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

(part 2 of 2)

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

This is the second of a two-part article on testing and managing signal levels/quality of cable signals in a typical TV-RF distribution system. The first article covered cable losses and RF measurements to determine signal level/quality. See *Managing the Cable Signal Levels/Quality in a TV-RF Distribution System* part 1. This article looks at the typical design of a TV-RF distribution system, covers how to calculate the minimum and maximum input levels to an amplifier and explains what options are available to change channel levels when needed.

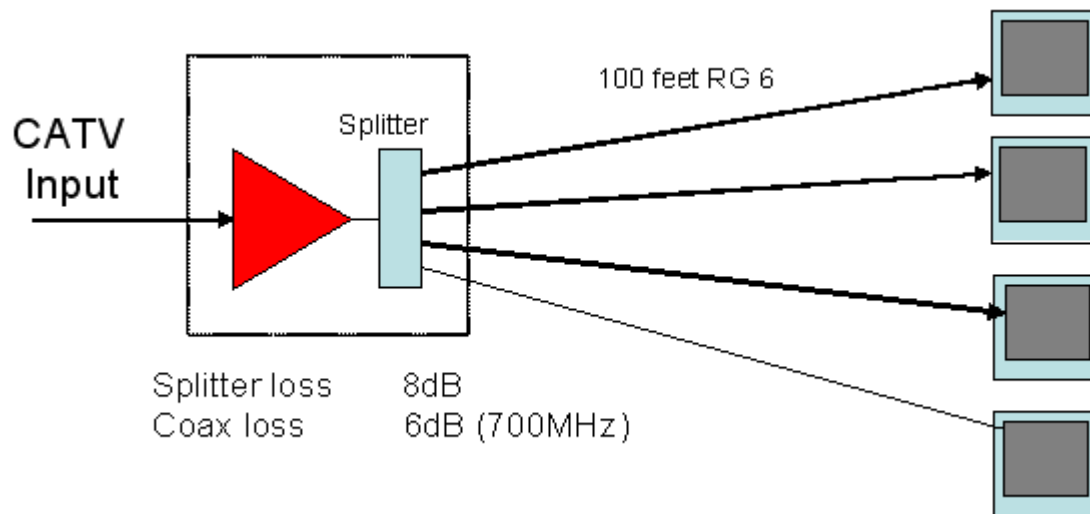
### **TV-RF Distribution System Design**

**The amplifier output is divided with a splitter, and routed through separate cable feeds to each room. The amplifier needs sufficient gain and frequency bandwidth to be sure signals are not degraded.**

A simple, but typical, residential TV-RF distribution system involves amplifying the input cable signals at the input to the structured wire enclosure. The amplifier's output is divided with a splitter and routed through separate cable feeds to each room.

To be sure the cable signals are amplified sufficiently to reach each room with levels above 0 dBmV requires some calculation. Calculating the amplifier gain needed by the TV-RF distribution system is important to be sure signals are not degraded. You need to be sure that the amplifier chosen for the job has sufficient gain and frequency bandwidth.

To calculate the amplifier gain needed for the system, figure the total attenuation of the cable based on the longest run, distance and type of cable. For example, figure 1 uses a 100 ft. RG6 distribution feed at 700 MHz, resulting in a 6 dB signal loss. Add this loss to the loss exhibited by the splitter. A 4 way splitter has about 8 dB loss to each of its outputs. In this example an amplifier with 15 to 20 dB gain would be sufficient. It would be wise to choose a 20 dB amplifier to allow for future system expansion.



**Figure 1. Distribution System Design – Calculate how much amplifier gain is needed by adding the losses of the distribution system at the highest cable channel frequency.**

If properly designed and calibrated, the signal levels/quality to each distribution point should be the same as that provided by the cable company. Use the Sencore SLM1453 to confirm signals are passing properly through the system and the signal quality is maintained.

