TESTING AND OPERATION HANDBOOK

SAM I & SAM II

Mid State

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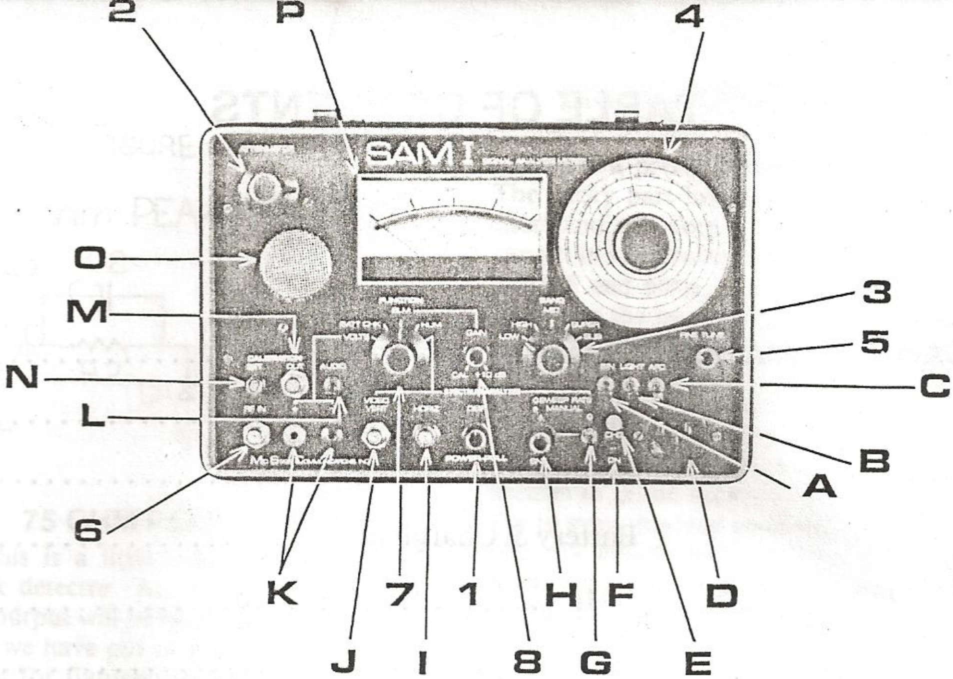


PRIMARY CONTROLS — SAM I

1. **Power-Pull:** On-off switch. Pull to energize unit. This control also functions as the dispersion control for the spectrum analyzer option.
2. **Attenuator:** Sets input range and changes meter scale to identify proper range.
3. **Band:** Selects one of the five frequency bands on the main tuning dial.
4. **Dial:** Tunes any frequency from 4 MHz to 300 MHz.
5. **Fine Tune:** Works with the main tuning dial and acts as a peaking control.
6. **RF IN:** Input jack for signals to be measured.
7. **Function:** Selects meter mode, i.e. level, hum, etc.
8. **Gain:** Provides 10 dB variable gain.

Other Controls & Indicators

A. **S/N:** Used to compensate noise readings for 4 MHz bandwidth.

B. **Light:** Illuminates meter.

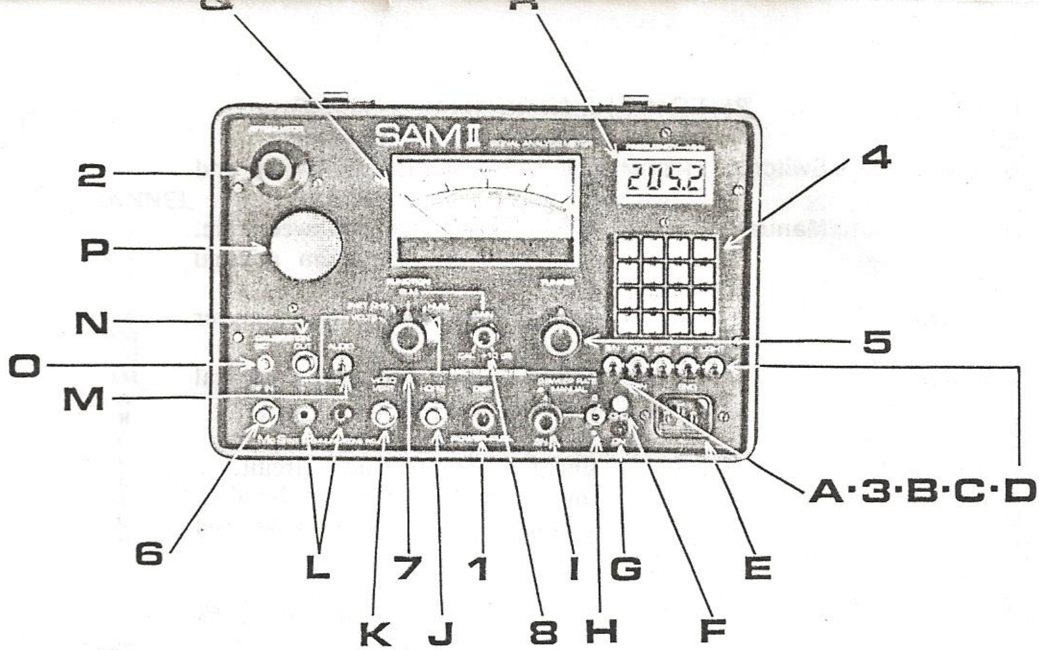
C. **AFC** Energizes AFC circuit to aid meter peaking.

D. **Jack:** 110 VAC input to charge circuit.

E. Charge:	Indicates battery being charged.
F. On:	Indicates SAM is turned on.
G. Manual/Rate Switch:	Selects between manual sweep and recurrent sweep control H.
H. Sweep Rate/Manual:	Rear control, spectrum sweep rate. Front control, spectrum manual rate.
I. Horiz.:	Sweep ramp output for analyzer option.
J. Video/Vert.:	Video output and scope vertical for analyzer option.
K. + — :	Voltmeter input jacks.
L. Audio:	Energizes internal audio circuit.
M. Out:	Internal calibrator output signal.
N. Set:	Calibration control for signal level meter function.
O.	Speaker
P.	Meter with scales for dBmV, % hum, & AC-DC volts.

STANDARD TEST SET-UP — SAM I

CONTROL	POSITION
1. Power-Pull:	Pull on
2. Attenuator:	Set for +15 to +25 dBmV in windows.
3. Band:	Set to MID.
4. Dial:	Set to 150 MHz.
5. Fine Tune:	Set to mid range.
6. RF IN:	No connection.
7. Function:	Set to SLM.
8. Gain:	Full CCW and detented.
A. S/N:	Normal (switch down).
B. Light:	Off (switch down).
C. AFC:	On (switch up).
D. Jack:	No connection.
E. Charger:	N/A.
F. On:	Should be lit.
G. Manual/Rate:	Recurrent Sweep (switch up).
H. Sweep rate	Mid range.
I. Horiz.:	No connection.
J. Video Vert.:	No connection.
K. + — :	No connection.
L. Audio:	Off (switch down).
M. Out:	No connection.
N. Set:	No connection.
O. Speaker:	N/A



PRIMARY CONTROLS — SAM II

1. **Power-Pull:**	On-off switch. Pull to energize unit. This control also functions as the dispersion control for the spectrum analyzer.
2. **Attenuator:**	Sets input range and changes meter scale to identify proper range.
3. **PGM/MAN.:**	Selects manual tuning or keyboard tuning.
4. **Keyboard:**	Selects channels to be measured.
5. **Tuning:**	Conventional coarse and fine tuning for signal level meter mode.
6. **RF IN:**	Input jack for signals to be measured.
7. **Function:**	Selects meter mode, i.e., level, hum, etc.
8. **Gain:**	Provides 10 dB variable gain.

OTHER CONTROLS & INDICATORS

A. **S/N:**	Used to compensate noise readings for 4 MHz bandwidth.
B. **AFC:**	Energizes AFC circuit to aid meter peaking.
C. **PIX/SND:**	Selects A or B function on key-board.
D. **Light:**	Illuminates meter.

E. Jack:	110 VAC input to charge circuit.
F. Charge:	Indicates battery being charged.
G. On:	Indicates SAM is turned on.
H. Manual/Rate Switch:	Selects between manual sweep and recurrent sweep control I.
I. Sweep Rate/Manual:	Rear control, spectrum sweep rate. Front control, spectrum manual rate.
J. Horiz.:	Sweep ramp output for analyzer.
K. Video/Vert:	Video output and scope vertical for analyzer.
L. + — :	Voltmeter input jacks
M. Audio:	Energizes internal audio circuit.
N. Out:	Internal calibrator output signal.
O. Set:	Calibration control for signal level meter function.
P.	Speaker.
Q.	Meter scales for dBmV, % hum & AC-DC volts.
R. Frequency:	Digital frequency display.

STANDARD TEST SET-UP — SAM II

CONTROL	POSITION
1. Power-Pull:	Pull on.
2. Attenuator:	Set for +15 to +25 dBmV in windows.
3. PGM/MAN.:	Set to MAN.
4. Keyboard:	N/A.
5. Tuning:	Set to 150 MHz on digital display.
6. RF IN:	No connection.
7. Function:	Set to SLM.
8. Gain:	Full CCW and detented.
A. S/N:	Normal (switch down).
B. AFC:	On (switch up).
C. PIX/SND:	N/A.
D. Light:	Off (switch down).
E. Jack:	No connection.
F. Charger:	N/A.
G. On:	Should be lit.
H. Manual/Rate:	Recurrent sweep (switch up).
I. Sweep Rate:	Mid range.
J. Horiz.:	No connection.
K. Video Vert.:	No connection.
L. + — :	No connection.
M. Audio:	Off (switch down).
N. Out:	No connection.
O. Set:	N/A.

MEASUREMENT RANGES

Frequency	4 MHz to 300 MHz 460 MHz to 920 MHz optional
Amplitude	−40 dBmV to +60 dBmV
Temperature	0 degrees Fahrenheit to +120 degrees Fahrenheit
Hum	0.5% to 5%
Voltage	5 - 100 volts AC-DC

ACCURACY

Frequency	SAM II ±100 KHz SAM I ±1 MHz
Amplitude	±0.5 dB at room temperature ±1.0 dB over temperature when calibrated at that temperature
Hum	±0.3%
Volts	10%

GENERAL

IF Bandwidth	280 KHz at 3 dB point 600 KHz at 40 dB point
Resolution	Sufficient to measure two FM signals of equal amplitude 400 KHz apart. Sufficient to measure a sound carrier in the presence of an upper video 40 dB greater than the sound carrier.
Video Output	1 volt for full scale reading
Power	Internal Nicad batteries external 110 VAC
Battery Life	Typically 8 hours continuous operation
Size	7'' high x 11'' wide x 10'' deep
Weight	11 lbs.

CALIBRATOR

Frequency	150 MHz ±2 MHz
Amplitude	+20 dBmV ±0.25 dB over temperature range

ANALYZER

Amplitude Range	40 dB on screen −40 dBmV to +60 dBmV
Frequency Range	4 MHz — 300 mHz
Rate	Variable 2 Hz to 40 Hz plus manual
Dispersion	Variable from 0.15 MHz to 300 MHz
Horizontal Output	Approximately 0-9 V.
Vertical Output	approximately 0-2 volts

CALIBRATION

The first part of this section is general background information on calibration techniques. Next, is the detailed procedure for calibrating a SAM. The SAM has been designed so that all necessary calibration can be performed from the front panel. If you can't do it without removing the instrument from the case, we assume the SAM does not need routine calibration, but requires alignment or repair which is covered in the maintenance manual. This manual is available on request. If you skip the background information, do not skip equipment checks before starting calibration.

Background Information

To understand calibration methods, we must look at our references and then examine sources of error to evaluate the technique to select. Figure 3-1 shows the calibration chain. First, the government decides how to measure. The second step is manufacturers that make the equipment to calibrate calibrators. The third step is manufacturers who make calibrators for CATV. The last step is calibration performed at the system level on a signal level meter.

Government Standards

You have to start somewhere, so we start with the National Bureau of Standards, (N.B.S.). These people work in cooperation with other governments around the world to tell us how an inch, pound, ohm, volt, second, etc. are defined. Voltage is measured by translation to power. Zero dBmV is one millivolt across 75 ohms. As we know the voltage and resistance by definition, we can translate this into power. Power = Voltage^2 divided by Resistance.

Power Meters are our second step in the calibration chain. They are not in wide use in our industry because they are of no use on a TV signal. All test equipment manufacturers and some large CATV calibration labs are equipped with these meters. We need to discuss them a little to understand possible errors later on in meter calibrators. Power is heat. The power sensing element is normally a bolometer. The bolometer mount contains a device that will change resistance when it changes temperature. When the bolometer is connected to an RF source, the RF energy heats the sensing element, which changes resistance and unbalances the bridge. The bridge unbalance is calibrated on a meter to indicate power. This heating is a function of average power. This is important to remember when working with modulated signals.

Zero dBmV is hard to measure because so little power (heat) is available. If you use about +50 dBmV, several methods are available. The least expensive is a calibrated detector. For a few dollars extra, you can purchase a detector with a calibrated DC output for +50 dBmV input.

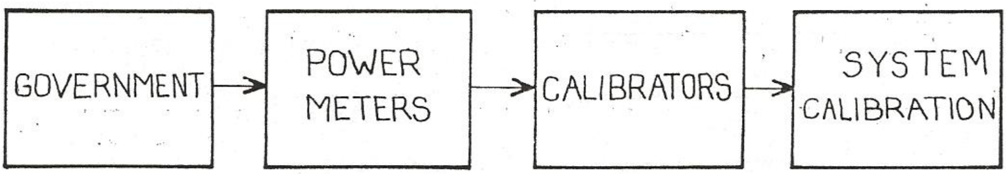


FIGURE 3-1 CALIBRATION CHAIN

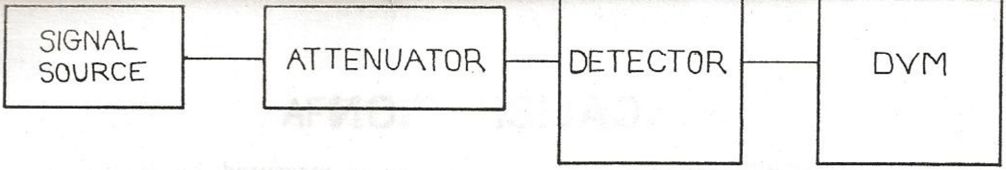


FIGURE 3-2 SIMPLE CALIBRATOR

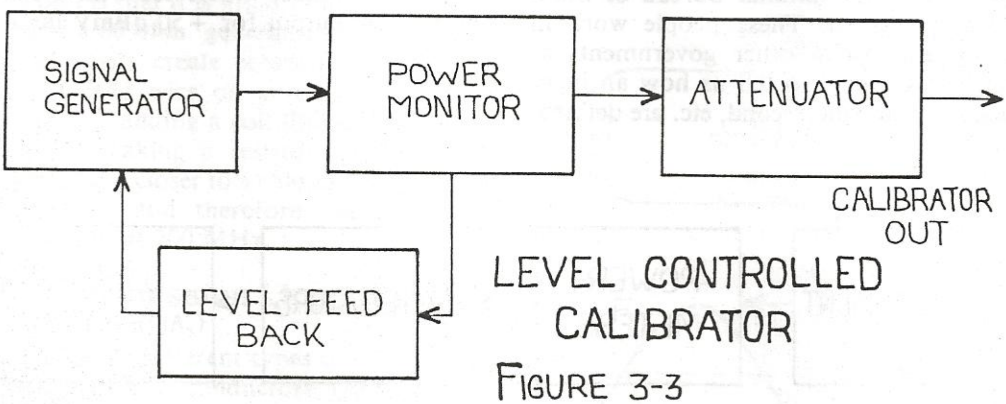
The signal source in Figure 3-2 is a standard signal generator or a sweep generator in the CW mode. The attenuator is a commercial 0 to 50 dB step attenuator. The detector is calibrated to put out 0.25 volts of DC for +50 dBmV RF input. To convert your signal generator to a calibration standard, adjust its output to get a reading of 0.25 volts on your meter or scope. Now, if you switch in 50 dB of attenuation, you have 0 dBmV, or switch in 30 dB, and you have +20 dBmV. This technique gets you a pretty reliable ±0.5 dB standard. The detectors are available from $35 to $75. Not too bad to convert present test equipment to a calibration standard.

