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Managing the Cable Signal Levels/Quality in a TV-RF Distribution System

(part 1 of 2)

Do the TV cable signals in your TV-RF distribution system sometimes get noisy or have lines of interference? If you are responsible for distributing TV-RF cable signals provided by a cable provider to multiple rooms in a residential or commercial building you likely have encountered many challenges with signal quality.

This is the first in a two part series of articles covering the basics of testing and managing signal levels/quality of the cable signals in a typical TV-RF distribution system.

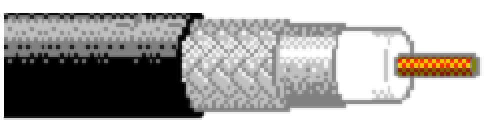

Figure 1. ***Cable signal attenuation is determined by the cable length, type, size and signal frequency. Cable loss is specified by frequency per 100 feet of cable.***

Understanding Cable Loss and Cable Signal Attenuation

The first requirement to understanding TV-RF distribution systems and troubleshooting problems is to understand how coaxial cable affects the signals. The coaxial cable provides a conduit to move the signal from place to place. However, some of the signal strength is attenuated or lost as the signal moves from the cable input to output. The longer the cable the more signal loss that occurs. How much loss occurs is calculated or measured using a decibel system. The unit of measurement is the dB.

The size and type of coaxial cable effects how much the cable signal is attenuated as it moves through the cable. A larger cable offers less resistance to the signal and therefore has less attenuation or signal loss compared to a smaller cable. RG59, RG6, and RG11 are common coaxial cable sizes used in distribution systems. RG59 is the smallest and has the most signal loss. RG11 is the largest and has the least loss. Cable loss is specified by stating the dB loss for a 100 ft. length of cable. The type of insulating material used in the coaxial cable also has an effect on the cable loss.

Attenuation or signal loss exhibited by the coaxial cable increases as channel frequencies increase.

An important factor of cable signal loss is signal frequency. All cable channel frequencies have a different amount of signal loss or attenuation traveling through the same coaxial cable. This creates the complexity that makes TV-RF system levels difficult to maintain through the system. As channel frequencies increase, so does the attenuation or loss exhibited by the cable. Figure 2 shows the signal loss at various frequencies for several different cable types.

Cable: Nominal Attenuation in dB per 100 feet					
CABLE	Ch. 2	Ch. 11	Ch. 54	Ch. 108	
	50MHz	200MHz	400MHz	700MHz	900MHz
RG59 Solid (FEP)	2.43	5.29	7.1	11.67	13.9
RG59 Foam (FEP)	1.84	3.53	5.35	7.07	8.02
RG6 Foam (FEP)	1.48	2.79	3.99	5.35	6.4
RG11 Foam (Polyethylene)	0.98	1.84	2.68	3.67	4.25

Figure 2. Chart showing cable loss by cable type vs. frequency.

Calculating Cable Signal Loss from the Tap to Structured Wire Enclosure

One of the first challenges in extending the cable system signals to multiple rooms involves getting sufficient signal levels/quality on all channels to the input of an amplifier in the structured wire enclosure.

TV-RF signal levels are quantified using a dB system that references 1mV of signal as 0 dBmV. Positive dBmV numbers indicate levels above 1 mV which make a good noise free picture when feed to a television receiver.

The FCC mandates that the cable company deliver a minimum signal level of 0 dBmV on all NTSC cable channels. Furthermore, the dBmV level difference between adjacent channels is to be no more than 3 dB and a level difference between all channels can be no more than 10 dB. Levels are measured using a signal level meter calibrated to read dBmV.

One dilemma is that cable signals between 0-5 dBmV satisfy FCC requirements but are two low in level to drive most distribution amplifiers without adding noise. Another dilemma involves dealing with cable tilt or slope. This is the difference in dBmV level between low frequency and high frequency cable channels. Low frequency channels may be so strong that they overdrive the distribution amplifier causing picture lines of interference.

Consider a 200 ft. cable signal drop to a home using RG6 cable as illustrated in figure 3. Using the attenuation values stated in the chart of figure 2 the loss for 100 ft of cable at channel 2 is 1.48 dB and loss at channel 108 is 5.35 dB. Therefore, the signal loss at channel 2 would total approximately 3 dB while the loss at channel 108 (700MHz) would be approximately 11 dB. The attenuation of all other cable channels would vary from 3 to 11 dB through this frequency range.