### TV-RF Distribution Amplifier – Calculating the Maximum Input Level

A very important, yet often ignored, design consideration of a TV-RF distribution system is the input level of the individual cable channels to the RF amplifier. Measuring and designing proper input signal levels on all cable channels is critical to maintaining good signal quality.

If the RF channel dBmV level is too low at the amplifier input, the output dBmV level will increase by the gain of the amplifier, but the signal seen on a television will be grainy or noisy. In effect, the carrier-to-noise ratio is significantly reduced on that channel(s) resulting in a noisy TV picture(s). If the input signal level on any channel is too high it overdrives the amplifier, resulting in cross-modulation or harmonic distortion which adds interference lines to the picture seen on a display.

Determining the maximum input level to an RF amplifier is not an exact science. However, you can get an idea by looking at the amplifier's specifications. They commonly state the maximum output capability in dBmV that the amplifier can produce, while maintaining a composite triple beat (CTB) below or near -60 dB. They will also indicate the total number of RF channels used to determine this specification. An example is shown in figure 2.

## RF Amp. Example 7020CD: 39 dBmV Output Capability (-58dB CTB @ 36 channels)



**Figure 2. Examples of TV-RF broadband amplifier specifications for several models.**

Model	7020CD	7034C	7054C
Passband	50-806 MHz	50-550 MHz	50-550 MHz
Gain	20 dB	33 dB	44 dB
Gain Control Range	N/A	18 dB	18 dB
Slope Control Range, 50 MHz	N/A	18 dB	18 dB
Noise Figure	4.5 dB	6.0 dB	4.5 dB
Return Loss, Input and Output	12 dB	12 dB	12 dB
Output Capability, -58 dB CTB, 36 channels	39 dBmV	50 dBmV	50 dBmV

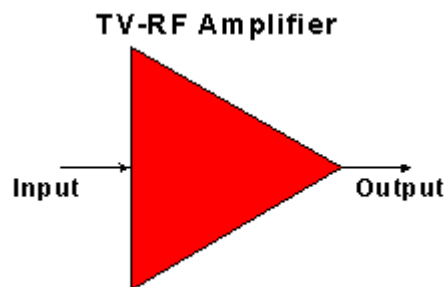
Composite triple beat is an amplifier distortion that results when input channel carrier frequencies in groups of three are added and subtracted in the amplifier, resulting in unwanted interference carriers. There are many groups of three, resulting in multiple triple beat products, or undesirable carriers. These carriers are not part of the original input signal and cause lines of interference. Keeping the CTB below -58 provides amplification without these visible distortion artifacts.

To calculate the maximum input signal to an amplifier, simply subtract the amplifier gain specified for the amplifier in dB from the maximum output specification in dBmV. For the example listed, if the gain of the amplifier is 20 dB, you could not permit any signal level above 19 dBmV to be input to the amplifier. Note that the CTB specification is for a 36 channel system. If the cable system has significantly more channels you must lower the input levels to compensate for the added input signal power to the amplifier. In order to maintain the CTB at -58 dB for 60 channels, you would need to reduce the maximum input by 3dB to 16 dBmV. For 90 channels, you would need to reduce the maximum input to 14 dBmV.

Notice that as you choose an amplifier with more gain, the maximum input signal levels decrease. Consider model 7054C in figure 2. The maximum output is 50 dBmV and the amplifier gain is 44 dB. This yields a maximum input of 16 dBmV for a 36 channel system, 13 dB for a 60 channel system and 11 dB for a 90 channel system.

### TV RF Distribution Amplifier – Calculating a Minimum Input Level

An equally important issue is the minimum input levels to a TV-RF amplifier. An amplifier has the potential to reduce the carrier-to-noise ratio of the cable signal(s) from input to output. If the carrier-



$$\text{Max. Input Level} = \text{Max. Rated Output (dB)} - \text{Amp Gain (dB)}$$

**Figure 3. Calculate the maximum input level by subtracting the amplifier's gain in dB from the maximum rated output of the amplifier.**

to-noise ratio is reduced below 40dB the video picture displayed on a TV set appears noisy or grainy, even though the dBmV level to the TV may be greater than 0 dBmV.