Meter Calibrators

The further you go down the calibration chain, the more equipment you find available. The type of units offered generally fall into two class, tunable signal sources and broadband noise sources. The Mid State Communications MC-50 is a tunable signal source. To evaluate the accuracy of your meters, as well as the calibrators, we will discuss the calibrator.

Figure 3-3 shows a simplified block diagram of the MC-50 tunable type meter calibrator. A signal is generated and then fed to a power monitor, which controls a leveling or feedback circuit to keep the output constant regardless of frequency or oscillator aging. The leveled system is then fed through attenuators which are set to achieve the desired output level. The obvious fact is the accuracy of the system relies heavily on the quality and reliability of the output attenuator. There is also a hidden error. Harmonics or spurious signals can effect the calibration of the unit.

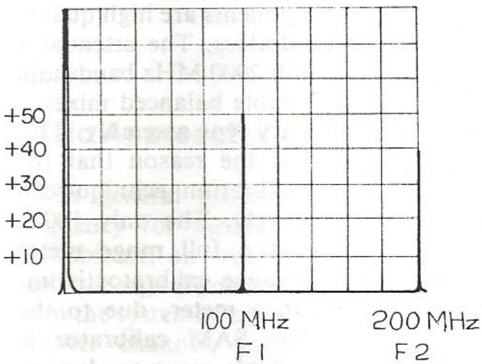
Figure 3-4 shows a spectrum display of a calibrator tuned to 100 MHz and set for +50 dBmV output. A harmonic at 200 MHz is only 10 dB down. When the calibrator is calibrated with a power meter, the power meter measures the total energy at 100 MHz + 200 MHz. When the signal is fed into a signal level meter, the meter selects only the 100 MHz signal, which will make it read low since it does not respond to the energy contained in the 200 MHz signal. This harmonic distortion or a spurious signal only 10 dB below desired will



LEVEL CONTROLLED CALIBRATOR

FIGURE 3-3

FIGURE 3-4



SPECTRUM DISPLAY OF A CALIBRATOR SIGNAL WITH A HARMONIC.

produce more than 0.5 dB error in your calibrator. All spurious and harmonious must be more than 25 dB below the fundamental to permit an accuracy of ±0.25 dB, which is the MC-50 specification.

Peak Detector Errors

This is a problem that has plagued the cable industry for years. The problem in the past was simply that signal level meters did a poor job measuring TV signals. The SAM has solved this problem. Peak detector errors are less than 0.25 dB anywhere on the meter face. The following discussion is to discuss the problems that may be encountered using the SAM calibrator on other meters.

The charging energy that is available from the detector diode to charge the peak detector capacitor, is a very important source for error. Most meters have a 20 dB meter swing. This is equivalent to a 10 to 1 voltage change on the peak detector circuit. The meter that has 1 volt

scale. This means the lower you read on a meter scale, the larger the peak detector error.

What does all this mean? It means, if you take a meter with a 2 dB peak detector error and set the sound carrier 17 dB down from the video, you really set it 19 dB down; and you are getting complaints on sync buzz. The sound signal has no amplitude modulation and, therefore, no peak detector error. The video carrier is modulated, now you have the signal really 2 dB higher than you thought you had it set.

At Mid State, when calibrating other brands of meters, we split the difference between CW and modulated signals. Our MC-50 calibrator has provisions for CW and modulated operation. Most meters have calibration controls that allow you to set the meter at its high and low end. This is done to assure that a 10 or 20 dB change in signal will read correctly on the meter. If you set the range on a CW signal, the meter will not read correctly on TV signals, and if you calibrate for TV, you will have errors on pilots and sound carriers. The decision is yours, as we said, we split the difference; on SAM the error is insignificant and can be ignored.

Environmental Effects on Calibration

In this type of meter, the environmental areas are usually confined to temperature and humidity. The other parameters of shock, vibration, dust and pressure are design parameters that decide if the instrument will or will not work. A great deal of design time was spent on the SAM looking at environmental conditions. The unit is very well built. The design called for water resistance, but not water proof. Water proof means an instrument is hermetically sealed, which adds so much to cost that it becomes impractical for system use. The SAM is designed so that humidity will not effect calibration and it is as water tight as is commercially practical. The main environmental condition that effects SAM is temperature. A meter such as SAM is designed to read level and tested for minimum temperature variation. If you look at level meter specifications, you will see that ±1.0 dB is as good as you can buy for temperature stability no matter what you pay. This is also true of $10,000 spectrum analyzers which have the same design problems. The SAM is equipped with a reference (calibrator) signal that is closed loop leveled to maintain a +20 dBmV ±0.25 dB output level over a temperature of 0° F. to 120° F. Using this calibrator, and calibrating the SAM at the temperature you are experiencing, lets you make a five times improvement over most other meters. If you are in an area that experiences wide temperature variations throughout the course of a day, it may be wise to touch up calibration a few times during the day to achieve maximum possible accuracy from your SAM. (See below)

Equipment Checks

Nothing is more frustrating than trying to calibrate a meter that won't calibrate, except calibrating a unit and finding that it's still bad. There are a couple of pitfalls in SAM that you should be aware of. One is battery level. The SAM battery check actually reads battery charge level. The line on the meter indicates the point that the power supplies will be regulated. It may be possible to calibrate the meter when battery levels are below required charge levels. The resultant operation will be unreliable. Always check the battery

in SAM that can be affected by temperature and aging are not related to the input tuning on the calibrated dial or digital readout. SAM is built like a modern spectrum analyzer. The input circuits are all passive. They include a connector, DC block, attenuator, and double balanced mixer. These components are high quality carefully chosen devices. The attenuator is a rotary style with 2000 MHz bandwidth capability. The double balanced mixer is a 1000 MHz military type assembly. This design approach is the reason that the single frequency calibration technique can be used so effectively. The only 100% sure calibration, is a full range meter calibrator. A full range calibrator is impractical to put in a meter, due to the cost involved. The SAM calibrator is excellent and we don't want to destroy your confidence in it, but felt it was necessary to point out the possible chances of error no matter how remote they are.

The calibrator built into SAM has a block diagram very similar to Figure 3-3. The signal source is a fixed 150 MHz signal. The attenuator is a fixed 30 dB pad and the level control is carefully adjusted to provide an output signal at the front panel of +20 dBmV. The calibrator's output is +20 dBmV because it is a typical test level and 150 MHz, because it is the midpoint of the SAM's operating range. The general procedure is to measure the calibrator signal and adjust the SAM calibration control until the meter reads correctly.

DETAIL CALIBRATION PROCEDURE

1. Set meter to standard test setup. (Section I).
2. Connect a cable from the Calibration OUT to RF IN.
3. Using the Fine Tune knob, peak meter for maximum reading. It should be very close to mid scale.
4. Adjust Calibration Set for exactly center scale reading. This will be +20 dBmV.

Note:

a. Calibrator output = +20 dBmV ±0.25 dB at 150 MHz.
b. When energized with no signal input, the SAM meter should rest down scale to the left.

CHARGING AND BATTERY CARE

The required charging circuitry for SAM is internal. All that is required for charging is 110 VAC. The batteries are nickel cadmium "C_S" cells. There are a few simple rules that can greatly prolong battery life. The main consideration is current consumption versus battery capacity. A good rule of thumb is to design an instrument for an 8 to 10 hour discharge time, which has been done. This means you can expect 8 hours of continuous use from a SAM before the batteries require charging. The other rules are under your control and they are:

1. **Try to recharge the batteries at room temperatures whenever possible.**
2. **Use the batteries. Don't short cycle by using for one of two hours and then recharging.**
3. **Don't overcharge. A completely discharged battery will recharge in about 14 hours or overnight. Try not to exceed this 14 hours by more than double.**

These tips are for trying to get maximum possible life from your batteries. The rules are general and apply for almost all nickel cadmium batteries. The charge light on SAM will gradually dim as the battery reaches full charge. At this point, remove the AC power. Please note, the 8 hour capacity is continuous and it may take several days of intermittent use to reach that 8 hours of use. It should also be noted that the 8 hours is approximate and will vary with the type of use the meter gets. For instance, night work requiring the use of panel lights or constant use of audio, will shorten the 8 hour period. By not using these items, it may increase to 10 hours. The SAM II keyboard circuitry uses additional power and could shorten life to 6 hours continuous. All these factors have been considered in the unit design; the batteries have adequate capacity for field use.

Battery Replacement

To replace the batteries it is necessary to remove SAM from its case. Remove the three screws from the back of the unit and slide SAM straight out of the case. The battery leads can be unplugged from the unit, and battery holder removed by removing the four mounting screws. The battery assembly may then be removed. Note the polarity and wiring before removing the batteries from the holder. There are 3 sets of batteries connected in series. Each battery set consists of 4 standard "C_S" cells. Replacements are available from Mid-State by ordering part number 050-008. Three sets are required per unit.

The SAM's are unique in that the UHF mode is not a convertor to VHF like most others. When switching to UHF the first local oscillator is changed to down convert to the first IF amplifier. The unit uses the same input connector and attenuator as in the VHF mode. All controls and function switches operate exactly the same on UHF as they do in the VHF mode. This technique not only makes the SAM easy to use but also produces a very accurate UHF instrument.

UHF frequency tuning of the SAM I is done by using the main tuning control. Channels 14-83 are tuned in 5 bands with a mark-on every TV video carrier. This 5 band technique provides excellent dial resolution.

UHF tuning of the SAM II is also done using the main tuning control. The digital readout is in MHz. The readout is accurate to + 0.2 MHz. The spectrum analyzer will also readout in MHz in the manual sweep mode.

SPECIFICATIONS UHF

These add to our supercede existing Sam specifications:
VHF

Accuracy of amplitude specified only from 10 MHz to 300 MHz
UHF
Amplitude accuracy −2.0 dB to + 1.0 dB

Sam I Dial tracking typically ± 1 Channel

HEADEND RESPONSE

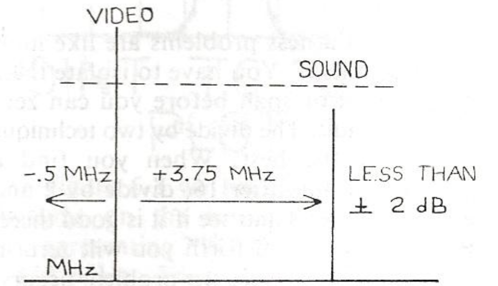


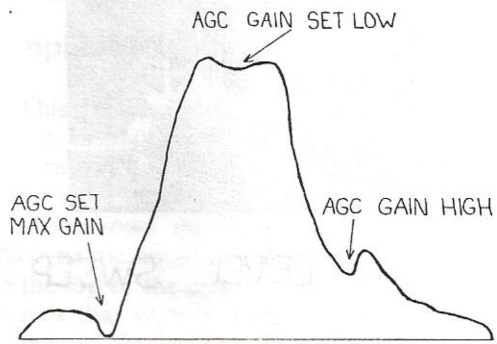
FIGURE 15-1 CHANNEL RESPONSE

The specification of ±2 dB from -.5 MHz to 3.75 MHz is referenced to the video carrier frequency. This means the total response cannot vary more than 2 dB from the amplitude of the response curve at the video carrier (Figure 15-1).

This is a fairly tight specification. It has already been relaxed twice by the FCC. The channel response, as written, includes everything from the antenna to the subscriber. In practice the system tilt will have almost no effect. UHF preamps are generally wider than one channel and most systems use manufacturers specifications to determine their effect on channel response. VHF preamps tend to be narrower and should be included in the test procedure. For the purpose of this procedure, we are assuming that there is not any tower-mounted electronics to be tested and will therefore start in the headend building.

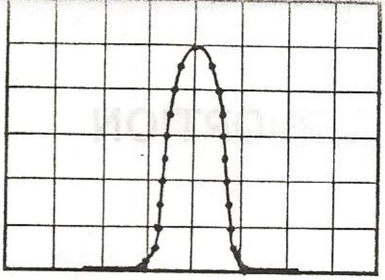
The main source of possible error in headend testing is due to AGC effects. There are very few headend processors or strip amplifiers that don't have AGC (Automatic Gain Control). This feature is necessary to maintain a constant level of signal in the system regardless of signal fades due to weather at the system antenna. The AGC loop monitors signal sc[illegible] here in the headend unit and corrects

you remove the input signals to perform a test, the AGC tries to correct for low signal and sets the gain of the processor amplifiers to maximum. A sweep signal applied for test purposes will be distorted by the AGC and give you an inaccurate picture of your response.

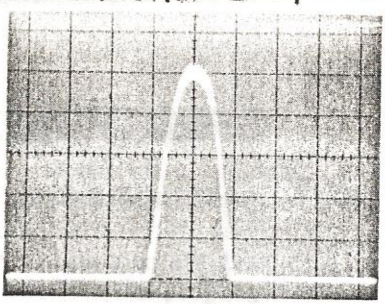


TYPICAL PROCESSOR CURVE
FIGURE 15-2

Figure 15-2 shows a typical processor curve. Following the response point by point, we start with the sweep going through an adjacent channel trap. The AGC thinks signal is low and raises gain to maximum, making the trap appear shallower than it really is. As the sweep gets up on the response curve the AGC sees a lot of signal and reduces again. As the processor tries to roll off to reduce sound output, the AGC picks up gain again. While this is all true in theory, in practice it is impossible to predict what will happen to the response curve. There are two approaches that may be taken to eliminate the AGC effect. 1) Switch to manual or 2) operate the test with normal signals on. We recommend the second choice. Some processors are not easily switched to manual, strip amps are near impossible and it is always a good idea to keep system signals on as much as possible. To prevent the test signals from interfering



POINT TO POINT PLOT



SPECTRUM DISPLAY

In figure 6-3 we have a graph with 8 divisions on the horizontal axis, each one representing 250 KHz. The center line is 150 MHz. The Y or amplitude axis is +20 dBmV at the top of the response. The graph in figure 6-3 is made by taking the 150 MHz calibrator signal and measuring its amplitude every 25 KHz. We have 20 points on the graph and have connected the points with a smooth line. The spectrum display in figure 6-4 is the same thing but with an infinite number of points. The spectrum analyzer measures and plots every point in frequency and automatically displays them for us. The plot of single CW carrier is a function of the resolution of the spectrum analyzer. This is the same thing as selectivity in a signal level meter. (Discussed in the signal level test section of this handbook). The resolution or resolving power of any analyzer is a function of the analyzer IF bandwidth. The resolution determines how close two signals can be together and still allow you to differentiate between them. As you see from figure 6-3, if a second signal were present within 100 KHz of the calibrator signal, it would be hidden by the calibrator signal. Resolution or resolving power is one of the items that dramatically adds to the cost of a spectrum analyzer. The resolving capability of the SAM analyzer is more than sufficient for level setting, video to sound setting, looking for harmonics and spurious signals and system sweeping. The resolving capability is not good enough for co-channel or cross mod work, but its price is a long way from $5,000 which is the cost of an instrument that does give you that capability.

