIV switch setting. Note in the examples how the direct readout of a Tektronix 7000 Series Oscilloscope enhances the readability of the display (figure 12-1).

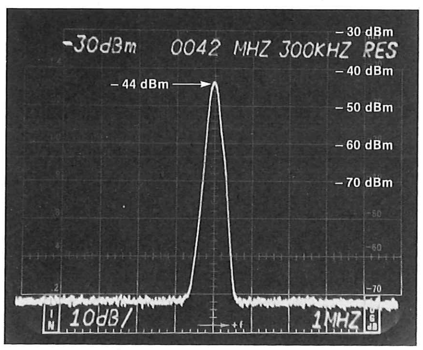


Figure 12-1. Reference level illustration.

Calibration for Accuracy

The modern spectrum analyzer should be calibrated periodically to insure continued high accuracy. Most analyzers can be calibrated for both amplitude measurements and horizontal accuracy.

Tek spectrum analyzers provide an internal calibration standard that simultaneously generates a highly accurate fundamental for amplitude calibrations and a series of harmonics to verify horizontal sweep accuracy (figure 12-2). Instructions for using the internal calibrator are contained in the instruction manual supplied with each spectrum analyzer.

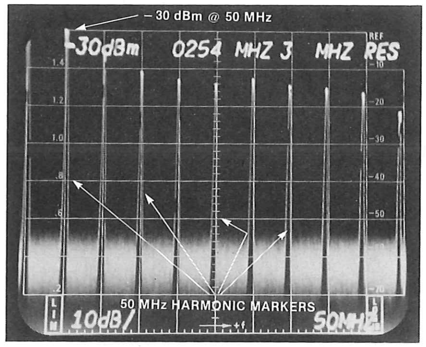


Figure 12-2. Internal 50 MHz calibrator frequency comb.

Whenever an analyzer is plugged into a different mainframe oscilloscope, the complete front panel calibration procedure outlined in the instruction manual should be performed to verify proper performance.

The 7K11 CATV Preamplifier includes a precision 75 ohm calibrator that should be used to calibrate the preamp and analyzer together. When using the 7K11, the dBm calibrator in the 7L12 should be ignored.

Sweep Rate Errors

When using a spectrum analyzer, a number of precautions must be observed to prevent distortion of the displayed waveform and resultant measurement inaccuracies. A spectrum analyzer includes filters in various configurations and it is quite possible to filter out or distort the desired waveform or frequency while trying to suppress an undesired one.

Critical relationships exist in the selection of RESOLUTION BANDWIDTH, FREQUENCY SPAN, VIDEO FILTER, and TIME/DIV. As narrower bandwidths and/or video filters are selected, it becomes necessary to reduce the sweep speed. Exact corresponding relationships vary with different analyzers, however, a good rule of thumb is to perform the following test each time one of the above controls are changed: Slow down the sweep speed progressively until the peak of the waveform is not compressed. Verify this by increasing the sweep until the peaks begin to compress, then return the sweep speed to the point of no compression.

Figure 12-3, a multiple exposure illustrates the effect of increasing the sweep rate progressively. Note how the axis is shifted to the right as the sweep rate is increased in addition to the amplitude distortion. In this case, an amplitude error of 8 dB is caused by the sweep speed. The use of narrow filters requires slow sweep rates to attain accurate measurements.

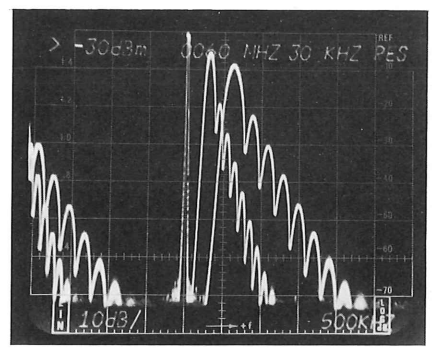


Figure 12-3. Sweep rate errors.

The use of mechanical interlocks on the Tektronix 7L12 and 7L14 FREQUENCY SPAN and RESOLUTION BANDWIDTH controls minimizes the occurrence of waveform distortion due to operator inexperience. Some analyzers such as the Tektronix 7L14 have an UNCAL light that illuminates when the sweep speed is too fast.

Video Modulation

The first time a quality spectrum analyzer is used for television analysis, a characteristic of video modulation will be observed; vertical interval roll through. Selection of a wide resolution bandwidth (300 kHz) and a frequency span of 1 MHz or less permits observation of these inverted waveforms (which are similar to that encountered on a conventional television waveform monitor). Depending on the sweep rate selected, the vertical interval will roll through in either direction (see figure 2-2).