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

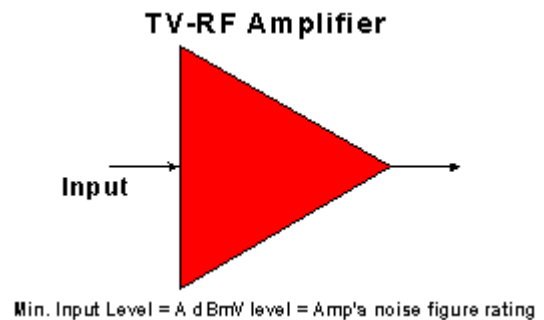
TV-RF amplifiers have a noise figure specification that can be helpful in determining minimum input levels. This is a specification that produces a number in dB typically from 2 to 10. A noise figure of 2 means the amplifier produces little noise that can be added to the input noise floor. A good example would be a low noise antenna pre-amplifier. A noise figure of 10 or more means the amplifier produces significantly more noise that will be added to the noise floor of the input. In figure 2 the noise figure specification for the 7020CD model amplifier is 4.5 dB.

An exact correlation between input level and noise figure ratings is not possible. However, in general terms if you have an input dBmV level that is equal to or higher than the noise figure dB rating you will not seriously degrade the carrier-to-noise ratio on the output of the amplifier. Ideally it is best to have a minimum input level that is 3 dB or more higher than the noise figure value. Ideally the best input level range for the model 7020CD is 7-14 dB on all channels and carriers applied to its input.

If you look closely at figure 2 and the specifications for the model 7054C, you will quickly notice a problem when you calculate maximum and minimum input levels. If you subtract the gain 44dB from the maximum output of 50dB @ 36 channels you get a maximum input of 6 dBmV (3dB @ 60 channels). If you follow the minimum level guidelines suggested using the noise figure rating of 4.5 dB, the minimum input level is 4.5 dBmV. What should you do?

It is apparent that this amplifier is extremely input level sensitive. If you operate it at full gain, the maximum input signal levels must be around 5 dB to maintain a -58 CTB @ 30 channels and 3 dBmV @ 60 channels. This amplifier is not going to be a good choice on a cable system with over 60 channels as its bandwidth is limited to 550MHz.

The bottom line is, if you need the full gain of the amplifier, you will have to fudge slightly with input levels below the noise figure. Unfortunately, some deterioration of the carrier-to-noise ratio is going to occur with these input levels to avoid CTB lines of interference at full gain. A better compromise would be to not run the amplifier at full gain, but operate the amplifier adjusted to deliver 35-40 dB gain. Now the input levels can be increased accordingly by the amount of gain reduction as to not sacrifice the carrier-to-noise ratio. This amplifier provides a good working example of the critical nature of input levels to a TV-RF amplifier in order to maintain good quality amplification of RF cable signals.



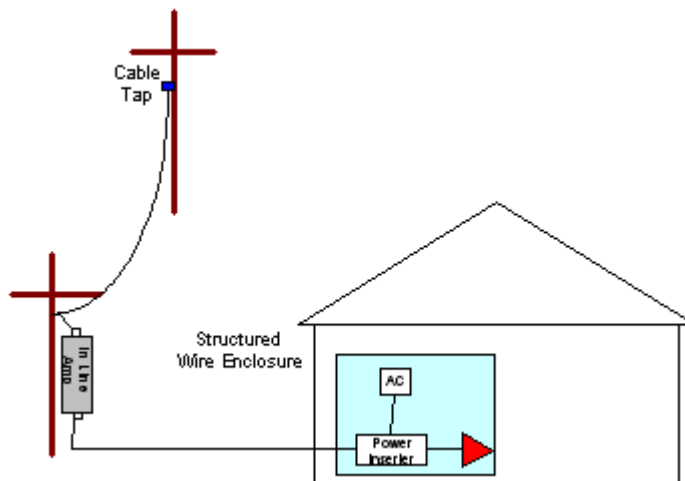
**Figure 4. A minimum dBmV level that is equal to or greater than the amp's noise figure rating provides amplification with little carrier-to-noise degradation.**