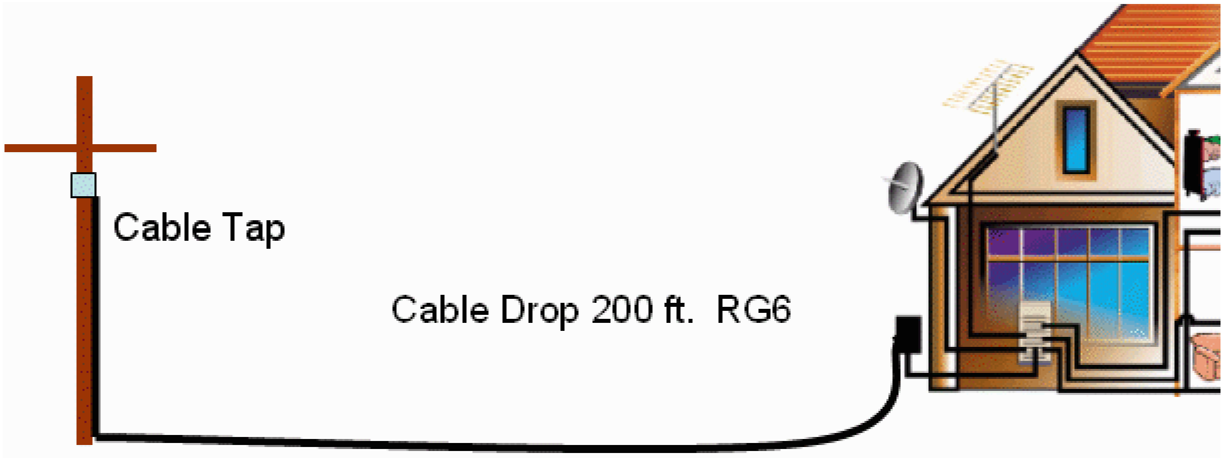

***Figure 3.** A 200 foot RG6 cable attenuates channel 2 approximately 3 dB while it attenuates channel 108 (700 MHz) approximately 11 dB.*

Input levels that are above 5 dBmV in an RF distribution amplifier provide clean outputs – no noise or graininess.

If, for example, all the channels were output from the cable tap at 12 dBmV, the level of channel 2 at the input to the structured wire enclosure would be calculated to be approximately 9 dB while the level at channel 108 (700MHz) would be 1 dB. While these input levels would meet the FCC requirements, they would not be ideal for amplification. An RF distribution amplifier typically needs input levels above 5 dBmV to avoid noisy or grainy outputs.

Quality Testing the Analog NTSC Cable Signals

The first step in verifying proper signal level from the cable provider is to analyze the cable signal using test instrumentation to quantify level and performance. Keep in mind there is nothing you can do to the distribution system components that will make a bad or marginal cable input signal better. A TV-RF distribution system is only going to transport the bad or marginal signal(s) to every room. Also keep in mind that you need enough signal level to input to a broadband RF amplifier for proper amplification to multiple rooms. You will be especially interested in the signal levels of the highest frequency channels.

NTSC Video Level, A/V Ratio & C/N Ratio

The A/V ratio is the difference between two dBmV levels, and 13 – 15 dB is recommended as a good ratio to practice.

The level or signal strength of the video carrier in the NTSC signal directly relates to signal quality and how good the picture looks on a television display. A video carrier level of 0 dBmV (1mV @ 75 ohms) or higher represents a good video carrier level resulting in good noise free pictures. Video carrier levels less than 0 dBmV will begin to produce grainy or noisy pictures when input to a TV receiver. Levels above +5dBmV are needed for inputs to an RF amplifier.

A cable system reduces the audio carrier level compared to the video carrier. This is commonly known as the A/V ratio and is express as a difference between two dBmV levels simply in dB. The FCC requires an A/V ratio of 6.5 – 17 dB but good practice recommends an A/V ratio of 13 – 15 dB. The Sencore SLM1453, alternately measures the level of both carriers and display the video level and A/V ratio simultaneously.

An additional measurement used to analyze an NTSC – RF signal is a carrier-to-noise ratio measurement. Noise exists with the NTSC signal when received by an antenna and is also present on a cable system. To prevent noisy pictures on a TV receiver the noise must be very weak in level (dBmV) compared to the level of the signal (dBmV). The difference between the video carrier level and noise level is the Carrier/Noise ratio and like the A/V ratio is expressed in dB. C/N ratios near or above 40 dB generally provide acceptable noise free TV viewing. Signals with a C/N ratio less than 40 dB will always be snowy or grainy no matter what you do in the TV-RF distribution system.