Amplitude Range

This is the Y axis on our graph or scope display. The amplitude range is generally thought of as dynamic range. This is the maximum number of dB that can be shown on the scope face. A 40 dB dynamic range means from the bottom to the top of the display, you can observe signals that vary in amplitude by 40 dB. The SAM dynamic range is 40 dB and it is logarithmic. Being logarithmic in dB means that a 10 dB variation at the top of the graph is the same as a 10 dB variation at the bottom of the graph.

FIGURE 6-5

LINEAR DISPLAY

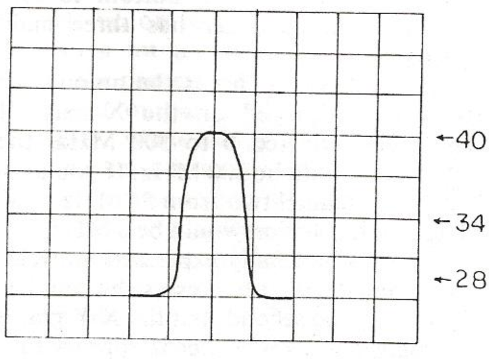
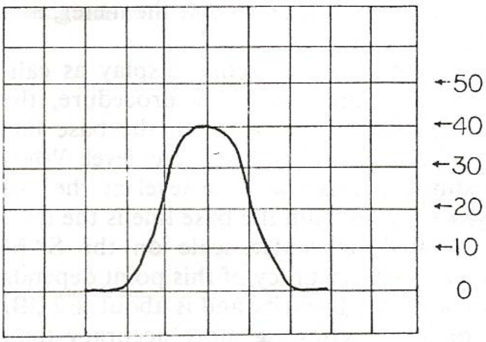


Figure 6-6 shows a log display. Figure 6-5 shows a normal sweep display of a filter which is not logarithmic. This is a linear display. Half of the trace is half voltage which is only 6 dB down from maximum amplitude. The spectrum display is logged to give you more dynamic range and to permit more accurate measurements of different signal levels.

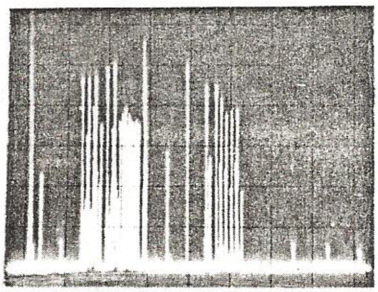
FIGURE 6-6
LOGARITHMIC DISPLAY



Reading A Spectrum Analyzer

To use a SAM analyzer, you have to adjust the oscilloscope vertical controls for a calibrated display. Before we do this, we will discuss some calibrated displays to familiarize you with the procedure for obtaining information from an analyzer.

FIGURE 6-7



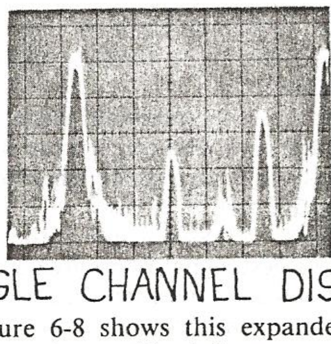
CALIBRATED DISPLAY

Figure 6-7 shows a calibrated display. The vertical scale is using six large divi-

dBmV. The horizontal axis is displaying 0-300 MHz over 8 large divisions or slightly less than 40 MHz per division. The large spike on the left is the analyzer IF or zero frequency mark. This is a normal analyzer display. Since the 5th line is +20 dBmV and each division is 10 dB, we can now look at signals ranging from -30 dBmV to +20 dBmV over a frequency range of 0 to 300 MHz. To say zero to 300 MHz is an over simplification. No analyzer goes to zero. The SAM starts at 4 MHz, everything below that is hidden by the zero mark.

Now looking at the photo in figure 6-7 let's look at the information provided. We see many signals present. The low band channels 2 through 6 are present with their aural carriers. A block of FM signals just after channel 6 and then the mid band gap. At 175 MHz, we start the high band channels 7 through 13 with their aural carriers (channel 8 is missing). In the center, there is a signal at 150 MHz with an amplitude of +20 dBmV. The amplitude at channel six is about +20 dBmV and at channel 13 it is about +8 dBmV. Now we will take the center frequency control and position channel 2 in the center of the scope and reduce the dispersion to take a closer look at channel two.

FIGURE 6-8



SINGLE CHANNEL DISPLAY

Figure 6-8 shows this expanded view of channel two. The left response is the video carrier. You can distinguish it by the sync pulse running through. The response on the right is the aural carrier which is 17 dB below the video carrier. The response just to the left of the aural

1. Set SAM up in the standard test set-up. (Section 1).
2. Function switch to spectrum analyzer.
3. Switch AFC OFF; switch down.
4. Dispersion control DISP fully clockwise.
5. Connect calibration OUT to RF in.
6. Connect VIDEO VERT to scope vertical.
7. Scope vertical 0.5 volt per large division.
8. Connect HORIZ. to scope horizontal input.
9. Set scope horizontal gain to 1 volt per large division.
10. Set attenuator for 0 dBmV center scale (-5 to +5 in windows).
11. The horizontal or frequency axis will now be fine adjusted. The scope horizontal gain and horizontal position should be adjusted so that the trace fills the whole screen from left to right. The analyzer zero mark should be on the left side with the calibrator signal in the center and the second harmonic of the calibrator at right side of the screen. The SAM frequency tuning and dispersion control may have to be slightly adjusted to achieve this positioning. We are now calibrated for 0 to 300 MHz on the horizontal axis.
12. The vertical or amplitude axis will now be adjusted. Set the scope vertical gain and position controls for a five division span from the baseline to the top of the calibrator signal. The amplitude scale is now calibrated for +20 dBmV equaling 5 divisions.
13. Disconnect the calibrator signal from the RF input and connect the system signals that are to be analyzed to the RF input.
14. Adjust the SAM attenuator until the largest signal is no greater than five vertical divisions. We are now ready to read or analyze the signals.

The analyzer should now be calibrated as in figure 6-7. Note that photo 6-7 also includes system signals.

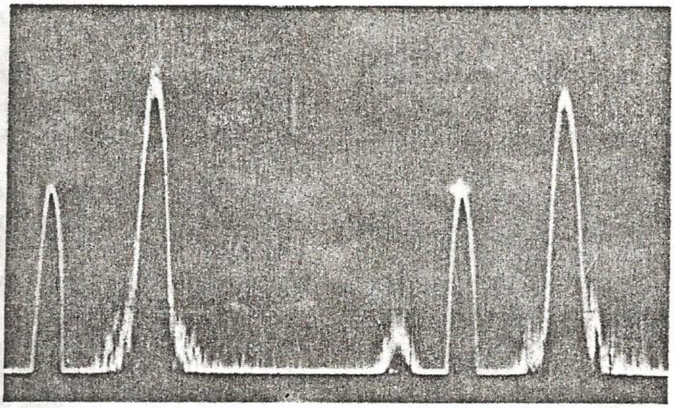
per large division and +20 dBmV is represented by signals that are 5 large divisions on the scope. +10 dBmV would be 4 large divisions, -20 dBmV would be 1 large division. We can now look at signals anywhere in the SAM measurement range (-40 dBmV to +60 dBmV) by using the SAM attenuator, no further set up changes are necessary on the oscilloscope.

Measuring Signal Level

There are two methods of measuring signal level with the SAM; the meter, and the scope display.

When using the scope display as calibrated in the preceeding procedure, the 5th graticule line up from the base line has been calibrated to an exact level. When calibrated this way, the level at the 3rd graticule up from the base line is the level indicated by center scale on the SAM meter. The accuracy of this point depends on analyzer linearity and is about ±2 dB. For levels requiring more accuracy than this, it is best to use the meter. This is easily done by placing the signal to be measured in the center of the screen and narrowing dispersion until it is the only signal present. Now turn the function switch to SLM, peak and read the amplitude from the meter.

FIGURE 6-9



MANUAL RATE

Identifying Frequency

The Sam II analyzer has a frequency identification feature that is not normally available on analyzers. The digital frequency readout can be used to identify the frequency of unknown signals to an accuracy of 200 KHz. The photo in figure 6-9 shows a typical system and an unknown carrier. To identify this signal, switch from recurrent sweep to manual sweep and with the manual sweep control position the trace at the peak of the unknown signal. Read the frequency from the SAM digital frequency readout. Neat isn't it? This procedure is made even easier if you narrow the dispersion (counter clockwise) and adjust center frequency so that you are only observing the unknown signal.

This handbook describes procedures for several system tests that are also FCC yearly requirements for all systems over 999 subscribers. Every required FCC test is listed. The specification listed as the FCC test is **our** interpretation. There are several things you must do to satisfy the FCC technical requirements. You must:

1. Have a testing file at the system and it must contain:
   a. Recorded test results;
   b. A copy of the procedures used;
   c. A list of the equipment used;
   d. Name or names of the personnel running the tests and their background qualifications;
   e. A file copy of the **current** FCC technical rules (76.605)
2. You must perform many of these tests at three locations in the system, one of which must be representative of the furthest point in the system from the headend (i.e. longest amplifier plus cable cascade). The tests are to be conducted annually if you have over 999 subscribers on a headend-count basis.

System Tests As Preventive Maintenance

As long as the tests have to be run, it is recommended that they be organized so you may utilize them in your daily operation. Test results that are changing are early warning indicators of problems to come. For example:

Test Symptom	Caused By
S/N degrading	Amplifier failing, and can be hidden by AGC of other amps correcting the problem.
Response bad	Pending amp failure, fittings about to break loose.
Hum bad	Power supply about to fail.
Radiation	Loose connector.

In other words, analyzing test results and comparing them with past results can save a midnight service run by correcting a malfunction **before** it fails completely. Many tests like signal to noise and hum, are so easy to perform with this meter that they should be made **every time** you measure signal level on an amplifier. It's a good idea to select standard check points throughout the system to periodically monitor. Checking levels, hum, and signal to noise once a month at your test points takes very little time and will really pay you back in system performance.

Handbook Tests

The procedures outlined should be read completely before you start a test. We have tried to go step by step, but reading and understanding them **before you start** will save you time.

SIGNAL LEVEL

FCC Specifications

1. At least 0 dBmV at the subscriber drop.
2. No more than 3 dB difference between adjacent video carrier.
3. No more than 12 dB between lowest and highest channel on system.
4. 13 to 17 dB differential between aural and visual carriers.

Basic Approach

A signal level meter is actually a frequency tuned voltmeter. We will measure signal levels in dBmV at specific frequencies; this means we are actually making amplitude vs frequency measurements.

We will connect the system to the RF input and tune the meter to read the channels to be measured. The frequency of the basic channels is on the tuning dial of the SAM I. The SAM II typically has the channels you need to measure on the keyboard. The amplitude control will be set for the proper meter scale.

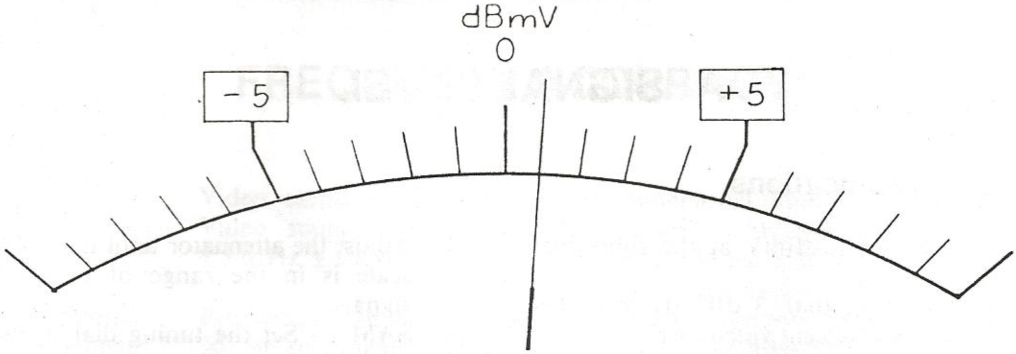
The procedure that follows is for measuring signal levels from -30 dBmV to +60 dBmV. To measure levels from -30 dBmV to -40 dBmV it is necessary to turn the front panel gain control fully clockwise, which adds another 10 dB of gain to the basic meter. When in this increased gain position, it is necessary to mentally subtract 10 dB from the meter reading. For all routine work, the gain pot should be kept in the detented, full counter-clockwise position. This position indicates CAL on the front panel.

Detailed Procedure

1. Place all controls in the standard test setup position. (Section 1)
2. Connect the signal to be measured to the front panel.
3. Turn on audio. This is an aid to finding signals. You can normally hear signals before the meter dis-
4. Adjust the attenuator until the meter scale is in the range of expected signals.
5. **SAM I** - Set the tuning dial to the channel or frequency to be measured. The left edge of the red arc is the video carrier, and the right edge is sound. Peak the meter with the fine tuning control.
   SAM II - For keyboard use, set the PGM MAN switch to the PGM position and press the desired channel. For manual tuning, set the switch to the MAN position and use the coarse and fine tuning control to set the digital display to the desired frequency.
6. Adjust the attenuator control if necessary.

FREQUENCY ALLOCATIONS

Using the SAM II, because of the digital frequency display, will cause you to become much more aware of the frequency relationship of TV video and sound carriers. This is really a good habit to get into because so many things in a cable system are frequency dependent. Most TV carriers have a definite relationship. All TV carriers, except channel 4, 5, 6, and 7 are at 6 MHz intervals from one another. Channel 2 video is at 55.25 MHz, channel three is +6 MHz or 61.25 MHz, channel four is +6 MHz or 67.25 MHz. Only between channel 4 and 5 is there a difference, in this case the differential is 10 MHz, putting channel five at 77.25 MHz. That's why 73.5 MHz is so common as a pilot carrier. **All** sound carriers are 4.5 MHz above the video carrier frequency. If you start memorizing a few channels, you can get any other by adding or subtracting 6 MHz segments. Channel 13 is 211.25 MHz, subtract six, which is 199.25



METER READING OF +1 dBmV

READING THE METER

There are three scales on the meter. The top scale is for dBmV. The dBmV scale covers a 20 dB range. The largest lines indicate 5 dB increments. The window numbers indicate 5 dB above minimum and 5 dB below maximum on the meter.

The meter example indicates +1 dBmV. As the amplitude range is rotated the meter scale numbers **automatically adjust** to show the correct range. When the SAM is off, the needle should rest on the left (large) division. When the meter is energized with no signal input, the meter should indicate down scale. (Left peg)

dB — WHAT'S A dB? deci Bell

All signal level measurements, in CATV systems, are made in dBmV. However, the difference between two levels is measured in dB. **The two are not the same;** 20 **dB** is not the same as 20 **dBmV.** dB is ratio between two signals. dBmV is a fixed and known signal level, related to voltage. Before we go into dBmV, let's look at dB voltage ratios.

