PRACTICAL METHODS OF TESTING CABLE SYSTEMS UNDER PRESENT FCC RULES

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In order to test a cable system according to FCC rules, we must first look at Subpart K of the Rules and Regulations for Cable Television Service; Cable Television Relay Service. This section tells what, when, where, and to a certain extent how to measure a cable system.

Subpart K directs that tests are to be made on all Class I cable television channels. A Class I channel is defined as "a signalling path provided by a cable television system to relay to subscriber terminals television broadcast programs that are received off the air or are obtained by microwave or by direct connection to a television broadcast station."

These tests must be made at least once a year at intervals no to exceed 14 months. Measurements must be made at a minimum of three widely separated places in the system at least one of which is representative of the longest system cable run. These measurements can be made at a point on the sytem other than the subscriber terminal provided data is included which would show what the performance would be at a nearby subscriber location. Another technique would duplicate the hardware that appears between the test point location and a typical subscriber terminal. Measurements would then be made after this equipment and would simulate the signal at the subscriber.

Data should be written in report form. Descriptions and serial numbers of equipment used must be included. Procedures used for each test must be included in the report as well as the qualifications of the person performing the tests. The resulting report must be kept on file in the local cable system office for at least five years.

These basic ground rules cover the things that must be done before and after making the required measurements. These procedures are in fact no less important than the measurements themselves, since they are set up to show the person who looks at the report everything that went into making the tests. Without this information the validity of any test could be subject to question.

After making the proper preparations for the tests, the next question is what tests have to be made and what equipment is required. The requirements are listed in Table I. Equipment and techniques used are described in the following sections.

Frequency Measurement

The first test to be made is a check of the frequency accuracy of all Class I channels carried on the system. There are a number of ways to check this, each with its own level of cost and ease of measurement. A simple way which probably requires the least expenditure of money for test equipment is the "zero-beat" technique. This method requires a frequency counter, generator and Field Strength Meter. The equipment setup is shown in figure 1a. Since a frequency counter is a broadband device, it doesn't know which frequency to measure when either one or a number of channels are fed into it. The "zero-beat" technique allows the counter to measure only the single frequency of the oscillator after it has been adjusted to match the carrier frequency of the channel. Matching is accomplished first by tuning the FSM to the video carrier of the channel to be measured. The generator is set up so that the frequency is close to the expected channel frequency. The output level is adjusted to make the level going into the FSM about equal to the level of the video carrier. With both the signal to be measured and the generator output combined and connected to the FSM, adjust the frequency of the generator until an audio "beat" frequency is heard in the headphone. Further adjust the oscillator to reduce the frequency of the beat to 100HZ or less. Disregard the weaker sounding beats heard as the generator is tuned through the 15.75KHZ sidebands above and below the stronger beat of the main carrier. If desired, the zero beat can be determined with greater accuracy by watching for it on the TV set tuned to the channel being measured. The generator frequency is then read from the counter directly.

This corresponds to the channel frequency with an accuracy dependant upon the time base accuracy and the frequency of the zero beat. For example, assume Channel 13 is measured with a video carrier of 211.25 MHZ, that the counter used has an overall accuracy of 1ppm and the zero-beat is adjusted no better than 100 HZ. The possible error could be as much as ±211.25 HZ from the counter and ±100 HZ from the zero beat, or a total error of ±311.25 HZ. This accuracy is better than required by the FCC for either visual or aural carrier measurements. The aural carrier is measured in the same way as the visual, with the exception that you must make the measurement during a period of silence on the audio, since during normal FM modulation a zero beat measurement connot be made.

Should the counter used have an upper frequency limit below the channel to be measured, the generator can still be set so that it falls within the frequency range of the counter, while the zero beat is produced by a harmonic of the oscillator. To determine the generator setting, divide the frequency to be measured by 2, 3, 4 or 5 etc. until the number falls within the range of the counter. This then is the frequency to which the generator must be set so that the harmonic will zero beat with the frequency to be measured.

Additional techniques can be used to measure frequency. A spectrum analyzer can be used as a zero beat detector in place of the FSM. Zero beat is observed when the analyzer is tuned to the carrier frequency and set to the zero sweep mode. The analyzer then acts as a tuned receiver, and a zero beat is displayed on the screen as the oscillator is tuned properly. The oscillator is measured on the counter as in the case of the FSM technique.

Another technique (Figure 1b) uses a tuner and limiter which selects the one frequency to be measured and through limiting action strips the sync from the carrier. The pure carrier frequency can then be measured directly. The same units generally provide a detector and 4.5 MHZ filter so that the intercarrier frequency can be measured directly. If this signal is fed into the counter and the 10 second measurement period is used, the aural intercarrier frequency can be measured in the presence of modulation.