Figure 4. ***NTSC analog signals should be tested for video carrier level, A/V ratio, and C/N ratio.***

Quality Testing the Digital QUAM Cable Signals

In the past several years many cable companies have implemented and announced the delivery of new digital service packages. These digital services place added signals onto the cable system. The digital service programming is transported through the cable system using 6 MHz channel bands. Each channel band is packed with several digital video programs. The modulation scheme used to develop the 6 MHz channel band signal is QUAM (Quadrature Amplitude Modulation). The QUAM modulation scheme is defined by the number of amplitude points, typically 256 or 64.

Analyzing cable TV signals must be expanded to include a means to test the level and signal quality of the 6 MHz QUAM signals. When installing or troubleshooting residential or commercial RF distribution system you must insure the digital service package QUAM signals are the proper level and quality. Insufficient levels or quality to the STB (set-top-box) decoder causes intermittent dropout or total loss of digital picture decoding.

QUAM Avg. Power, Flatness, C/N Ratio & BER Measurements

The digital Quam channel has no RF carrier to measure for signal level. In theory, the sideband signal energy is distributed evenly across the digital channel band. For an accurate level measurement the meter must automatically tune through the channel band, taking multiple measurements which are averaged to determine signal power.

The Sencore SLM1453 analyzes the QUAM digital signals for the average power level in dBmV. The level is important as most cable systems place the new QUAM digital carriers at the high frequency end of the cable bandwidth. Added cable and passive device signal losses along with insufficient amplifier gain at these higher frequencies often result in marginal signal levels to the receiver or decoder.

A digital signal level of -15dB serves as a good minimum level for proper receiver decoding and to prevent loss of reception.

Typically the more signal level, the more dependable is the digital TV channel reception. Proper receiver decoding is possible with signal levels below 0 dBmV. Receivers may be able to receive and decode digital signals down to -25 dBmV. However, for a good window of decoding to prevent a loss of reception, keep the signal level greater than -20 dBmV. A digital signal level of -15dB serves as a good minimum level and is comparable to a 0dBmV analog level.

In addition to a level measurement of a digital TV signal, a flatness reading is important. A flatness reading indicates the difference between the maximum (peak) and minimum (valley) signal levels of all the level samples taken during the digital channel measurement. The closer you can get to a perfectly flat signal power across the digital band the better. A reading of 1-4 is normal while higher readings indicate poor flatness caused by a cable or equipment defect.

The carrier-to-noise ratio test indicates the difference in power in dB between the TV digital channel power and the noise in the frequency spectrum near the channel. A larger value indicates a stronger signal or less noise. C/N ratios over 20 dB are good for digital channel reception. C/N ratios decreasing and approaching 15 dB can intermittently begin to cause digital decoding difficulty and occasional signal dropout. C/N ratios of 15dB or less cannot be properly decoded by the receiver resulting in loss of reception.

The Emulated b BER measurement provides a bit-error-rate indication. This bit-error-rate readout is an indication of how many digital bit errors are estimated to occur each second when the decoder in the receiver attempts to read the digital data that represents the picture and audio program information. Ideally, one error in 10 billion data bits is desirable. This is expressed as 1 X 10 $^{-10}$. The BER measurement is expressed as a number with a negative exponent to the power of 10. (See figure 5)

BER: Bit – Error – Rate

$$\text{BER} = \frac{\text{Number of Errors}}{\text{Bit rate}} \qquad \frac{30}{270 \times 10^{6}} \qquad \text{BER} = 1.1 \times 10^{-7}$$

Example: 30 bit errors in 270 Mbps (Million bits per second) results in BER of 1.1 x 10 $^{-7}$

***Figure 5.** Bit-error-rate (BER) is a measurement or estimation of how many bit errors will result when the receiver decodes the digital data stream.*

Reduced signal level, multi-path or other interferences may reduce the BER considerably. The SLM1453 indicates Emulated BER measurements of <10 $^{-8}$ when the bit errors are insignificant and will not cause reception difficulties. Emulated BER values less than this can begin to effect reception. Typically emulated BER values of 1×10^{-6} or better can still be decoded properly. Values less than this (Example 1×10^{-5}) can cause occasional signal dropouts. Worsening values (Example 1×10^{-4}) eventually cause a complete loss of reception.