Please note that this is **voltage** ratio chart; not a power ratio chart. A 6 dB voltage change is equal to a 3 dB power change. So dB is just a ratio. If you cut signal level by 6 dB you reduce signal voltage 2 to 1, or cut it in half.

$$\text{dB Difference Signals} = 20 \text{ Log}_{10} \frac{\text{Voltage Signal 1}}{\text{Voltage Signal 2}}$$

dB	Voltage ratio difference
1	1.11 to 1
6	2 to 1
20	10 to 1
40	100 to 1
60	1000 to 1

Figure 8-2

dBmV

Now we are tying ratios to a fixed point. By definition, 0 dBmV is 1 millivolt of signal across 75 ohms. So if you read 0 dBmV, you have 1 millivolt.

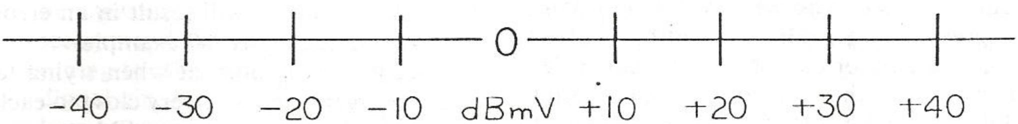
dBmV	=	Voltage
+ 40 dBmV		100 mv
+ 20 dBmV		10 mv
+ 6 dBmV		2 mv
0 dBmV		1 mv
− 6 dBmV		0.5 mv
− 20 dBmV		0.100 mv or 100 uv
− 40 dBmV		0.010 mv or 10 uv

Figure 8-3

The chart in figure 3 shows some typical voltage levels for typical dBmV levels. You see now that dBmV is a convenient method of referring to widely differing signal levels. As an example, let's assume you need to deliver a level of 1 to 2 millivolts to a subscriber and you measure 15 millivolts on the system. How do you calculate the proper tap value? It's far more convenient to say system level is +26 dBmV and the drop should be about +4 dBmV, so 26 dBmV — 4 dBmV suggests you need a 22 dB tap.

Adding and subtracting dBmV is an algebraic subtraction process. It's more easily seen on the graph in figure 8-4.

FIGURE 8-4 dBmV SCALE



dBmV Scale

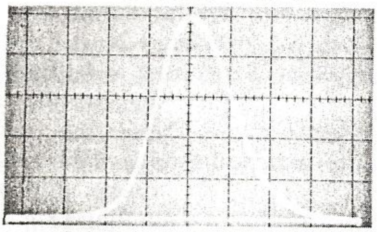
Other examples:

ie.
1. +10 dBmV — (−10 dBmV) = 20 dB difference
2. +17 dBmV — (−9 dBmV) = 26 dB difference
3. +10 dBmV — (+5 dBmV) = 5 dB difference
4. −15 dBmV — (−3 dBmV) = 12 dB difference

In example 1, we are subtracting two negatives which become a plus, you add the two numbers. Example 2 is the same thing. Example 3, we are subtracting a plus from a plus, normal math. Example 4, the two negatives make a plus so +3 and −15 equals 12; this addition can be more clearly seen by looking at the total dB range in figure 8-4.

As we said earlier, we are actually making voltage measurements at specific frequencies and thinking of this information as dBmV versus channel information. The SAM displays dBmV on the meter and the frequency on the digital readout or tuning dial. All meters have a specification which is called selectivity. This determines how close two signals can be to one another and still be measurable. The selectivity is a function of IF bandwidth and shape factor.

FIGURE 8-5



OLD STYLE METER BAND PASS

In talking about selectivity and shape factors, dB-ratios in volts is normally our reference. The selectivity is normally expressed as a 3 dB bandwidth. That is, the spectrum or bandwidth of frequencies contained within the IF curve to a point 3 dB below the peak signal reading. The 3 dB bandwidth of SAM is 280 KHz. This means that if two signals are closer together than 280 KHz they will both be and you will be unable to determine accurately the level of either signal. One signal could be 10 dB lower, and you wouldn't know it because the meter would only see the larger one. Most other meters have 3 dB bandwidths or 450 to 650 or more.

The second determining characteristic is shape factor. This determines resolving power 40 to 50 dB down from the peak. SAM has a shape factor of 4 to 1 at the 50 dB point. This means the IF bandwidth at the 50 dB point is 4 times that bandwidth at the 3 dB point; i.e. 3 dB = 280 KHz 50 dB is 280 KHz x 4 = 1.120 MHz. Now referring to figure 8-6, let's look at a TV sound carrier with a strong adjacent video. The video carrier is 40 dB stronger than the sound carrier, yet we can still measure the sound carrier without getting interference from the stronger video.

Figure 8-7 shows how another meter specifies the adjacent sound shall be 46 dB below the received video. After you sort all that out, you see from the graph that in this situation the meter will read the sound and video carrier at the same time creating a large error in the measurement. More normal system levels are about 20 dB apart, which will result in an error of 0.5 dB in the figure 8-7 example.

Selectivity is important when trying to measure signals that are very close to each other as is the case with many FM stations. SAM will do a better job of this than other meters because of its excellent selectivity.

FIGURE 8-6
GOOD SHAPE FACTOR

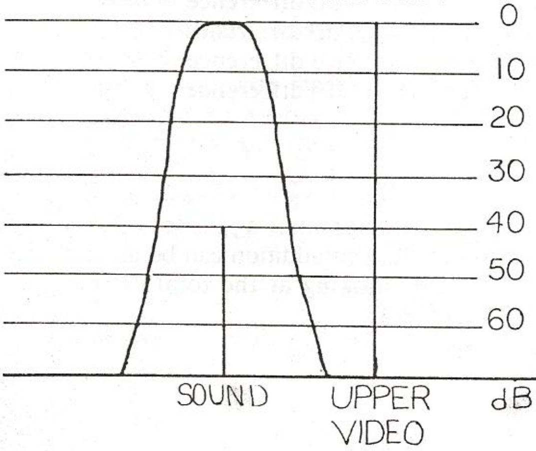
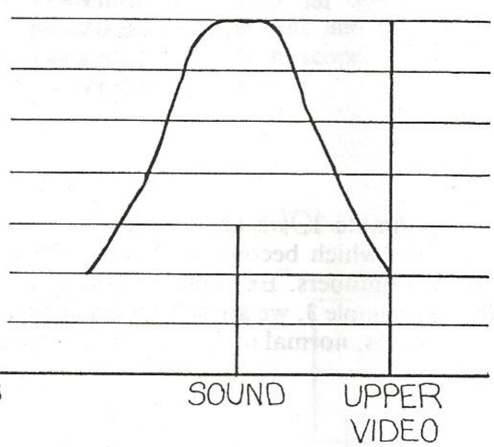


FIGURE 8-7
POOR SHAPE FACTOR



SIGNAL TO NOISE — S/N

FCC Specifications	Ratio of peak signal to 4 MHz system noise, shall be greater than 36 dB.
Typical Readings	40 to 50 dB

BASIC APPROACH

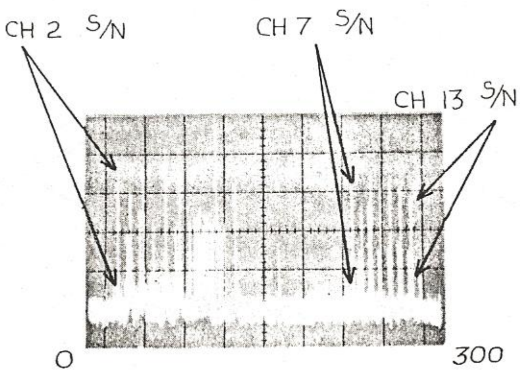
There are two basic procedures for doing signal to noise. One involves turning off system signals; we will describe the other. Both procedures have FCC acceptance. First, a short discussion on noise.

There are three main causes of noise or noisy pictures:

1. System noise from amplifiers.
2. Headend noise from processors and strip amps.
3. Noise received from noisy distant signals.

System noise is generally quite flat, and varies only a few dB across the whole 0 to 300 MHz spectrum. The noise will vary in proportion to system flatness which will keep the S/N ratio about the same. Headend noise will be frequency selective and produce noise only in the output band of the amp or processor. The noise to be measured in either case is average noise power inside a 4 MHz bandwidth. We will do the test in two parts, system and headend. The system test will be done by the offset or carrier to noise method.

FIGURE 9-1



SPECTRUM DISPLAY

Figure 9-1 shows a spectrum display of noise and video carriers. To measure S/N, we will measure signal on channel 2 and noise just below channel 2. For the highband we will measure signal on channel 7 and noise just below, and again signal on channel 13 and noise above channel 13.

SYSTEM DETAIL PROCEDURE

1. Set SAM for standard test set up. (Section 1)
2. Connect the system signals to SAM RF IN.
3. Measure the signal level of channel 2 or your lowest channel. To complete the test you should have a signal level of at least +20 dBmV. If sufficient level is not available, use a low noise preamp, such as the Mid State PA-20, to amplify the system signals or move to a location where more signal level is available.
4. Record the peak signal level measured in step 3. (i.e. 24 dBmV)
5. Switch audio on.
6. Tune the SAM down to about 50 MHz.
7. Adjust the attenuator for a meter range about 50 dB below the range in step 4.
8. Vary the SAM tuning for minimum meter reading and listen to the audio to make sure you are not tuned to a beat or spurious signal. The sound should be a hiss with no sync buzz or audio signals.
9. Hold the S/N switch up, read and record the noise level. (i.e. — 21)

The S/N switch on the SAM automatically makes the compensation for 4 MHz bandwidth and average power. Simply subtracting, algebraically, the two numbers will produce the signal to noise ratio, +24 — (−21) = 45 dB signal to noise ratio. Repeat these steps for channel 7 and 13. Be careful on channel 13 to get above channel 13 sound. Systems with mid band or super band channels will have to adjust this procedure to find empty spectrum area.

The headend check is more complex, so before it's run, see if it's necessary. Noise ratios of less than 40 dB will start to show on a TV set. Hook up a TV and tune through all channels. If all channels look good, the test is complete. If one or two channels appear noisy, and these are grade 3 contour or better signals, proceed to measure the headend pieces of those channels.

HEADEND PROCEDURES

It is necessary to remove the channel to be tested from the system. The procedure is to measure the signal level at the output of the processor strip amp in normal operation. The headend unit must then be set to manual gain and the output level control reset to read the same output level. The instruction manual for most headend pieces describes this procedure. The **input** of the processor is then disconnected from the antenna and the **input terminated.**

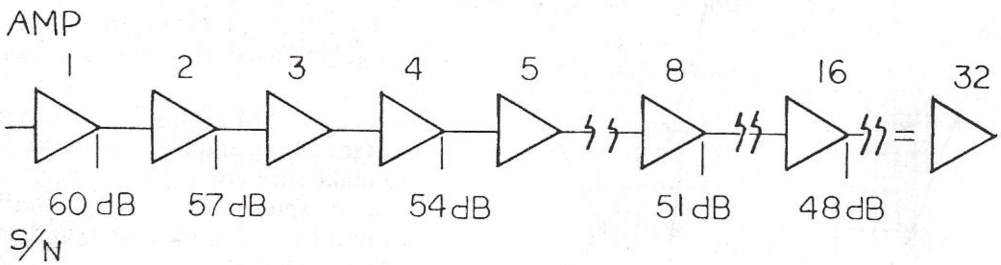
1. Set SAM for standard test set up.
2. Connect the output of the headend unit to be tested to the SAM RF IN.
3. Adjust the SAM tuning and attenuator controls to measure the output level. (i.e. +50 dBmV)
4. Disable the AGC on the processor or amplifier and manually reset to the output level measured in step 3. Record level.
5. Remove the input to the processor and terminate the input to the processor.
6. Adjust the attenuator control until a meter reading is obtained.
7. Switch the S/N switch up and read and record the noise level.
8. Algebraically add the level in step 7 to the level in step 6. This is the S/N ratio in dB. The S/N switch has performed all necessary compensation.

NOISE TROUBLE SHOOTING

System noise can be thought of as an infinite number of low level carriers all at about the same level and evenly dispersed throughout the entire range of your amplifiers. Each amplifier adds noise, but noise does not add directly, as the noise carriers do not always fall exactly on top of each other. To find a noise problem or to improve the noise figure of a system, we must understand the normal noise degradation of a system.

FIGURE 9-2

AMPLIFIER CASCADE

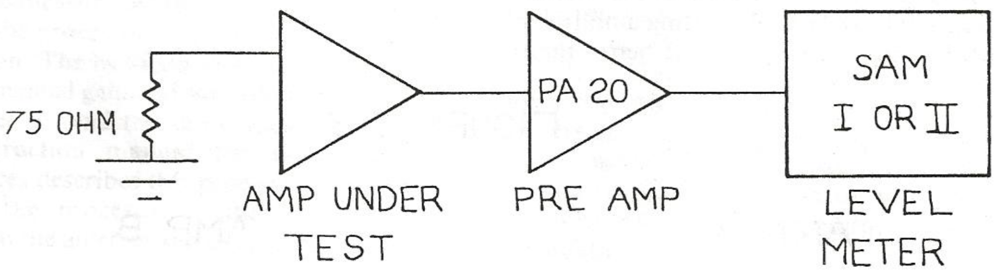


SORTING AMPLIFIERS THROUGH RELATIVE MEASUREMENTS

There are two variables in the noise output formula, amplifier gain and noise figure. If you take 4 amplifiers and set them all to have exactly the same gain, the following test set up can be used to determine which amplifier has the lowest noise figure.

FIGURE 9-4

NOISE TEST BLOCK DIAGRAM



This is a relative measurement. The unit with the lowest reading on the meter has the best noise figure. The different between the lowest and the highest is a direct dB difference in noise figure. If you use the same preamp and always set amplifier gain the same, this test set up will be good year after year to compare new amplifiers and general QC on repaired amps. It should be remembered that putting these lower performance amplifiers deeper in the system, will have no measurable effect on system performance.

FCC Spec:	Less than 5% peak to peak
Typical	1% to 2%

Basic Approach

Hum modulation is generally thought of as low frequency amplitude modulation caused by interaction of system signals and system AC power. Hum modulation is called out in FCC specifications as low frequency disturbances. This is a correct description because hum is composed of a variety of signals. A distorted sine wave contains harmonics of 60 Hz, at least, up to 240 Hz. Square wave supplies produce harmonics up even further. The SAM hum circuit is designed to monitor modulation produced by signals up to 500 Hz.

Detailed Procedure

1. Set SAM for standard test set up.
2. Connect the signals to be measured to the SAM RF IN.
3. Tune to the unmodulated signal to be measured. On the SAM II we recommend this be done in manual tuning to eliminate the possiblity of digital circuitry spikes effecting the hum measurement.
4. Adjust the attenuator control for a meter reading in the top half of the meter range.
5. Switch the function switch to HUM. The meter may momentarily peg to the right, it will then come down and read the correct hum level on the red scale.

Television signals are already amplitude modulated, making the test on TV signals extremely difficult. The accepted procedure is to make this test on an unmodulated signal such as a pilot carrier. If no pilot carrier is available on your system, it is recommended that you insert a signal for test purposes. Hum modulation is generally not frequency dependent. This means the test need be performed at only one frequency.

System Trouble Shooting

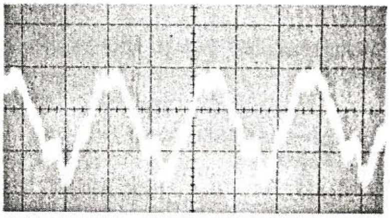
Looking for hum problems starts with a divide by 2 technique. If you are at amplifier 24 and get an unacceptable reading, divide 2 and go to amplifier 12, if it's still bad, divide 2 and go to amplifier 6. When you find a good reading, go back out halfway towards the bad reading until the trouble has been localized to a particular span or amplifier.