Visual and aural signal levels

The measurement of visual and aural signal levels must be made at three widely separated points in the system. One of these points must be at the longest cable run from the head-end. Although these tests need not be made in a subscriber's home, all of the cable and equipment loses between the point of measurement and a "typical" nearby subscriber must be included in the measurements whether by calculation or actual insertion of the equipment. A conventional FSM can be used for these measurements. However, the qualified person making the test must be reasonably certain that the unit is accurately calibrated. Comparison with recently calibrated meters or calibration against a signal generator with metered output and standard attenuator is generally acceptable.

No video carrier on the system should differ in level by no more than 12db from any other video carrier, and by no more than 3db from any visual carrier within 6MHZ (Figure 2).

Channel Frequency Response

The measurement of frequency response within each Class I channel on the system can be done in a number of ways. Tests can be run from the antenna input through all head end preamplifiers, processors, filters, converters, etc. to the system test locations, or response measurements for the head end and the system can be made separately and then combined to give the overall response.

A simple overall test can be made with a CW signal generator and FSM at the head end and a FSM at the test locations (Figure 3). Radio or telephone communication is required for this type test.

The processor output for the channel under test should be measured, and the unit switched to manual mode. The gain should be adjusted to give the same output level as measured previously. The standby carrier in the processor should be disabled, and the CW generator should be connected in place of the antenna. Care should be taken that this test signal is inserted prior to all devices associated with the channel to be tested. The generator is now tuned to the visual carrier frequency of the input channel, and the level adjusted to give the same output as measured before. The signal is then measured at the test location and recorded. The generator is then moved in .5MHZ increments to cover the required - 1MHZ to +4MHZ range. For each frequency the level is recorded at the test location. This procedure is followed for each Class I channel on the system.

Hum and Low Frequency Disturbances

With the processor input terminated and the standby carrier on, adjust the level to be equal to that of the TV visual carrier. The lower adjacent channel should be turned off or disconnected while making the measurements.

The equipment required at the test location includes a FSM and DC coupled oscilloscope. The FSM is tuned to the standby carrier and the oscilloscope is connected to the video output of the FSM. With the scope in the DC mode measure and record the DC voltage out of the FSM, this voltage represents the level of the standby carrier. The scope is then switched to the AC mode and the gain is increased so the peak-to-peak hum voltage can be measured. Hum modulation in percent is then calculated from the formula:

$$\text{Modualtion } (\%) = \frac{100 \text{ Eac}}{2 \text{ Edc}}$$

where Edc is the dc output recorded from the FSM, Eac is the peak-to-peak voltage output recorded from the FSM.

Prior to making these measurements at the test locations, it would be helpful to check the equipment at the head-end to see how much hum is generated or picked up by the test equipment setup. Obviously, this should be well below the hum level of the system if the measurements are to be meaningful.

Hum can also be measured on the spectrum analyzer by using it in the zero sweep mode and linear rather than log display.

Carrier to Noise

The measurement of carrier to noise is done at the system test locations and should include head-end equipment. This measurement can be made with a FSM or a spectrum analyzer.

The head-end processor should be set in the manual mode and controls set for normal operating levels. After the carrier is measured, the input of the processor (or preamp) is terminated and the standby carrier is disabled. The FSM is then tuned to the center of the channel and a noise reading is made. The difference between carrier level and noise level is the uncorrected carrier to noise ratio.

A correction factor must now be applied to account for bandwidth, detector response and meter responses. The uncorrected signal to noise ratio should be reduced by the following charts for Jerold 704B and 727 meters. Corrections for other FSM's should be found in the respective manuals for the particular meter.

Meter Reading	704B Correction (db)	727 Correction (db)
0	4.2	3.5
+2	4.0	3.3
+4	3.9	3.1
+6	3.7	2.9
+8	3.6	2.7
+10	3.5	2.6

Measurements using a spectrum analyzer can be made without removing the standby carrier by setting the analyzer bandwidth to 300KHZ and setting 1MHZ/division to show the entire channel.

Carrier level is set to Odb reference on the analyzer and the noise level is read directly as so many db below carrier level. The correction factor for bandwidth and logarithmic display response is 13.5db and must be subtracted from the reading taken. Care should be taken to note that the analyzer noise level is to 10 db lower when no signal is applied. This means the correction due to signal to noise combinations is less than about .5db. The noise level increase if less than 10db can be noted and the proper corrections made from a signal to noise combination chart.

Offset Co-Channel

Offset co-channel can be measured on a spectrum analyzer set up with 300 Hz bandwidth and 5KHz/division frequency span. The co-channel is then observed 10KHz (2 divisions) above or below the channel visual carrier, and the level is measured and recorded.