If narrow bandwidths are used during co-channel testing, vertical interval roll through will be observed; although the similarity to a television waveform will not be as apparent (figure 12-4). Novice operators tend to misinterpret this waveform as random beats or interference. The following simple tests can be performed to identify or separate the normal vertical interval roll through from a suspected beat or distortion:

1. Vary the sweep speed. Vertical interval roll through patterns will change speed and/or direction. Beats will remain stationary.
2. Increase video filtering and use variable persistence. Vertical interval roll through patterns will decrease in size, while beats will remain the same size.

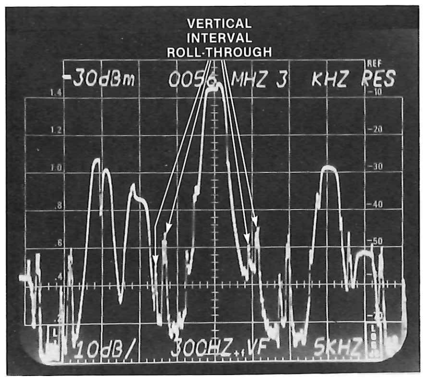


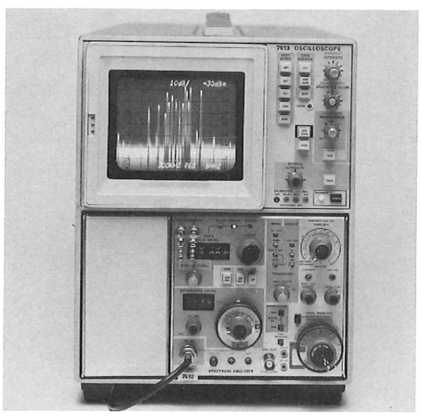
Figure 12-4. Vertical interval roll-through.

Summary of Technical Standards (FCC: 376.605)

1. Frequency of the visual carrier: 1.25 MHz, 25 kHz above channel boundary
   a. At output of converter: 1.25 MHz, 250 kHz
2. Frequency of aural subcarrier: 4.5 MHz, 1 kHz
3. Minimum visual signal level: 1 mV across 75 ohm (0 dBmV)
4. Permissible signal level variation: 12 dB total/24 HR period
   a. Maximum adjacent channel variation: 3 dB
   b. Maximum of all channels: 12 dB
5. Maximum signal level: Below threshold of degradation (Overload) point
6. Maximum hum and low frequency disturbance level: 5 percent
7. Within channel frequency response: 2 dB from −5 MHz to 3.75 MHz
8. Aural signal level: 13 to 17 dB below visual signal level
9. Signal-to-noise level for all signals picked up or delivered within its grade B contour: 36 dB S/N ratio, 36 dB co-channel
10. Signal to intermodulation and non-offset carrier interference: 46 dB intermodulation
11. Subscriber terminal isolation: 18 dB or more if required
12. Radiation:
    a. Up to 54 MHz: less than 15 μV/m at 100 feet
    b. 54 to 216 MHz: less than 20 μV/m at 10 feet
    c. Above 216 MHz: less than 15 μV/m at 100 feet

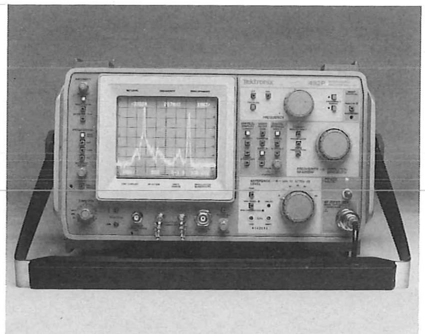
Tektronix offers a range of high performance communications products that will help you make reliable and repeatable measurements. CATV system operators maintain signal quality and integrity with a high level of confidence using Tek instrumentation. And, when maintenance is required, Tek has a network of capable service centers across the United States and in many countries around the world.

7000 Series Plug-in Spectrum Analyzers offer laboratory performance with a high degree of measurement versatility. Each plug-in can be used with any 7000 Series Mainframe. The 20 Hz to 5 MHz 7L5, 1 kHz to 1.8 GHz 7L14, and 1.5 to 60 GHz 7L18 all offer digital storage display and noise averaging. The 7L12 — used to illustrate "No Loose Ends" measurements — covers 100 kHz to 1.8 GHz.



The Tek 7L12 Spectrum Analyzer provides – 115 dBm sensitivity at 300 Hz, and automatic phaselock.