Probable Trouble Spots

1. Bad amplifier power supply. If an amplifier supply goes bad, it is common for a large amount of AC ripple to be present on the DC voltage. This will cause hum and will also, many times, give an early warning that a complete failure is about to occur.

2. Passive components. Directional couplers, taps and splitters **can** cause hum mod. A corroded connection has an oxide which, with the aluminum, produces a dissimilar metals situation which is the same as a diode. The diode produced forms a mixer circuit for your AC power supply and system signals. The resultant mixing produces hum modulation.

FIGURE 10-1



SCOPE DISPLAY OF SYSTEM HUM

PERCENT MODULATION

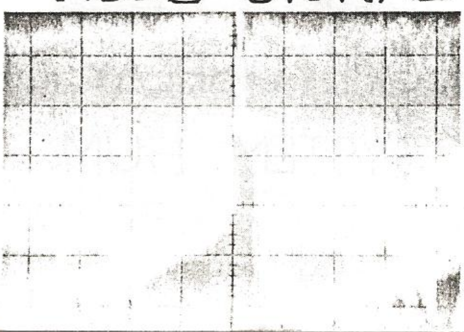
Percent Modulation (% Mod) is an operating test for modulators. Modulators used on local origination or from incoming microwave can change % modulation. Both over or under modulation can affect picture quality. Over modulation can produce objectional buzzing in the audio of the effected channel. This test uses the SAM as a receiver and demodulator and an oscilloscope as the read out device.

The photograph in figure 11-1 shows an oscilloscope displaying video information. Just after the vertical sync pulse there is a flag modulated almost to the zero or baseline. This test signal is available on most network video signals received by microwave. The procedure that follows describes how to use this pulse to set % mod on a modulator. The test set up is as in figure 11-2.

1. Set up SAM for the standard test set up.
2. Connect the channel to be measured to the SAM RF IN.
3. Tune frequency and attenuator controls to obtain a meter reading on the desired channel.
4. Adjust the attenuator for a meter reading on the top half of the meter range.
5. Connect video out to the oscilloscope vertical.
6. Set scope time base for 5 milliseconds per division.
7. Set scope vertical for DC coupled and approximately 100 millivolts per division.
8. Remove or ground the scope vertical lead and set the scope trace to the bottom of the scope.
9. Connect the vertical or unground it and adjust the scope vertical gain until the sync peak is eight divisions above the reference obtained in step #8.
10. Repeat steps 8 and 9 until all interaction between scope controls is eliminated.
11. You are now calibrated for 100% modulation for 8 divisions or 12.5% per division. The modulation depth should be 87.5% which would be a downward spike from the sync peak of 7 divisions.
12. Recheck that the SAM is peaked on signal and set the modulator so that the test flag (spike) goes down seven divisions or one division above the zero reference line.

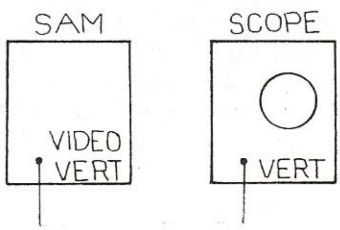
Note: Oscilloscopes often have trouble syncing on complicated signals like composite video. It may be easier to leave your scope on line sync and let the video pattern crawl across the scope.

VIDEO SIGNAL



11-1

% MODULATION TEST UP



11-2

```
DATA TAKEN AUTOMATIC-
LY WITH  MID STATE
  COMMUNICATIONS
  MODEL SAM II-D

DATE  DEC. 10, 1979

TIME 11:48 AM

LOC................

 2 PIX 5.3 DBMV
 2 SND 18.3 DB DOWN

 3 PIX .5 DBMV
 3 SND 18.3 DB DOWN

 4 PIX 7.8 DBMV
 4 SND 16.7 DB DOWN

 5 PIX 8 DBMV
 5 SND 17.9 DB DOWN

 6 PIX 3.2 DBMV
 6 SND 18 DB DOWN

 7 PIX 5.5 DBMV
 7 SND 18.5 DB DOWN

 8 PIX 7 DBMV
 8 SND 17.2 DB DOWN

 9 PIX 1.2 DBMV
 9 SND 16.6 DB DOWN

 10 PIX 3.1 DBMV
 10 SND 16.5 DB DOWN

 11 PIX 5.6 DBMV
 11 SND 18 DB DOWN

 12 PIX 1.1 DBMV
 12 SND 16.5 DB DOWN

 13 PIX 7.9 DBMV
 13 SND 17.8 DB DOWN
```

Basic Approach

The intent of this specification is to verify that temperature variations throughout the course of the day to obtain 24 hour period readings. It is not necessary to get up at 3:30 A.M.! Readings made very early in the morning, say 6-7 A.M., a few times during the warmest period of the day and again when the temperature has cooled down in the evening are sufficient to fulfill the test.

Detailed Approach

1. Measure signal levels as in the signal level portion of this handbook.
2. Record all levels for your records.
3. Repeat several times throughout the day.

The Sam II is now available in computer controlled and self-programmed configurations. The printout on the left is an example of what can be done to aid 24 hour tests with this option. Probes automatically record the temperature and the internal clock records the time of the test. This is an extremely easy way of running 24 hour tests.

FREQUENCY ACCURACY

FCC Specifications	Video carrier ±25 KHz Video sound separation 4.5 MHz ±1 KHz.
Additional Equipment Required	Frequency Counter (CM-20, or equivalent) Signal generator, (MC-50), or signal processor, (SP-2).

General Information

Frequency counters will **not** read **video modulated** carriers. All the problems of checking frequency of cable channels revolve around this fact. Mid State does make a unit (SP-2) that removes the video modulation so you can read frequency directly with the counter. This technique is fast, accurate, and the unit only costs $595.00. You don't use the SAM, all you need is the SP-2 and a frequency counter. If you don't have, or don't want an SP-2, read on.

We are going to use a SAM and a counter and a signal generator such as an RCA WR99 or Mid State MC-50. Since the counter won't count the TV modulated signal, we are going to put another signal (from a signal generator) that the counter will count on the same frequency as our TV signal and count the generator. How stable your signal generator is will greatly affect the ease of performing the measurement. A good warm up is necessary for maximum stability.

To understand what we are doing, a short review of heterodyning techniques is in order. When mixing (heterodyning) two signals, the **output** of the mixer will always contain the **two** signals being mixed **and** the **sum and difference** of the signals. For example,

Mixing signals A & B
Mixer outputs A, B, A + B, A-B

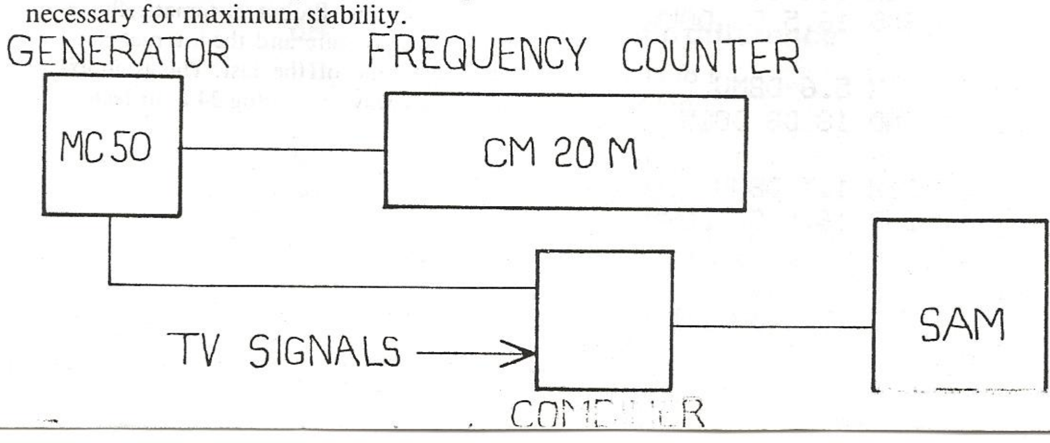
Example A

Take a TV signal at 55.25 MHz (ch.2), and mix it with 56.25 MHz.
Mixer outputs = 55.25, 56.25, 111.5, 1.0 MHz.

Example B

Now take a TV signal at 55.250 and mix it with 55.251 MHz.
Mixer outputs = 55.250, 55.251, 111.501, .001 MHz.

The .001 MHz signal is 1 KHz, which is an audible tone. By taking the two signals in example B and feeding them into a level meter, the detector in the level meter will act as a mixer, and the 1 KHz tone can be heard on the SAM speaker. As the two signals are moved



will become less, until there is zero frequency difference between the two carriers. Hence the term zero beat. The method we will use is the zero beat technique.

We will connect the output of the signal generator (MC-50) to the combiner, and connect the counter jack on the rear of the MC-50 to the counter (CM-20). If you don't have an MC-50, you will have to use a splitter on the output of your signal generator. The TV signals and the generator signals should be at about the **same** signal level.

Detailed Procedure

1. Connect the equipment as in figure 13-1.
2. Adjust SAM controls for the standard test set up. (Section 1)
3. Tune SAM for the channel to be measured.
4. Set the attenuator for an on scale reading.
5. Peak the meter.
6. Switch audio on.
7. Tune the signal generator for the frequency that the headend unit **should** be at.
8. Listen to the audio for a beat frequency and fine tune the generator for the lowest possible beat frequency.
9. Read the frequency counter.

Repeat for all visual carriers to be measured.

Network signals. These are almost never off frequency. Every video carrier is at its assigned frequency ±10 KHz assigned offset. This means channel three, for instance, will read: 61.240 or 61.250 or 61.260, if you read something else, you're probably doing something wrong. The Aural - Visual separation will be 4.5 MHz ± 100 Hz.

UHF-VHF conversions. There is a good chance you could be off frequency on the visual carrier. We have seen converters off 2 MHz. The visual-aural difference is usually right on frequency.

Modulators. Anything goes, this is the most troublesome part of system for frequency control.

Off channel conversion. Aural separation always good, video carriers usually within spec, but at odd frequencies, i.e. 61.257.

A Different Technique For Aural-Visual Separation

The **relationship** between video and sound carriers doesn't change when heterodyning. If you have a demodulator with a 4.5 MHz output, you can use it and a set top convertor to measure your 4.5 direct.

Figure 13-2

This really increases your accuracy. The specification on separation is 1 KHz or 1000 Hz. .0001% of channel 13 is 211 Hz. At 4.5 MHz you only have to be .01% to get 450 Hz resolution.

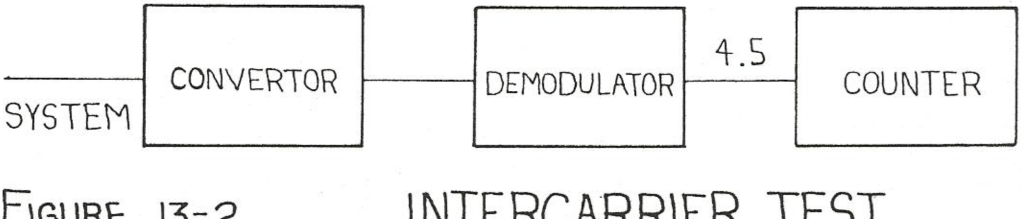


FIGURE 13-2 INTERCARRIER TEST

SYSTEM RESPONSE

Sweep Tests

FCC Spec.	a. System flatness shall be no more than 12 dB from channel 2 to channel 13.
	b. The response of any channel shall be better than ±2 dB from 0.5 MHz below the video carrier to 3.75 MHz above the video carrier.
Equipment Required	Sweep Generator or Signal Generator, Oscilloscope, & SAM with spectrum Analyzer option

System response and channel response are both X - Y or frequency versus amplitude measurements. If you are not completely familiar with thinking this way, we suggest you read the spectrum analyzer section before proceeding.

We are going to divide this test into two sections, headend and system. The 12 dB specification on low to high is primarily a function of system components, while the ±2 dB channel response is primarily affected by headend processors, traps, filters, etc. We will do system sweeping first.

System Sweeping

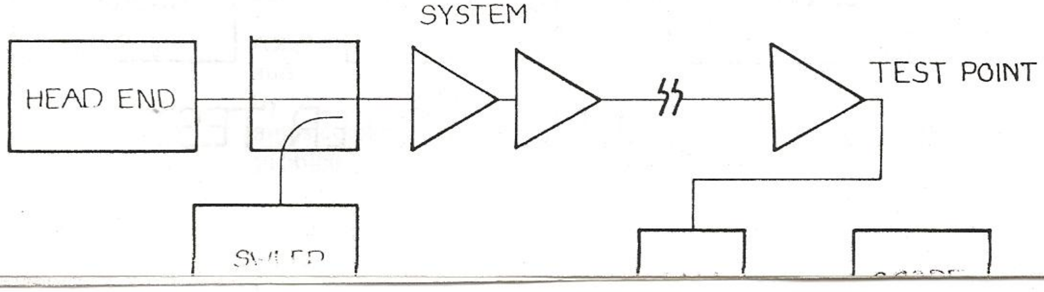
There are many techniques presently being used in systems for this test. Some are:

1. High level sweeping
2. Low level sweeping
3. Noise and spectrum analyzer
4. Sweep and spectrum analyzer

As in any area when you find many different methods or techniques being used the reason is that usually there is no clear cut superior method. This is the case here. High level sweeping is hard to use. Low level sweeping is very expensive. Using noise or sweepers with an analyzer, has been less expensive than low level, but still expensive. However, the spectrum analyzer on SAM now makes this technique very attractive. This sweep and spectrum analyzer method is used by many MSO's that could afford to use any of the available techniques. It is the procedure used by the FCC compliance vans and the one we recommend. There is some interference with subscribers sets, but all techniques except low level have this problem and field experience has shown that the amount of interference is tolerable and usually short lived.

FIGURE 14-1

SYSTEM SWEEPING DIAGRAM



A sweep test signal will be inserted at the headend. The SAM and an oscilloscope will then be taken in the field, and the system response measured and recorded or photographed.

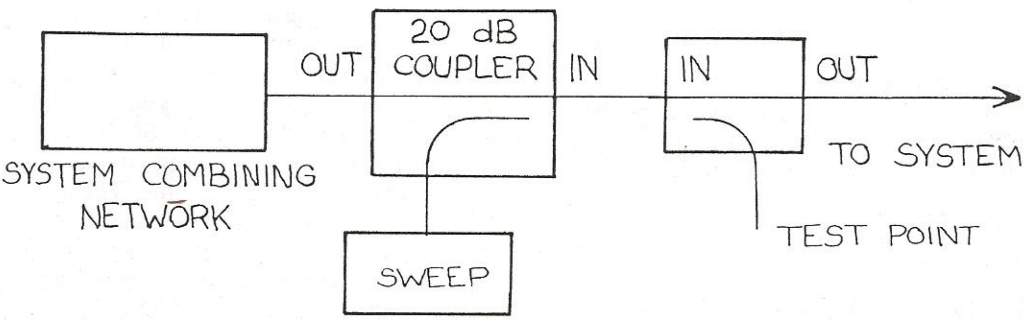
Headend Hookup

The sweep generator used must have the capability of slow variable sweep rates. We use a Wavetek model 1801 for this discussion. Other models from Wavetek and other manufacturers will also work. We are going to insert the sweep signal **20 dB below** the video carriers at a fairly slow rate. To do this, we must hook the sweeper into the cable system **after** all signals are combined.

We are going to put the sweep signal 20 dB below the video carrier. The first step is to go to the system output test point, measure and record the levels of channels 2, 6, 7, and 13. Typical readings depend on the size of the directional tap you are using at the test point. You must know the value of this tap because we want to determine what the system output level is. Every headend is different, but we will look at two typical ones.