It should be noted that if there is no visually observable co-channel interference as indicated by a "venetian blind" effect when each Class I channel is checked on a normally operating CATV system with a properly adjusted TV set, then it may be assumed that the system meets the 36db FCC requirement.

Carrier to Coherent Frequency

The term carrier to coherent frequency includes spurious responses such as 2nd and 3rd order products, harmonics, crossmodulation, etc.

Measurements can be made with a spectrum analyzer either in the presence of a TV signal, or with the input to the preamp or processor terminated and the standby carrier on. Spurious signals at the FCC maximum level of 46db below visual carrier are easily seen with the frequency span set at 1 MHz/division and a bandwidth of

300 KHz. Reducing the bandwidth further will allow greater resolution of lower level spurious signals for quantitative measurements.

Cross-modulation should be looked for at 15.75KHz from the visual carriers and the levels recorded. However, since cross-modulation is normally measured with synchronics 15.75KHz square wave modulation on each channel, an accurate measurement would require all standby carriers to be modulated by the same source, except of course the channel being measured.

It is also possible to observe on a properly adjusted TV receiver whether beats, bars, or background video are visible. If none are observed, it is likely that any which do exist are more than 46db below visual carrier as required by the FCC. The same holds true for a blank screen observation of cross - modulation if no windshield wiper effect or background video is observed.

The FCC at this time has not indicated whether subjectives tests as indicated are acceptable. However, precedence at the FCC indicates that alternate tests may be used at the discretion of the engineer making the measurement, if in his judgement such tests will produce reasonably accurate results.

Terminal Isolation

This test must be performed at the three selected system test locations for each Class I channel. It would also be a good practice to duplicate or make actual measurements at the subscriber installation having the least amount of isolation.

For this test, a signal generator and FSM are required. The CATV signals are removed from the distribution leg to be tested. The generator is tuned to the channel to be measured and the output adjusted to a convenient level (+30dbmv). This signal is then back-fed to the system from the subscriber terminal location (or simulation). The signal is then measured at the closest (in terms of least isolation) subscriber tap. This procedure is repeated for each Class I channel.

In addition to this test, a test at the same locations should be made with the CATV signals on. The subscriber terminal location should be both open-circuited and short-circuited and observations made of a TV receiver at the same point the FSM readings for isolation were taken. There should be no visible degradation in the picture due to reflections.

Radiation from CATV System

Radiation measurements should be made at the three system test locations with a dipole antenna and a FSM or spectrum analyzer. In the event that measurements exceed the FCC requirements, immediate action should be taken to correct the problem.

The antenna should be adjusted to 1/2 wavelength at the channel to be measured. The dipole should be positioned 10 feet below the system components and 10 feet or greater above the ground. The dipole must be rotated around its vertical axis to obtain a maximum reading. Readings should be taken in microvolts and multiplied by a conversion factor applied to obtain microvolts/meter. A list of dipole lengths and conversion factors for the standard VHF channels is given in Table II. The voltage in microvolts corresponding to the FCC maximum field intensity of 20 μV/m is also included for convenience. It is assumed that a 75 Ω or FSM is used for the measurements.

Data Recording and Reporting

As indicated at the beginning of this paper data must be taken and put on file in a report form. To facilitate this, sample data sheets have been prepared and are shown in Figures 4 through Figures 9. Procedures used for each particular test should also be written up and included with the report. Finally the qualifications of the person performing or supervising the tests must be included.

TABLE I

TEST	REQUIREMENT
Frequency	
Visual Carrier Frequency	1.25 MHZ ± 25 KHZ above lower channel boundary
Aural Carrier Frequency	4.5 MHZ ± 1 KHZ above the frequency of the visual carrier.
Signal Amplitudes and Flatness	
Minimum Visual Carrier Level	Odbmv
Maximum Visual Carrier Level	Below overload degradation
Overall Visual Carrier Level Variation	12 db (maximum)
Variation of Visual Carrier Levels with 6 MHZ separation	3 db (maximum)
Maximum Aural Signal Level	13 db below visual carrier
Minmum Aural Signal Level	17 db below visual carrier
Channel Response	± 2 db (-1 to +4 MHZ of Visual Carrier)
Spurious Responses	
Hum or low frequency disturbances to Carrier	5%
Carrier to noise	36db
Carrier to Co-channel	36db
Carrier to Coherent Interference (2nd Order, Intermod, Discrete Frequency, Etc.)	46db
Isolation	
Subscriber - Subscriber Isolation	18 db (Must also be sufficient to prevent reflections due to open or short circuit to any other subscriber.)
Radiation	
Up to 54 MHZ	15 uV/M @ 100'
54 to 216 MHZ	20 uV/M @ 10'
over 216 MHZ	15 uV/M @ 100'