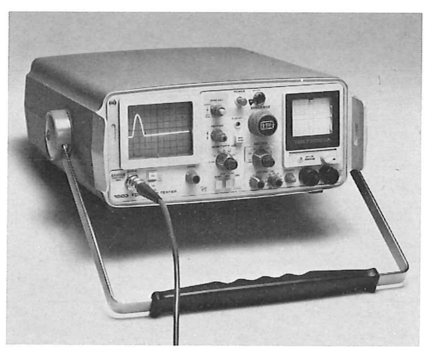
490 Series Spectrum Analyzers are rugged, portable instruments offering full lab grade measurement capability. They are easy to use and ideal for demanding field measurements. The broad-banded 492 covers 50 kHz to 21 GHz, and above 21 GHz with optional external waveguide mixers. Make baseband, if, fundamental frequency, satellite up/down link measurements with one analyzer. The Tek 496 is optimized for 1 kHz to 1.8 GHz coverage, and costs less than the 492.



The easy-to-use Tek 492 provides digital storage and MAX HOLD for easily checking path alignment and frequency drift problems. Its wide usable frequency range means you make most, or all of your rf measurements with one instrument!

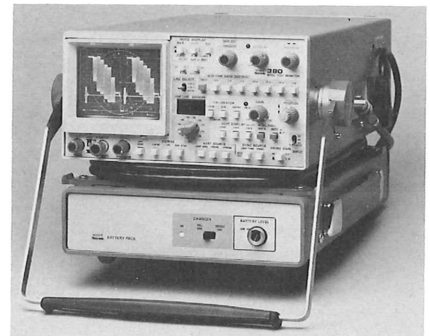
Spectrum analyzer ancillary products: The Tek 1405 TV Sideband Analyzer displays frequency response characteristics of rf and if circuits of modulators to 1 GHz; the Tek 7K11 may be used in a 7000 Series Mainframe with the 7L12 Spectrum Analyzer to provide: extra sensitivity for demanding measurements; a 75 ohm input impedance; and calibration in dBmV.

1500 Series Portable Cable Testers will help you locate cable problems fast. Using highly accurate Time Domain Reflectometry (TDR), you can see faults to 2,000 feet with the Tek 1502, 50,000 feet with the 1503. Check for crimped, shorted, crushed, abraded, or corroded cables.



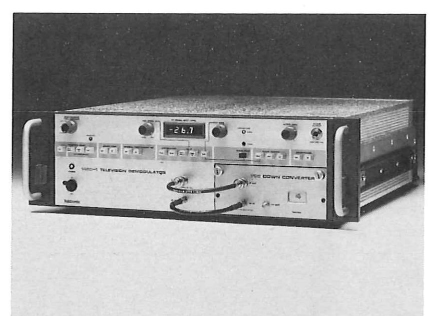
The Tek 1503 Cable Tester locates faults to 50,000 feet with distance accuracy ±2%.

The 380/381 Test Monitor has the combined capabilities of a precision waveform monitor, vectorscope and general purpose oscilloscope optimized for portability. Ideal for many applications, such as maintenance of audio and video equipment, ENG/EFP and video test and measurement.



The 380 provides waveform monitor, vectorscope, and oscilloscope functions in a single, portable package.

The 1450 Television Demodulator provides measurement quality performance resulting in negligible distortion. The demodulator has synchronous detectors to eliminate quadrature distortion or switch to envelope detection for accurately determining differential phase. Surface acoustic wave filters provide precise Nyquist slope and excellent long and short term stability. Digital readout of the input power level provides easy, accurate field strength readings. Select fixed channel or tunable down converters to cover both the VHF and UHF bands.

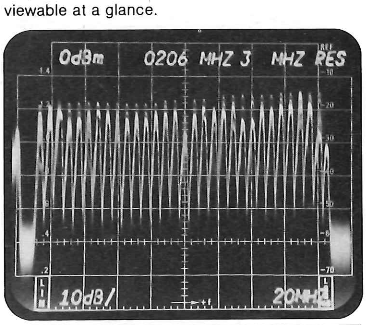


The 1450 is a measurement-grade television demodulator that introduces negligible distortion of its own. The user can accurately assess system performance.

No Loose Ends was updated and revised by Linley Gumm, Frequency Domain Instruments Engineering staff member. The original 1973 version of this application note was written by Clifford B. Schrock.

The Tek 492 Spectrum Analyzer measuring signals out of a 4 GHz antenna LNA. The 492 measures everything from baseband to satellite up/down link signals — at your headend, antenna site, or at a remote cable location.

Amplitudes of 30 channels . . .
viewable at a glance.



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