FIGURE 14-2

HEAD END TEST SET-UP



Example A

CHANNEL	2	6	7	13
SYSTEM A READING	+20	+20	+20	+20 dBmV
TAP VALUE	20	20	20	20 dB
	40	40	40	40 dBmV

Example B

CHANNEL	2	6	7	13
SYSTEM B READING	+20	+20	+25	+26 dBmV
TAP VALUE	20	20	20	20 dB
	40	40	45	46 dBmV

System A. The level going out is a flat +40 dBmV. The backwards coupler being used to insert the sweep signal is 20 dB so the output level of the sweeper must be set at +40 dBmV to produce a system signal 20 dB below video carrier level.

System B. We have trouble. The sweeper puts out a flat signal, but the system is tilted. If we set the sweep 20 dB below channel 2, we will be 26 dB below channel 13. The sweeper we selected has an output tilt control to compensate for this situation. If the sweeper you use doesn't have this feature, you will have to build a compensator to correct the sweep output or check for a pre-built passive unit from RMS or Jerrold.

We now have a rough idea where to start in signal level. To start the frequency set-up it is usually best to put the sweep generator in the CW mode of operation and set the frequency control to a point where you don't have a channel. About 150 MHz is a good point in most systems. However, be careful if you have mid band channels. Note that we have not actually hooked the test signal into the system yet! Improper levels or frequencies can bother subscribers, so we are setting up first.

Analyzer Set Up

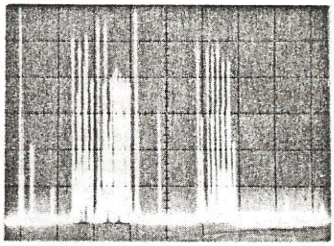
Hook the SAM and scope up in the analyzer mode, and insert the system signals from your test point. Set the analyzer functions to display the whole 0 to 300 MHz range (see analyzer section). This is sweep width-maximum; sweep rate-maximum; center frequency 150 MHz. For a 12 channel system the display should look like figure 14-3.

Adjust the SAM amplitude and scope controls to display a 40 dB range on the oscilloscope.

Connect the test signal into the SAM along with the system signals. This is easily done by combining the two signals with a splitter.

While looking at the display, vary the center frequency control back

FIGURE 14-3



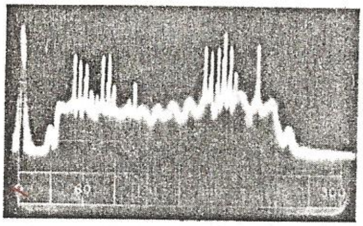
12 CHANNEL SYSTEM DISPLAY

mode with the sweep width control at maximum and the sweep rate control very slow. The test signal should start on the left side of the screen and slowly travel across to the right side. If you don't see the test signal, stay calm. Some sweep generators have a blanking signal that turns them off 50% of the time. The signal will be off for the same amount of time that it takes it to travel across the display. Adjust the sweep generators controls for a slow sweep and a sweep width in the range you are interested in (i.e. 50-220 MHz for a 12 channel system). Adjust the analyzer controls for the same band of interest. If you speed up the sweep rate control on the generator or slow down the rate of the analyzer you will lose resolution on the test signal. Verify that the test signal stays 20 dB below your video carriers, if not adjust the output or tilt on the sweeper until it is optimized. We are testing for 12 dB tilt so ±1 dB on the test signal should be sufficient. The **exact** level **down** from the video carriers is not important; only their relationship to the system carriers.

If you are confident of the analyzer and sweeper operation, connect the test signal into the system. Readjust the sweep generator output level to place the test

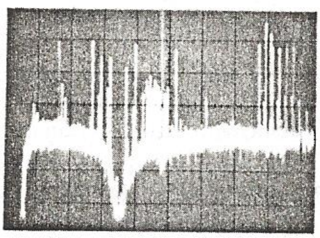
Go to the system test points and observe system signals and test signals to determine flatness. Figure 14-6 is the type of display you will see as the sweep signal travels across the spectrum display. Figure 14-4 is a photo of a low level test system which is showing a VSWR ripple pattern due to a bad match. Figure 14-5 is a 0 to 220 MHz display of a system using noise inserted in the headend 30 dB below video carrier level. Note the large notch in the middle of the low band.

FIGURE 14-4



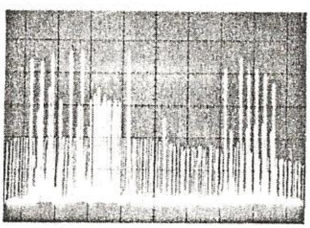
LOW LEVEL SWEEP

FIGURE 14-5



NOISE SWEEP

FIGURE 14-6
SPECTRUM DISPLAY
WITH TEST SIGNAL



Trouble Shooting System Flatness

System flatness problems are like most other problems. You have to isolate them to one area or span before you can zero in on the fault. The divide by two technique is usually the best. When you find a problem at amplifier 16, divide by 2 and go to amplifier 8 and see if it is good there. By going back and forth you will zero in on a small area where the problem occurs. System flatness problems generally fall into four catagories.

1. Notching - a suckout or notch in the response generally caused by cracked or corroded fittings, many times on taps.
2. Ringing - a sinewave appearing on the sweep response caused by bad VSWR. Usually bad connectors or cracked cable. The closer the sinewaves appear to each other, the farther you are from the problem.
3. Tilt - excessive tilt caused by waterlogged cable or bad amplifier response.
4. Signature response - This is the most difficult to correct. By signature we mean the characteristics of your amplifiers. An example would be an amplifier series that tends to roll off a little at the low and high end. If the amplifier tends to roll off .5 dB per amplifier at channel 13 after 10 amps, your down 5 dB. If it takes you out of spec, the only solution is to bench align your amps.

HEADEND RESPONSE

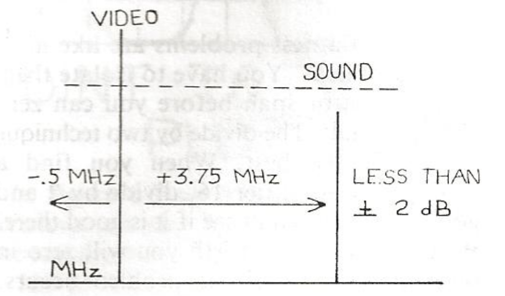


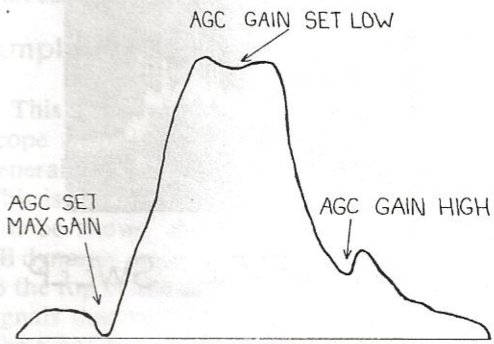
FIGURE 15-1 CHANNEL RESPONSE

The specification of ±2 dB from -.5 MHz to 3.75 MHz is referenced to the video carrier frequency. This means the total response cannot vary more than 2 dB from the amplitude of the response curve at the video carrier (Figure 15-1).

This is a fairly tight specification. It has already been relaxed twice by the FCC. The channel response, as written, includes everything from the antenna to the subscriber. In practice the system tilt will have almost no effect. UHF preamps are generally wider than one channel and most systems use manufacturers specifications to determine their effect on channel response. VHF preamps tend to be narrower and should be included in the test procedure. For the purpose of this procedure, we are assuming that there is not any tower-mounted electronics to be tested and will therefore start in the headend building.

The main source of possible error in headend testing is due to AGC effects. There are very few headend processors or strip amplifiers that don't have AGC (Automatic Gain Control). This feature is necessary to maintain a constant level of signal in the system regardless of signal fades due to weather at the system antenna. The AGC loop monitors signal sc... here in the headend unit and corrects

you remove the input signals to perform a test, the AGC tries to correct for low signal and sets the gain of the processor amplifiers to maximum. A sweep signal applied for test purposes will be distorted by the AGC and give you an inaccurate picture of your response.



TYPICAL PROCESSOR CURVE
FIGURE 15-2

Figure 15-2 shows a typical processor curve. Following the response point by point, we start with the sweep going through an adjacent channel trap. The AGC thinks signal is low and raises gain to maximum, making the trap appear shallower than it really is. As the sweep gets up on the response curve the AGC sees a lot of signal and reduces again. As the processor tries to roll off to reduce sound output, the AGC picks up gain again. While this is all true in theory, in practice it is impossible to predict what will happen to the response curve. There are two approaches that may be taken to eliminate the AGC effect. 1) Switch to manual or 2) operate the test with normal signals on. We recommend the second choice. Some processors are not easily switched to manual, strip amps are near impossible and it is always a good idea to keep system signals on as much as possible. To prevent the test signals from interfering

DIAGRAM

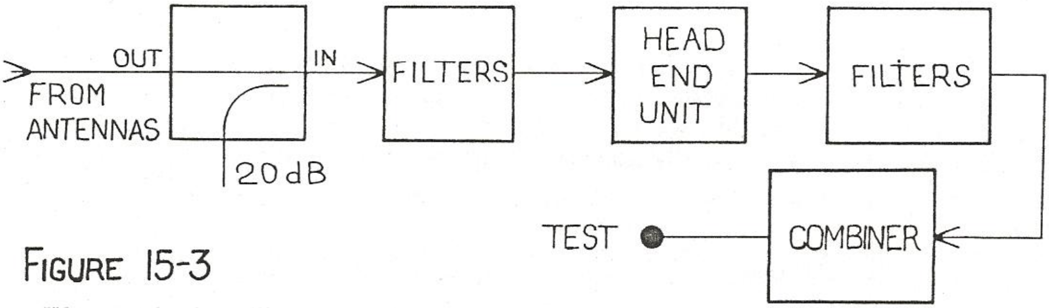
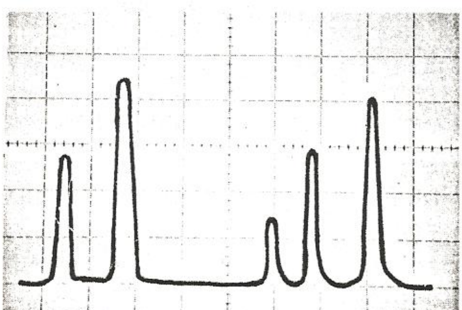


FIGURE 15-3

We start by installing a 20 dB coupler backwards in front of units to be tested. We recommend a permanent installation as this is a yearly test so why not be set forever? The only caution is on channels with very weak signals be sure to use a high value tap. We choose 20 dB and the higher the tap value the lower the insertion loss; this is important if the signals are already weak. Figure 15-3 shows the testing block diagram. Most manufacturers of new style processors recommend that you do not use filters, but in the past most headend units or strip amps had a generous supply of filters. Filters are part of the headend system and if you have them they must be part of the test. We will make the test by putting a test signal in the tap and looking at the channel response after the combiner. We will use the SAM analyzer to evaluate the response. Start by setting up the channel to be tested on the face of the CRT screen as shown in figure 15-4.

FIGURE 15-4



SINGLE CHANNEL DISPLAY

Change the SAM amplitude control to make it 10 dB more sensitive (the next lower level in dBmV). This should make the video carrier go off the top of the scope face and the sound carrier come up about mid way on the vertical scale.

Inserting The Test Signal

We are using a MC-50 signal generator, a sweeper or other type signal generator will work equally as well. The signal will be reduced 20 dB in the coupler and we want the signal on the system about 25 dB below the video carrier. Let's say the output level of the processor is +55 dBmV, the 25 dB down test signal would then be at +30 dBmV as the signal from the generator will lose 20 in the coupler. The generator will be set at +50 dBmV output. Generator output = coupler loss + processor output - dB down + 50 dBm V = 20 dB + 55 dBmV - 25 dB.

All this is just to put you in the ballpark so you don't fire up with a signal bombing through and overloading your cable system. Set the generator frequency to about the middle of your channel (i.e. halfway in between video and sound or 2.25 MHz above video carrier frequency).

We know that the video and sound carriers are 4.5 MHz apart, give or take a few KHz. If we set the two carriers exactly 9 horizontal divisions apart we have calibrated our horizontal base for .5 MHz per division. We will now be able to easily pick out our -.5 MHz point which will be one division to the left of the video carrier. The +3.75 MHz will be 7½ divisions to the right of the video carrier.

We now must set up the vertical display. The absolute level in this case is not important, we are interested in the relative amplitude referenced to the video carrier point. To do this, we will set up a 20 dB per 8 large divisions. This will produce a 2.5 dB per large division. To set this up, proceed as follows:

CONTROL	ACTION
1. SAM Funtion	Set to SLM
2. SAM Tuning	Tune to desired channel. Video carrier and peak meter.
3. SAM Aplitude	Set for mid scale reading on meter
4. SAM Function	Set to analyzer
5. Scope Vertical Gain	Set Video carrier peak 8 divisions up from the bottom of the CRT screen.
6. SAM Attenuator	Increase attenuation 20 dB.
7. Scope Vertical Position	Set video carrier to the bottom of the scope face.
8. SAM Attenuator	Decrease attenuation 20 dB
9.	Repeat steps 5 through 8 until interaction eliminated.
10.	Change the SAM aplitude control to make it 10 dB more sensitive (the next lower level in dBmV). This should make the video carrier go off the top of the scope face and the sound carrier come up about mid way on the vertical scale.

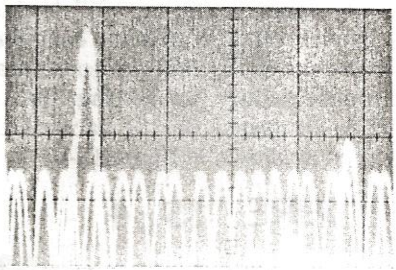
Set the test signal as close to the video carrier as possible without losing it in the video carrier response. This level is your zero reference, the signal may not go 2 dB above or below this point. (It will be more convenient if you adjust the generator output so that the test signal falls on an even large graticule line). Now tune the generator one large division (.5 MHz) below the video carrier and note the level change, it should be less than 2 dB, then tune up 7½ divisions (3.75 MHz), watching the response along the way for standing waves, notches, or roll off. The amplitude variation should be less than 2 dB. One large division is 2.5 dB, so 2 dB would be eight tenths of a large division. Most scopes have the large division broken into five - two tenths sections.

Figure 15-4 shows from left to right, video, test signal, color burst and sound carriers. This display is not calibrated as in the preceeding procedure. Figure 15-5 shows the test signal walked through the channel demonstrating flatness.

Figure 15-6 shows a correctly calibrated display with the test signal in the center and the analyzer sweep width and oscilloscope controls correctly adjusted.

Remember, this is how to test a pro-
…on don't meet spec, you're
… the unit out of service.

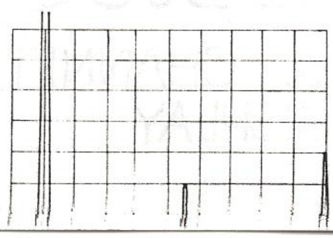
FIGURE 15-5



SINGLE CHANNEL DISPLAY WITH TEST SIGNAL

FIGURE 15-6

SPECTRUM DISPLAY WITH TEST SIGNAL



FCC Spec	Less than 20 uv/m at 10'
Typical Readings	Where no problems exist, 1 to 2 uv/m. At breaks and leaks, 100-300 uv/m.
Additional Equipment Required	Dipole and Preamp (RD-1)

Basic Approach

The general procedure is to select a frequency for measurement that is not available off air. Any off air signals will mask the signal you are trying to measure from the system. Popular selections are, a weather channel, local origination, or microwave that is not transmitted locally. If a pilot frequency is selected, care must be taken to take into account any difference in pilot level from system level. A test at one frequency is sufficient to meet the requirements of the specification. The signals to be measured are quite small, (-36 dBmV at channel 2, -46 at channel 13). Therefore, when using a standard test dipole, a low noise preamp is required. The Mid State RD-1 has a battery operated amplifier built in.