TABLE II

TV Channel	Dipole Length (inches)	Conversion Factor 75 Ω Termination	FCC Requirement μV o FSM
2	89.8	1.16	17.2
3	81.8	1.29	15.5
4	73.7	1.41	14.2
5	64.2	1.62	12.4
6	59.6	1.75	11.4
7	28.3	3.68	5.4
8	27.4	3.81	5.3
9	26.5	3.93	5.1
10	25.7	4.06	4.9
11	24.9	4.18	4.8
12	24.2	4.31	4.6
13	23.5	4.44	4.5

FREQUENCY MEASUREMENT USING A FSM OR SPECTRUM ANALYZER

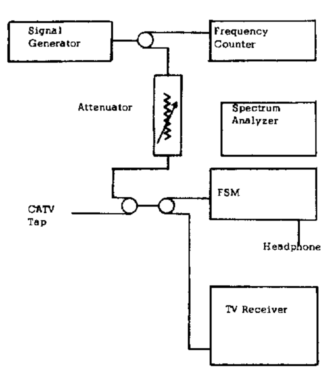


Figure 1a

FREQUENCY MEASUREMENT USING A LIMITER - DEMOD

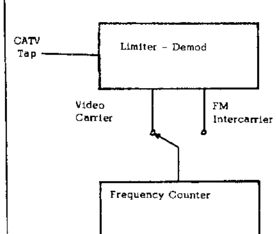
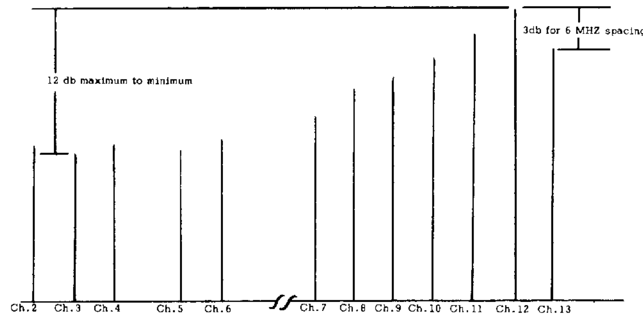
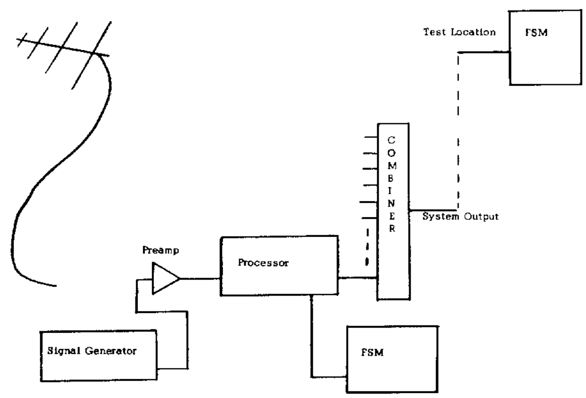


Figure 1b



VIDEO CARRIER LEVEL VARIATIONS

Figure 2



CHANNEL RESPONSE TEST SETUP

Figure 3

FREQUENCY MEASUREMENTS

Channel	Visual Carrier Frequency (MHz)	Measured Visual Carrier Frequency (MHz)	Deviation (KHz)	Aural Carrier Frequency (MHz)	Measured Aural Carrier Frequency (or Intercarrier) (MHz)	Deviation (Hz)

Equipment:

Date____________

Signed____________________

Figure 4

SIGNAL AMPLITUDES

Channel	Visual Carrier Level	Level Difference of 6 MHz Carriers	Maximum Difference of Any Channel	Aural Carrier Level

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 5

CHANNEL RESPONSE

Levels at .5 MHz Spacing from Carrier

Channel	-1.0	-0.5	0	+0.5	+1.0	+1.5	+2.0	+2.5	+3.0	+3.5	+4.0	Maximum Deviation (db)

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 6

SPURIOUS RESPONSES

	HUM			CARRIER TO NOISE				CO-CHANNEL	
Channel	Volts DC	Hum p-p AC	% Hum Modulation	Carrier Level	Noise Level	Correction Factor	Carrier to Noise(db)	Co-Channel Level	Carrier to Co-Channel

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 7

SPURIOUS RESPONSES (CONT'D)

Channel	Carrier Level	Frequency	Level	Frequency	Level	Frequency	Level	Frequency	Level

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 7

ISOLATION

Channel	Generator Level	Subscriber Level	Isolation	Visual Observation Open Circuit	Short Circuit

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 8

RADIATION

Channel	Reading (μV)	Correction Factor	Field Strength (μV/M)

Equipment:

Date:______________

Location:______________

Signed:______________

Figure 9