## Adding an In-Line Amplifier to the Cable Drop

Now that you can determine the best input levels for a particular RF distribution amplifier, how do you achieve these input levels? At this point, it goes without saying that you will need a way to measure the input signal levels provided by the cable company. If they are below the noise figure rating of the amplifier, you'll want to look at alternatives to achieving higher input signal levels.

One possible alternative is with the use of an in-line amplifier. These amplifiers are especially useful when the cable drops are more than 200 feet from the cable tap to the structured wire enclosure. The long drop lengths will often attenuate the high frequency cable channels below the amplifier's noise figure.

An in-line amplifier may be placed at the cable tap or a convenient point along the drop cable to amplify the cable channels. A typical in-line amplifier provides a 15-18 dB gain and includes a power inserter and power supply. Voltage to power the amplifier is derived by a power supply in the structured wire enclosure and inserted on the drop cable with the power inserter. The voltage travels along the cable to the in-line amplifier to power it.



*Note: Like all TV-RF amplifiers, you will need to be careful that you provide it with the proper input signal levels.*

**Figure 5. An in-line amp, powered from the structured wire enclosure can be placed along a long cable drop to boost the incoming cable signal levels.**

## Attenuation & Equalization to Reduce Signal Levels

More is not always better relating to the dBmV signal levels of TV-RF signals. Too much signal level can overdrive the input to an amplifier. A simple and cost effective method to reduce the level of all the cable signals simultaneously is with the use of an in-line attenuator or "pad." Common values of attenuators are 3, 6, 10, and 20 dB. For example, if you calculated 15 dB as a maximum input level to an amplifier, but the signal level meter measured 18 dBmV, you would want to use a 6 dB attenuator on the input of the amplifier to reduce the signal level.



**Figure 6. In-line attenuators reduce the signal level of all channels on the TV-RF distribution system.**

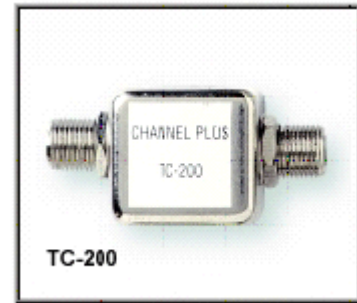
**“Tilt” or “slope” is the difference in level between high and low frequency channels.**

A common problem in any TV-RF distribution system is the unequal levels between the low frequency cable channels and high frequency channels. As the cable channel frequencies pass through a cable, the higher frequency channels are attenuated much more than the low frequency channels. The more cable the signals go through, the worse the level difference becomes. The difference in level between high and low frequency channels is called “tilt” or “slope.”

Consider a 200 ft. RG6 cable drop from the cable tap to a home with 15 dB provided on each channel from the cable tap. The expected input levels to the RF amplifier in the structured wire enclosure would vary from channel 2 at 12 dBmV to channel 108 at approximately 4 dBmV. If all the channels were amplified the same and passed through an additional 200 ft. of cable, the cable tilt would cause the level at channel 2 to be 16 dB higher than the level of channel 108.

Two methods may be used to equalize the high and low cable channels so they are the same level. You can use an in-line equalizer such as the one shown in Figure 12. This equalizer is fixed to compensate for 200 ft of cable. It creates an attenuation loss equal and opposite to a 200 ft. cable loss.