Detail Procedure

1. Adjust dipole length for the frequency of the channel to be measured for leakage.
2. Adjust SAM controls for the standard test setup.
3. Connect the dipole to the SAM RF IN.
4. Tune the SAM to the frequency to be measured.
5. Position the antenna ten feet under and parallel to the cable. Rotate the antenna to the maximum meter reading.
6. Read meter. If you have a RD-1, its manual will indicate the allowable amplitude reading of each frequency. If you have other dipoles and amplifiers you must do some calculations.

The specification is written in microvolts per meter (uv/m). This must be converted to microvolts (uv) and then to dBmV. The necessary formulas are shown below.

Formulas for conversion of uv per meter to microvolts

uv/m = .021 x Microvolts × F (MHz)
i.e. 20 uv/m = .021 x uv x 211.25
20 uv/m = 4.436 uv at channel 13

Formulas for Microvolts = dBmV

dBmV = 20 log (Millivolts)
i.e. channel 13 = 4.436 uv = .004436 mV
dBmV = 20 log x .004436
dBmV = -47.060

Possible Errors

Distance: A two foot error in your ten foot distance can change the measurement 5 dB.

Interfering cables: Guy wires and other cables, grounds on poles can reradiate leaks. Whenever possible, keep all interfering items ten feet from your dipole.

Dipole length: A two inch setting error on dipole length can produce 2 to 3 dB errors.

Finding Leaks

The procedure previously described is for measuring the amount of leakage. This is not the best procedure for finding leaks. We recommend a patrolling technique similar to the Mid State ST-1 "Cuckoo" or ST-1C and CR-1 combination.

Radiation Spots

The causes of leaks are numerous. Illegal hookups, bad fittings, cracked cable, loose housings on taps and amplifiers and squirrels eating cable are but a few. The largest number of radiation problems are usually found in distribution; primarily F connectors.

Patrolling Regulation

Systems carrying signals in the 108 MHz to 136 MHz range and the 220 MHz to 270 MHz range are subject to additional patrolling and record keeping requirements. We have additional information on this subject, it is available at no charge. Call or write Mid State Communications.

It is not always possible to keep interfering cables ten feet away as is shown in figure 16-1. It is also nor always possible to get ten feet below a cable as shown in figure 16-2. In cases like this, there is no answer. Do the best you can and make a note on the test data of problems encountered.

Figure 16-3 shows a typical problem with a burnt drop cable. No complaints were received, but the problem was found by patrolling techniques.

FIGURE 16-1

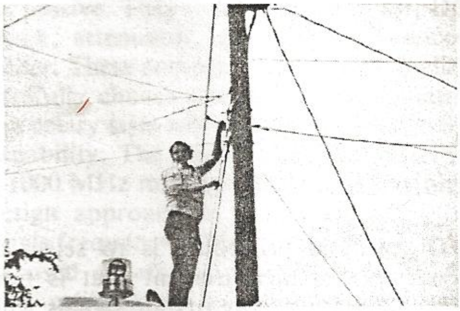


FIGURE 16-2

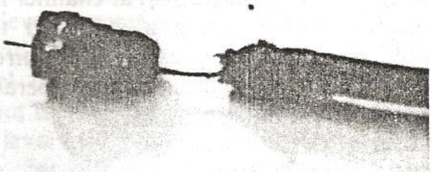


FIGURE 16-3

DIVIDER NETWORKS

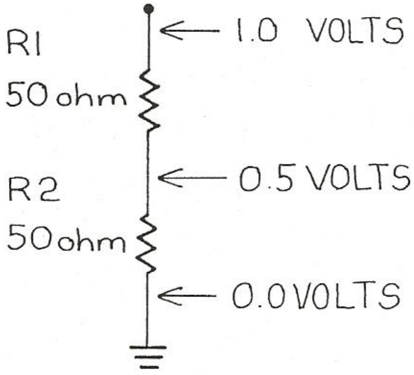


FIGURE 17-1

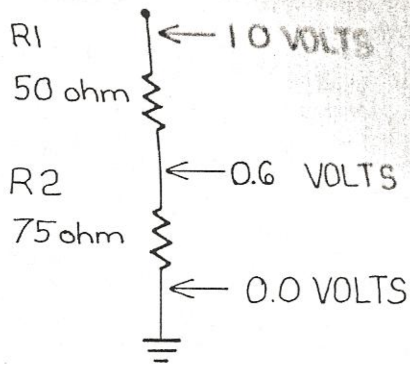


FIGURE 17-2

Effects on Measurements

Poor return loss can cause measurement errors. Mismatching can cause errors. To see this, we will define some terms and look at some simple transmission line theory and mismatch problems.

Matching and loading

DC-OHMS — If you start with 1 volt DC and apply it to a pair of 50 ohm resistors connected in series, the entire 1 volt will be dropped across the two resistors as the resistors are of equal value and each will drop half the voltage. See Figure 17-1.

The voltage divider in figure 17-2 has unequal resistors. The first resistor, 50 ohms, drops .4 volts leaving .6 at the midpoint. The .6 volts is then completely dissipated in the second 75 ohm resistor. E (voltage drop) = I (current) x R (resistance ohm). First calculate:

$$I = \frac{E\text{ (volts)}}{R\text{ (total circuit ohms)}}$$

Signal generators, meter calibrators and power meters all have specified impedances. Most CATV generators have the output or source impedance specified at 75 ohms (while most other industries use 50 ohms as a specification). In figure 17-1 and figure 17-2, consider the R_1 resistor as the signal generator source and R_2 as the termination you put on the front panel. Figure 1 would show a generator with a specified 0.5 volts output into 50 ohms. Using this generator on a 75 ohm meter or amplifier will allow the output to go up to.6 volts; more than 2 dB error. This is straight loading or mismatching error and does not include the standing wave effect which we will discuss later.

Impedance

Is symbolized by the letter Z. It is specified in ohms and takes into account the inductive and capacitive reactances of the circuits. Everything has inductance or capacitance; even a resistor. The amount of capacitance or inductance may be so small that it may be ignored, but there is still some there. Capacity and inductance are frequency sensitive items. The higher you go in frequency, the lower the impedance a fixed value of capacity becomes. A 10 pF capacitor at 55 MHz (ch. 2) equals 300 ohms Z. That same 10 pF capacitor has an impedance (Z) of 80 ohms at 200 MHz (ch.11). Now look at Figure 17-3 which is representative of a 75 ohm generator terminated with a 75 ohm resistor that also has 10 pF (pico

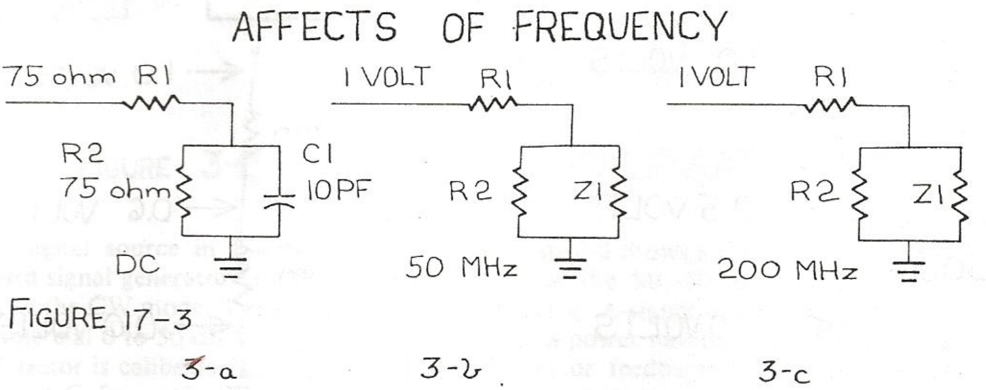


FIGURE 17-3

Farad) stray capacitance. In figure 17-3A, a 1 volt DC signal will produce 0.5 volts at the junction of R_1 and R_2 since the DC voltage won't see the capacitor. But in the same circuit at 50 MHz (figure 17-3B) the capacitor has a Z of 300 ohms, which paralleled with 75 ohms equals

$$\frac{R_2 \times Z_2}{R_2 + Z_2} = \frac{75 \times 300}{75 + 300} = 60 \text{ ohms}$$

Calculating voltage drop would produce an output level of .444 volts at 50 MHz. Repeating this again for figure 17-3C at 200 MHz:

$$\frac{R_2 \times R_2}{R_2 + Z_2} = \frac{75 \times 80}{75 + 80} = 38.7$$

This would compute to an output voltage of .34 volts at 200 MHz. The point is that it is important to understand that a **50 ohm** generator or power meter can really create erroneous readings. A long lead wire on a termination is the same as adding a coil (inductance) at 200 MHz. Taking a resistor and physically moving it closer to a chassis will change its capacity and therefore change its impedance at 200 MHz.

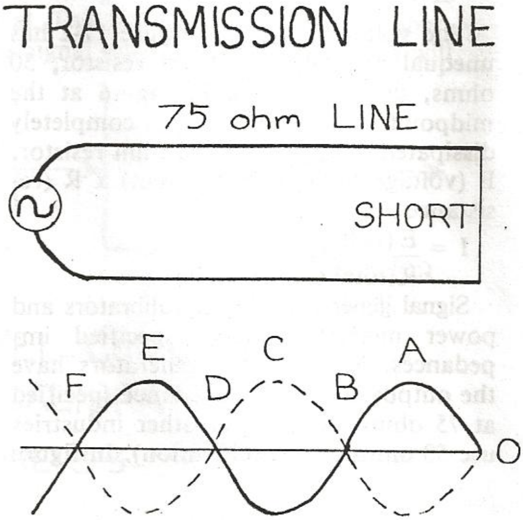
Transmission Lines (Cables)

There are different types of transmission lines; parallel conductors, (300 ohm twin lead), coaxial cable, waveguide, etc. The [illegible]c measurement problems associated

two year course, you're going to have to accept some basic "truths" concerning lines:

1. Transmission lines (cable) have a characteristic impedance.
2. A finite amount of time passes while a signal travels down the line.
3. If the line is terminated by its characteristic impedance, all the signal is absorbed by the load.
4. If the line is terminated by a short or an open, all the signal is reflected back to the source.

Now let's look at a long cable being used as a transmission line with a short on the line.

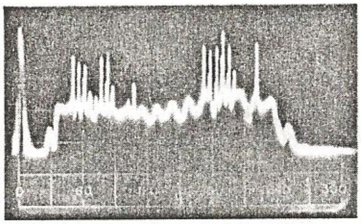


signal voltage along the line while the dotted line is the reflected signal voltage caused by the short. The voltage **at the short** is zero for **both** the forward and reflected wave. As you travel along the cable, however, you see that no matter what polarity you look at, there is voltage at points A, C, E, and none at B, D, and F.

If you look at the total voltage excursion you would see the two signals 'add' each ¼ wavelength and 'cancel' at ½ wavelength intervals. If you prepare a chart of the voltage peaks (E max, E min.) you would have a voltage standing wave ratio.

V S W R

The time delay, amount of mismatch and frequencies involved combine to produce a ripple pattern like the sweep response of the system pictured in figure 17-5.



RIPPLE PATTERN ON SYSTEM RESPONSE

FIGURE 17-5

The reflected signals add and subtract from the forward signal to produce the ripple pattern. In a system, the reflected signal bouncing around will cause ghosting. The ripple effect on the system can also happen on your test bench. For example, if you use long mismatched cables you can change test level readings because of standing waves.

The return loss spec we see on CATV equipment simply means the amount of signal that is lost (loss) because it is reflected (returned) due to a mismatch. **A 20dB return loss means the returned signal will be 20 dB lower (weaker) than the forward signal.** If you put 1 volt of signal into a device with a 20 dB return loss, a signal 20 dB down from 1 volt, or .1 volt will be returned (reflected) and lost. In other words, a 20 dB return loss will prevent 10% of your signals from being coupled into whatever you're trying to put it into. A 6dB return loss will reflect half, or 50%, of the signal. The lower the number (i.e. 3 is lower than 6 is lower than 20 dB) the larger the returned signal is, and the worse the VSWR is. The worse the VSWR is, the more measurement inaccuracies you have.

Return loss indicates the quality of the termination. if your amplifier has a 14 dB input return loss, that figure describes the deviation of the input impedance from 75 ohms and also describes the VSWR created by the amplifier's input or output circuits.

This whole subject was really just skimmed to give you an idea of how matching and mismatching effect measurements. If you want more information on the subject, the Radio Amateurs Handbook does a good job on transmission line theory (available from American Radio Relay League, Newington, CT, 06111).

TESTING SPLITTERS AND TAPS

First, there is no better way of testing passives than a good sweep generator. If you don't have one, the SAM can do a good job, not quite as thorough as the sweeper, but adequate. Before we get into testing, let's discuss the passives and the things we would like to test. You should also be familiar with making level readings with SAM.

TAPS

The taps, we so casually refer to, are really broadband directional couplers. A directional coupler or tap is shown in figure 18-1 with ports labeled.

DIRECTIONAL TAP

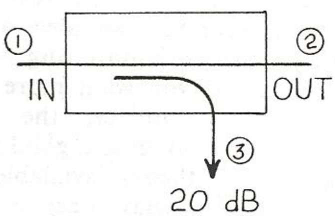


FIGURE 18-1

One, two, three is the in-out terminology. The tests run on taps are nonmally return loss and insertion loss tests. We will use the SAM to do the insertion loss tests. The tests are:

1. Through loss	Port 1 to port 2
2. Tap loss	Port 1 to port 3
3. Isolation	Port 3 to port 2

When testing passives, **all** unused ports must be **terminated.** We will use the SAM 150 MHz calibrator signal as our source and then use the SAM as the receiver to make all our measurements. [illegible] all seem to be extremely [illegible]

dBmV calibrator signal reads exactly +20.0 dBmV (see calibration section). To measure through loss, hook up as in figure 18-2.

THROUGH LOSS TEST

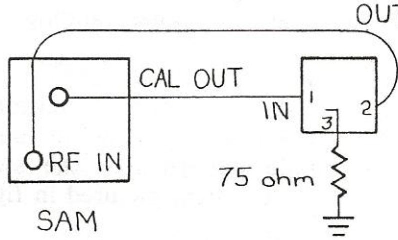


FIGURE 18-2

Through loss = 20.0 dBmV - level reading
0.8 dB = 20.0 dBmV - 19.2 dBmV

Measure the calibrator signal through the tap with the tap terminated. The difference between the calibrator signal (+20 dBmV) and the measured signal (i.e. 19.2 dBmV) is the tap through loss (i.e. 0.8dB).

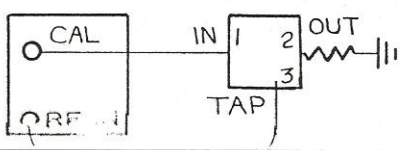
TAP LOSS

This is the loss from the in port (No. 1) to the tap port (No. 3). If you have a 20 dB tap, then the signal at the tap port should be 20 dB lower than the input to the device ± the manufacturers specification hook up as in figure 18-3.