The digital quality test indicates the overall quality of the digital signal and indicates pass (pas), marginal (mar), or fail (fai). The quality is determined by an algorithm analysis of the digital channel measurements including the Level, Flatness, BER, and C/N ratio tests. For consistent decoding and reception the quality test should show a "pas" reading. A fail or marginal readout indicates the digital signal reception is not as good as it needs to be for consistent decoding by the receiver. A fail indication generally results in a complete loss of reception and output from the receiver or severely interrupted reception.

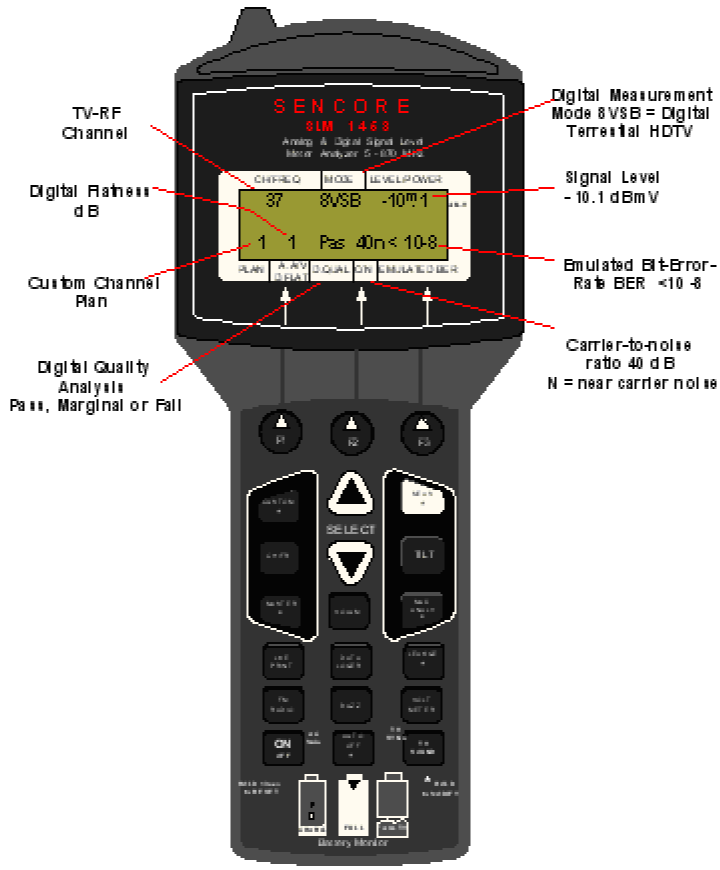

***Figure 6.** Cable Quam Digital signals should be tested for average signal level, flatness, C/N ratio, and BER (bit-error-ratio).*

Working With Your Cable Provider

Once you have analyzed the signals provided by the cable company to the structured wire enclosure you may need to work with the cable technician or engineer. Keep in mind you will both have a common goal of delivering good quality cable TV signals to each TV receiver or digital set-top-box decoder in the building.

Use a professional approach when explaining your needs. A chart or report showing the signal levels and performance measurements is very helpful. See the example of a site survey form. Review your testing results obtained with the SLM1453 and ask for resolution to the signal level and quality issues. If signal levels are below 5 dBmV, explain how you desire a slightly higher level to drive an amplifier properly for distribution. Now that you can understand and can calculate cable drop loss, you can suggest ways to improve the signal level. You may suggest updating the cable from RG59 to RG6 or RG11, rerouting the drop to shorten the distance, suggest a higher level output from the cable tap or discuss the possibility of adding an in-line amplifier at a convenient location at the tap or along the drop cable.

Site Survey Form (CATV)

Customer:

Address:

Phone: e-mail:

CATV Company: Phone: Contact:

Type of cable box IRC/HRC/Std Bi-directional?

CH. I.D.	Analog CH.	C/N Ratio	Signal Strength	Digital CH.	Signal Strength	Flat-ness	C/N Ratio	B.E.R.	Grade

Contact us at 1-800-Sen-core

In part one of this article, we discussed cable loss and cable signal attenuation, how to calculate signal loss, how to verify cable provider analog NTSC and digital QUAM signal levels, and how to work with your cable provider to deliver quality cable TV signals. In part two of this two-part article we will discuss the typical design of a TV-RF distribution system, how to calculate the minimum and maximum input levels to an amplifier and what options are available to change channel levels when needed. If you have any questions, please contact us at 1.800.SEN.CORE.

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