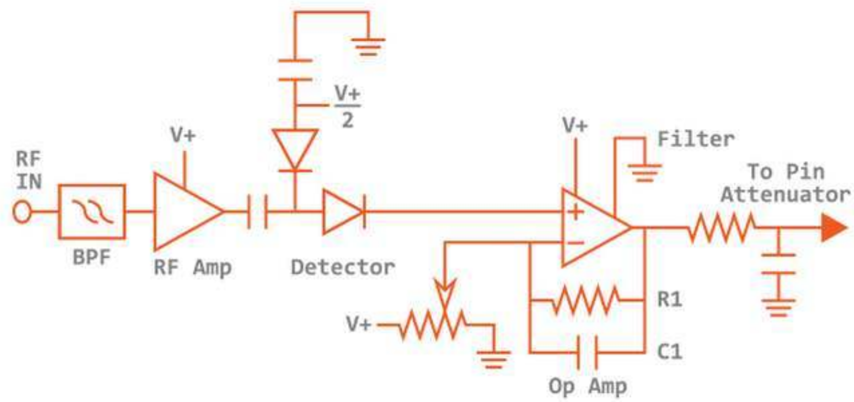
Engineering

# Automatic Gain Control, Part 01: How AGC Circuits Control Levels, And Why We Still Need Them In Modern CATV Systems

April 11, 2016 | Steve Ritchey, President, 4CableTV International




My company, 4Cable TV, was recently called in to consult on an automatic gain control (AGC) problem. The customer stated that the AGCs in his amplifiers that had been sent out for repair were no longer working. They would install the modules, then within two to three days, the levels would be off by two to three decibels.

I asked if they knew why the amplifiers had AGC modules. The customer said, correctly, "To keep the levels constant." But, funny enough, they didn't know what was changing. More and more, we run into folks in the industry who lack a working knowledge of important fundamentals. You see, what the customer didn't know is that transmission loss in a coaxial cable changes with the temperature at a predictable rate of 0.1 percent per degree Fahrenheit. If it gets cold, the cable attenuation goes down, and if it gets hot, the attenuation goes up. This means that if your ambient temperature changes by 10 degrees, your cable loss will change by 1 percent.

It may not seem like much, but if you go to a place like Bishop, CA, where temperatures can swing 100°F in 24 hours, a lot can happen. Now let's say that you have a three-amplifier cascade with 30 dB spacing, for a total of 90 dB of cable transmission loss. If you set your levels in the afternoon, when the temperature was 100°, then the temperature fell to a low of 0° overnight, your cable loss would have dropped by 9 dB. Without controls of some kind, the levels at the end of your line would have increased by 9 dB, and your system would be in trouble.

Today's amplifiers are comparatively very temperature-stable. However, they do vary with temperatures by 0.5 - 1.0 dB, and usually the gain goes up when the temperature goes down, potentially adding another 1.5 - 3 dB to your already 9 dB too-high signal.

Fortunately, in a modern CATV system, we have AGC, or as it is also called, ALC, for "automatic level control." Both terms are correct. The circuit controls the output level of the amplifier by automatically adjusting its gain.

In a modern AGC circuit (above), a sample of the output signal is split off using a directional coupler and fed to a band-pass filter, which selects one frequency or channel to used for measurement and control.

In the early days of cable, special frequencies, such as 73.5 MHz and 166.5 MHz, were inserted just for level control. As the industry matured, actual channels were used in lieu of pilots for more efficient use of the spectrum. |||||