Tap loss = calibrator signal - (level reading)
20 dBmV - 0.5 = 19.5 dB Tap Loss

Read the signal from the tap and subtract from the +20 dBmV calibrator signal.

TAP LOSS TEST



Because the tap is a directional coupler this test measures how much directivity you get. If the unit were **perfect,** a signal put in port 3 would not reach port 2, and the signal at port 1 on a 20 dB coupler would be 20 dB down. In practice, the 3 to 2 isolation will be about 20 dB plus the tap through loss. Hook up as in figure 18-4.

ISOLATION TEST

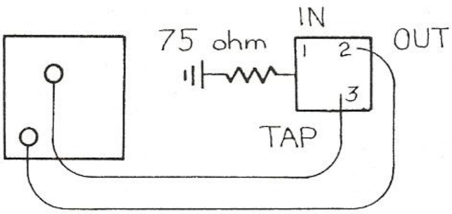


FIGURE 18-4

Isolation = calibration signal - level reading
20 dBmV - (-19 dBmV) = 39 dB Isolation

SPLITTERS

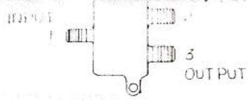
A splitter is a broadband power divider. A typical two way splitter will lose about 3.5 dB of signal in each leg and have about 20 dB of isolation between output ports.

The splitter testing procedure is like that of a tap. Always terminate the unused port. To check through loss, connect the meter and calibrator signal to ports 1 and 2. Terminate 3 and calculate the signal loss.

Through loss = Calibrator signal - measured reading

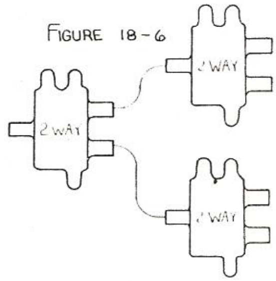
Isolation is measured by connecting the calibrator signal between ports 2 and 3, and terminating port 1.

Four-way and eight-way splitters and combiners are just multiple splitters.



SPLITTER

FIGURE 18-6



FOUR WAY SPLITTER

LOW HIGH SPLITTER

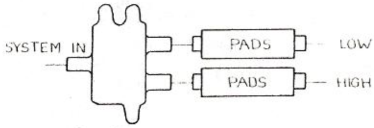


FIGURE 18-7

Four Way Splitter

The four-way splitter shown is simply three splitters in one can. If you turn them around, you have a four-way combiner. The through loss in a four-way splitter is typically 6.75 dB, which is 3+ dB from the first splitter and 3+ dB from the second.

ONE MORE WAY

The previous method's shortcoming is that it makes the tests at only one frequency (150 MHz) and that frequency is not in the standard TV band. Every cable system is blessed with a large number of frequency stable signals, the TV signals. Checking passives by using channels cable 2 and 13 will give you an excellent check on performance. Take a pad box or fixed pads and set the levels to something convenient. You can even make a permanent test set-up with pads and a low-high splitter.

If you have some old AGC strip amps not in use, you can add these to your test set-up and get more signal and better long term level accuracy. This set-up would also be a great quick check for your other signal level meters.

REFERENCE DIPOLE LENGTHS

CHANNEL	FREQUENCY MHz	LENGTH INCHES	20uv/M = dBmV
2	55.25	102½	−35.3
3	61.25	92½	−36.3
4	67.25	84¼	−37.
5	77.25	73¼	−38.2
6	83.25	68	−38.9
FM	88.00	64½	−39.3
FM	98.00	58	−40.3
FM	108.00	52½	−41.75
A	121.25	47¼	−42.1
B	127.25	44½	−42.55
C	133.25	42½	−42.95
D	139.25	41	−43.35
E	145.25	39½	−43.75
F	151.25	38	−44.05
G	157.25	36½	−44.4
H	163.25	35	−44.7
I	169.25	34	−45.
7	175.15	33¼	−45.3
8	181.25	31½	−45.6
9	187.25	30½	−45.9
10	193.25	29¾	−46.1
11	199.25	29¼	−46.4
12	205.25	28	−46.7
13	211.25	27	−46.95

dBmV-MICROVOLT EQUIVALENTS

dBmv	uv	dVmv	uv	dBmv	uv
-40	10	0	1,000	40	100,000
-39	11	1	1,100	41	110,000
-38	13	2	1,300	42	130,000
-37	14	3	1,400	43	140,000
-36	16	4	1,600	44	160,000
-35	18	5	1,800	45	180,000
-34	20	6	2,000	46	200,000
-33	22	7	2,200	47	220,000
-32	25	8	2,500	48	250,000
-31	28	9	2,800	49	280,000
-30	32	10	3,200	50	320,000
-29	36	11	3,600	51	360,000
-28	40	12	4,000	52	400,000
-27	45	13	4,500	53	450,000
-26	50	14	5,000	54	500,000
-25	56	15	5,600	55	560,000
-24	63	16	6,300	56	630,000
-23	70	17	7,000	57	700,000
-22	80	18	8,000	58	800,000
-21	90	19	9,000	59	900,000
-20	100	20	10,000	60	1.0 volt
-19	110	21	11,000	61	1.1 volt
-18	130	22	13,000	62	1.3 volt
-17	140	23	14,000	63	1.4 volt
-16	160	24	16,000	64	1.6 volt
-15	180	25	18,000	65	1.8 volt
-14	200	26	20,000	66	2.0 volt
-13	220	27	22,000	67	2.2 volt
-12	250	28	25,000	68	2.5 volt
-11	280	29	28,000	69	2.8 volt
-10	320	30	32,000	70	3.2 volt
-9	360	31	36,000	70	3.6 volt
-8	400	32	40,000	72	4.0 volt
-7	450	33	45,000	73	4.5 volt
-6	500	34	50,000	74	5.0 volt
-5	560	35	56,000	75	5.6 volt
-4	630	36	63,000	76	[illegible]
-3	700	37	70,000	77	[illegible]
-2	800	38	80,000	78	[illegible]
-1	900	39	90,000	79	9.0 volt

50 ohm to 75 ohm Matching Pad

This is a resistive match and is built just like an attenuator pad. It will have about 6 dB of loss.

PAD

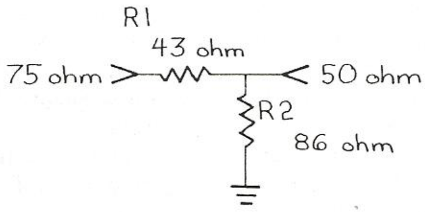


FIGURE 20-1

DETECTORS

We will show three different detector types.

1. 75 ohm peak
2. 75 ohm peak to peak
3. High impedance peak

There are many different variations, but these are three types that seem to be very popular in our engineering and test departments. The peak to peak 75 ohm is great for test set-ups for sweeping amplifiers. It also makes a super cheap calibration standard. Many systems, who have sweep generators, could use this detector with the sweeper as a calibrated test set-up.

The high impedance detector probe is really handy for trouble shooting. It lets you look at an amplifier stage by stage and determine where the problem occurs.

75 ohm PEAK DETECTOR

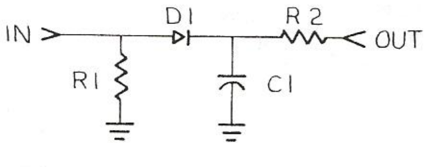


FIGURE 20-2

75 OHM PEAK DETECTOR

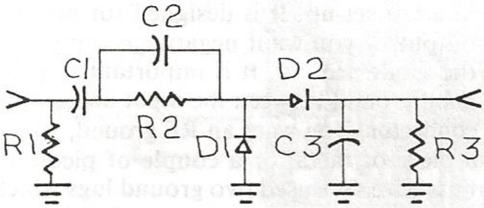
The schematic shows our simple peak detector. Please note that this does not mean synchronous peak as in signal level meters. This unit will respond to modulation or notches, which is what you want in a test set-up. It is designed for positive output, if you want negative, simply turn the diode around. It is important to get a good ground between the input and output connector. You want an RF ground, so use a piece of metal or a couple of pieces of buss wire. We used two ground lugs which we use in our products. A couple of pieces of the center conductor from some scrap 412 or ½ cable would be great. The main thing is to get a couple of good ground connections between the input and output connectors. This also gives your detector a good mechanical strength which will prevent connections from going intermittant on you.

Remember before the signal gets past the diode, it's high frequency RF. Lead length is important. At 300 MHz long leads are inductors. The resistor's physical placement changes capacitance. After the diode, it's not important, but before the diode, keep leads short and neat.

Parts List	Circuit Ref.
2 "F" Connectors	
2 ground Connections	
1 75 ohm ¼ watt resistor	R1
1 100K ¼ watt resistor	R2
1 25 pf capacitor	CI
1 IN82A Diode	DI

FIGURE 20-3

75 ohm PEAK TO PEAK



75 OHM PEAK TO PEAK

This is a little classier version of the peak detector. As we are peak to peak, the output will be twice the peak detector, and we have put in some input compensation for flatness correction. There are a lot more components ahead of the diodes. Be careful and keep all these leads short and neat. Capacitor C2 is a selected value to optimize the flatness error due to component variation. Its leads must be short. If you don't have a sweeper or generator, you know is flat, just use a 1 pf.

Parts List	Circuit Ref.
2 F connectors	
2 Ground Connections	
1 75 ohm ¼ watt	R1
1 100 ohm ¼ watt	R2
1 100K ¼ watt	R3
1 .001 uf	C1
1 25 pf	C3
1 1pf (*.47 to 2 pf)	C2
1 IN82A Diode	D1 and D2

HIGH IMPEDANCE PEAK

This is a pretty handy detector probe. The tricky part here is to keep RF leads short and still keep the end small so you can get in and probe around in tight spots. The RF end piece, is an F-61 connector. Note that the buss wire ground that connects the output connector to the input connector protrudes past the washer so it may be used as a ground lead.

Even when you're probing around in an amplifier, you need to have a ground connection to get an accurate response curve. Try to keep this lead somewhat flexible as you will usually have to bend it around when using the probe to keep from shorting things out. The connector lead acts as the probe lead.

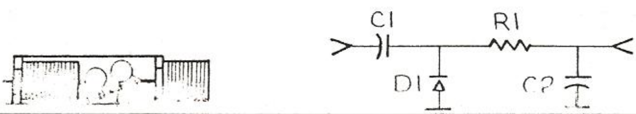
The capacitor lead is pushed into the front connector to become the input circuit. The four pieces of buss wire form a cage to hold the two connectors together mechanically as well as providing a ground path between input and output.

We offer you two different diodes to choose on this unit. The probe will be used on active circuits. It is possible that good-size spikes can be passed through CI and into the diode. The first moment the probe touches 30 volts, a spike of as much as 30 volts can be generated. The IN82A will give you the best frequency response (flatness), but the IN34A will be most resistant to voltage spikes.

Parts List	Circuit Ref.
2 F connectors F61A	
4 pieces buss wire	
1 20 pf capacitor	C1
1 IN34A diode or	DI
1 IN82A	D1
1 100K ¼ watt 10%	R1
1 20 pf capacitor	C2

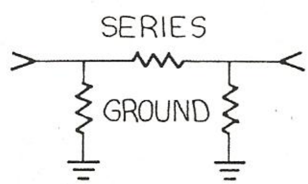
FIGURE 20-4

HIGH IMPEDANCE PEAK



The attenuator pads described here are π pads which we find are easy to build and have good frequency response in the 1 MHz to 300 MHz range. The resistor chart gives the actual value of resistor required for a perfect pad. For simple work, you can use the nearest value Allen Bradley ¼ watt 5% resistor. Many distributors also stock 1% and 2% film resistors that will work well below 300 MHz. The pads are simply a series resistor with two resistors of equal value to ground.

FIGURE 20-5



75 ohm PADS

75 OHM PADS

Figure 20-5	Series Resistor (1 ea. per pad)	Ground Resistor (2 ea. per pad)
1.0 dB	8.65 ohm	1304.00 ohm
2.0 dB	17.42 ohm	654.80 ohm
3.0 dB	26.43 ohm	438.20 ohm
4.0 dB	35.78 ohm	331.40 ohm
5.0 dB	45.58 ohm	268.30 ohm
6.0 dB	56.00 ohm	225.80 ohm
7.0 dB	67.22 ohm	196.10 ohm
8.0 dB	79.28 ohm	174.10 ohm
9.0 dB	92.40 ohm	157.50 ohm
10.0 dB	106.70 ohm	144.40 ohm
15.0 dB	204.10 ohm	107.40 ohm
20.0 dB	371.20 ohm	91.65 ohm

U.S. CABLE CHANNEL FREQUENCIES

CHANNEL	VIDEO CARRIER	SOUND CARRIER
T- 7	7.	11.5
T- 8	13	17.5
T- 9	19	23.5
T-10	25	29.5
T-11	31	35.5
T-12	37	41.5
T-13	43	47.5
2	55.25	59.75
3	61.25	65.75
4	67.25	71.75
5	77.25	81.75
6	83.25	87.75
A-2	109.25	113.75
A-1	115.25	119.75
A	121.25	125.75
B	127.25	131.75
C	133.25	137.75
D	139.25	143.75
E	145.25	149.75
F	151.25	155.75
G	157.25	161.75
H	163.25	167.75
I	169.25	173.75
7	175.25	179.75
8	181.25	185.75
9	187.25	191.75
10	193.25	197.75
11	199.25	203.75
12	205.25	209.75
13	211.25	215.75
J	217.25	221.75
K	223.25	227.75
L	229.25	233.75
M	235.25	239.75
N	241.25	245.75
O	247.25	251.75
P	253.25	257.75
Q	259.25	263.75
R	265.25	269.75
S	271.25	275.75
T	277.25	281.75
U	283.25	287.75
V	289.25	293.75
W	295.25	299.75
14	471.25	475.75
15	477.25	481.75
16	483.25	487.75
17	489.25	493.75
18	495.25	499.75
19	501.25	505.75
20	507.25	511.75
21	513.25	517.75
22	519.25	523.75
23	525.25	529.75
24	531.25	535.75
25	537.25	541.75
26	543.25	547.75

CHANNEL	VIDEO CARRIER	SOUND CARRIER
27	549.25	553.75
28	555.25	559.75
29	561.25	565.75
30	567.25	571.75
31	573.25	577.75
32	579.25	583.75
33	585.25	589.75
34	591.25	595.75
35	597.25	601.75
36	603.25	607.75
37	609.25	613.75
38	615.25	619.75
39	621.25	625.75
40	627.25	631.75
41	633.25	637.75
42	639.25	643.75
43	645.25	649.75
44	651.25	655.75
45	657.25	661.75
46	663.25	667.75
47	669.25	673.75
48	675.25	679.75
49	681.25	685.75
50	687.25	691.75
51	693.25	697.75
52	699.25	703.75
53	705.25	709.75
54	711.25	715.75
55	717.25	721.75
56	723.25	727.75
57	729.25	733.75
58	735.25	739.75
59	741.25	745.75
60	747.25	751.75
61	753.25	757.75
62	759.25	763.75
63	765.25	769.75
64	771.25	775.75
65	777.25	781.75
66	783.25	787.75
67	789.25	793.75
68	795.25	799.75
69	801.25	805.75
70	807.25	811.75
71	813.25	817.75
72	819.25	823.75
73	825.25	829.75
74	831.25	835.75
75	837.25	841.75
76	843.25	847.75
77	849.25	853.75
78	855.25	859.75
79	861.25	865.75
80	867.25	871.75
81	873.25	877.75
82	879.25	883.75
83	885.25	889.75

Mid State