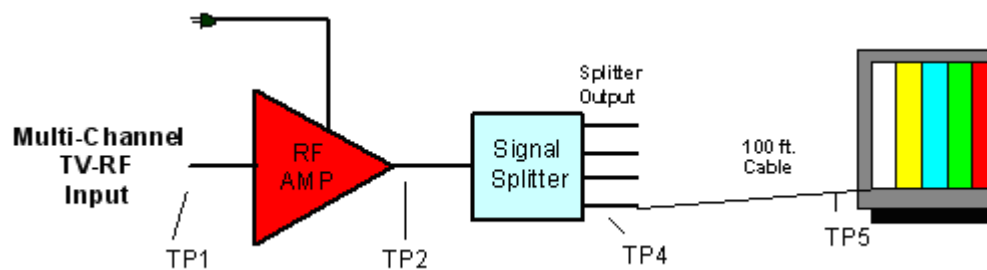
The second method of equalizing is through the use of an amplifier that includes a slope or tilt control. The slope control is adjustable so it can compensate for various lengths of cables and level differences between the highest and lowest cable channels in the system.



**Figure 7.** *An in-line equalizer corrects for cable channel level tilt.*

### Analyzing Signal Levels in the TV-RF Distribution System

What could go wrong? You have made the calculations, installed a suitable TV-RF amplifier, cable, connectors and splitter, and it should work, right? Yes, but it often doesn't (snowy or interference) and you need to verify if the cable signal is proper, modify the input levels to the amplifier as needed, adjust the amplifier gain and slope controls and verify good level and video pictures to the end of each distribution leg.



**Figure 8.** *Measurements are needed to analyze the input cable signal, modify the amp input levels, adjust gain and slope controls and verify proper signal to each room.*

#### Test Cable Input Levels:

To test the input cable signal, connect the cable input to the SLM1453 at the structured wire enclosure. The cable signal level will depend on the signal level output from the tap, the cable type, and cable length. Expect a range of levels typically from 5 to 10 dBmV for NTSC analog channels and -10 to -5 on the digital channels. Always measure level at the highest two cable channel as these will be the lowest in dBmV

level. Check the signal level of one or two of the lowest cable channels to note the tilt (Difference in level). Determine if any attenuation or consultation with the cable company is required to increase signal levels.

### **Adjust Amplifier Gain & Slope Controls**

The amplifier gain control is set using the highest frequency NTSC cable channels. Set the gain control so the amplifier's output, in dBmV, delivers 5-10 dBmV at the end of the longest distribution feed. To determine the output needed, calculate the cable loss to this room and add any splitter loss. (100 ft of RG6 @ 700MHz = 6dB, 4 way splitter = 8 dB, 6 + 8 = 14 dB). To deliver 10 dBmV would require an amplifier output of 24 dBmV. With the input connected to the amplifier, connect the signal level meter to the output and measure the signal level of the highest NTSC channel frequency. Adjust the amplifier gain control for 24 dBmV.

If the cable system carries digital QUAM channels at frequencies above the highest NTSC channel, test the highest digital channel power level. Make sure the digital channel levels are about 15 dB lower than the NTSC channels. In this example the QUAM digital channels should be in the range of 5 -10 dBmV.

The amplifier slope control is set using the lowest frequency cable channel. Set the amplifier slope control so the level of the lowest channel is approximately the same at the end of the longest distribution leg. Adjust the slope control so the lowest channel dBmV output level is 20 dBmV. If the slope control does not have enough range, you may need to add an in-line equalizer at the amplifier input. Check the highest channel again, and reset the gain control for 24 dBmV output.

### **Test the 4-Way Splitter & Verify Proper Levels to Each Room**

Once the amplifier output is known, check the output of the 4 way splitter. The output level dBmV should be approximately 8 dB lower than the input or 16 dBmV on the highest cable channel. In a distribution system using an 8 way splitter, figure a splitter loss of 12 dB. Be sure to terminate each unused output of a splitter with a 75 ohm termination resistor. Verify signal level (10dBmV), A/V ratio and C/N ratio to each room, and check the picture quality to be sure the system is working properly. Verify proper digital QUAM signal level and performance to insure proper digital channel decoding.

### **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 discussed 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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