*Steven K. Ritchey is the founder and President of 4CableTV International*

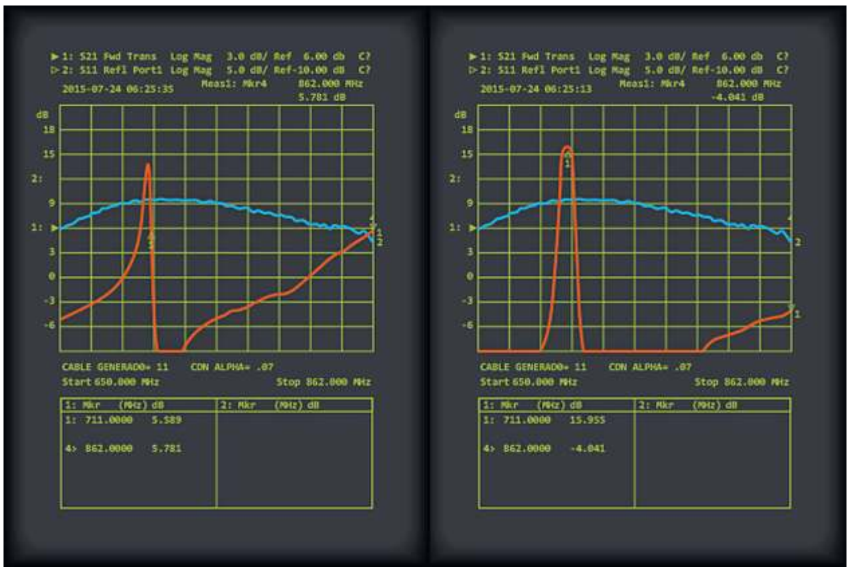
**TRANSMIT** The Broadband Conversation



Engineering

# Automatic Gain Control, Part 02: The Signal's Journey

April 14, 2016 | Steve Ritchey, President, 4CableTV International




**INCORRECT & CORRECT FREQUENCIES:** The meter on the left shows the incorrect frequencies. Notice that 711 MHz is about 9 dB down. Note also that 860 Mhz is at the same level as 711 Mhz. The meter on the right shows the frequencies corrected by AGC.

The band-pass filter used is normally a very narrow piece of equipment, with a 3 dB bandwidth of about 0.5 MHz to ensure that the adjacent channels do not contribute to the sample.

After the signal passes through the band-pass filter, it is amplified, and fed into a detector, the most common of which is a voltage doubler type that has been raised to a potential of about half the supply voltage. The half-supply-voltage rule of thumb is not critical, but it does have to be raised to a potential that is above DC ground to allow the operational amplifier to work with a single supply voltage, rather than a positive and a negative supply.

After the detector, the resultant voltage is fed into one of the inputs of an operation amplifier. In the example shown it is fed into the positive input. The negative input is connected to a variable reference voltage.

The output of the operational amp is fed into an attenuator circuit, usually a BODE bridged T attenuator. A BODE attenuator is designed to mimic cable loss over the frequency range of the amplifier, providing more attenuation at the higher frequencies and less attenuation at lower frequencies.

The easiest way to understand how an operational amplifier works in an AGC is to think of it as a comparator. When the positive input goes above the reference, the output voltage goes up. As the voltage goes up to the attenuator, the attenuation increases also, which will bring the positive input down. When the positive input and the negative input (the reference) are equal, the output voltage of the operational amp will stabilize and the output of the amplifier will be in the preset location.

The output level of the amplifier is set by varying the reference voltage. If the reference voltage is lowered, the reference will now be below the input voltage from the detector. The output of the operational amp will decrease, and the amplifier level will go down.

Once the amplifier is set, the operational amplifier will adjust the gain of the amplifier to keep both inputs equal; thus the amplifier output will remain constant even though the input to the amplifier may vary. The gain is automatically adjusted and the output remains constant.

## ANOTHER DESIGN ISSUE

Diodes used in the detector change with temperature. You can apply thermistors to compensate for it, but mobile broadband engineers have developed integrated circuits whose sole function is to provide temperature-compensated RF detection. These can be used for CATV.

Capacitor C2 removes the high frequency components of the detected signal and functions as a part of the detector. This capacitor is typically much smaller than the capacitor that is a part of the output filter. If it is any larger the operational amplifier may oscilla



the bandwidth of too

On the output of the operational amplifier, there is a filter to remove any residual elements of the original video modulation. Without this filter, the AGC circuit will put hum bars in the picture.

In yesterday's world, all channels were analog. Now, we can use of QAM channels to provide the pilot channel.

For a few years after QAM became widespread, many techs mistakenly thought it wasn't possible to use a QAM channel as the pilot. If they had been a student of CATV history, they would have known that 35 years ago General Instruments used a noise pilot carrier that looked just like today's QAM channels for AGC in their return systems. Those insights helped us build the first QAM-activated AGC, which we successively deployed in 2005. To change to a QAM channel, the filter needs to be wider by about 4 Mhz at the 3 dB point. Ceramic and SAW filters are available to achieve that goal. The gain of the AGC amplifier may need to be adjusted, the reference may need to be changed, or both, so that the AGC operates in the center of its range.

Since channels are becoming increasingly valuable; changing your AGC to a QAM channel is an easy way to regain valuable bandwidth.

## COMMON PITFALLS

- Incorrect Frequencies
- Level Fluctuations
- Temperature Instabilities

If you are having your amplifiers changed to QAM, verify that the company doing the work provides you with documentation that the conversation is:

- At the correct frequency (Figure 3)
- Band-pass correct
- Stable over temperature |||||

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