Originally appeared in the **February 2007** issue of *Communications Technology*.

EQUALIZED OR UNEQUALIZED? THAT IS THE QUESTION

By RON HRANAC

Equalized or unequalized modulation error ratio (MER), that is. The answer is, “it depends.”

Let’s back up a bit and look at the concept of equalization from the perspective of a coaxial cable distribution network. As you know, in a given length of cable, higher frequencies are attenuated more than lower frequencies. For instance, if the all downstream signals in the 50-860 MHz spectrum have the same amplitude at the output of an amplifier, we say the overall frequency response—technically speaking, amplitude (or magnitude)-vs.-frequency—is flat. To simplify this discussion, let’s assume there is no slope at the amp’s output (and the amplifier has no internal slope or tilt), and our signals travel through 1,000 feet of 0.500-inch coax to the next amp.

Since 0.500 cable’s attenuation is about 0.5 dB/100 ft. at 50 MHz and 2.3 dB/100 ft. at 860 MHz, our hypothetical 1,000-foot span of coax has a total of 5 dB of attenuation at 50 MHz and 23 dB of attenuation at 860 MHz. The 50-860 MHz spectrum will be tilted a bunch at the second amp’s input! Ideally, we want to see a flat frequency response, so we need to install a fixed-value plug-in equalizer at the second amp. The equalizer is a small passive circuit that has the opposite amplitude-vs.-frequency response of the 1,000 feet of coaxial cable preceding the amp. The equalizer “cancels” the tilted response, resulting in a flat amplitude-vs.-frequency spectrum at the second amp’s internal gain stages.

Adaptive equalization

Adaptive equalization performs a function similar to that of a cable amplifier’s equalizer. However, rather than equalizing the entire 50-860 MHz downstream or 5-42 MHz upstream RF spectrum, an adaptive equalizer deals with just a single digitally modulated signal. “Adaptive” means the equalizer can change its characteristics as channel conditions change. Adaptive equalization is used in cable modem or digital set-top box downstream receivers; cable modem termination system (CMTS) upstream inputs; DOCSIS 1.1 and 2.0 cable modem upstream transmitters; and even the input stages of certain test equipment such as quadrature amplitude modulation (QAM) analyzers.

An adaptive equalizer is a digital circuit that compensates for a digitally modulated signal’s in-channel complex frequency response impairments. Complex frequency response includes amplitude (or magnitude)-vs.-frequency and phase-vs.-frequency. Adaptive equalizers can deal with cable network nasties such as micro-reflections, amplitude tilt or ripple, and group delay.

The adaptive equalizer uses sophisticated algorithms to derive coefficients for an equalizer solution “on the fly”—in effect, creating a digital filter with essentially the opposite complex frequency response of the impaired channel. Ideal equalizer coefficients yield maximum MER by minimizing total impairments including inter-symbol interference (ISI), within the limits of the equalizer’s capabilities. If the in-channel impairment suddenly changes or goes away, the adaptive equalizer will distort the signal until new equalizer coefficients for the current channel conditions are derived and the equalizer’s operation updated. This adaptation process is very fast, typically completed in milliseconds.

The real world

Given the usual impairments that exist in real-world cable networks, adaptive equalization is pretty much mandatory in cable modem and set-top downstream QAM receiver circuits. The high modulation orders used in the downstream—64- and 256-QAM—would have a tough time operating reliably without adaptive equalization. The vast majority of cable modems and set-tops used by the cable industry are also capable of reporting a parameter called "SNR," which is really downstream equalized MER. That is, the reported MER is after the modem or set-top QAM receiver's adaptive equalizer performs its magic on the signal.

Likewise, the vast majority of QAM analyzers used by the cable industry report equalized MER. I know of only one that supports both equalized MER and an unequalized equivalent MER measurement. (Check with your QAM analyzer manufacturer for more information.)

CMTS upstream burst receivers can report "SNR," too, which is also MER. Depending on the burst receiver used in the CMTS's upstream receiver circuit, the reported MER value can be either equalized or unequalized. Most of the current crop of CMTSs can measure upstream MER on a per-channel basis (an average of all cable modems or a snapshot of the most recently active modems) or on a per-cable modem basis. Make sure you know which of these you're evaluating.

SNR, MER, CNR

If you're a regular reader of this column, you're no doubt familiar with the seemingly never-ending confusion that exists with regard to upstream "SNR" (MER) vs. carrier-to-noise ratio (CNR). As I've discussed on these pages numerous times, upstream MER and CNR that one measures with a spectrum analyzer are not the same thing.

But what about equalized vs. unequalized MER? They're not the same thing, either. Well, they're both MER, but unequalized MER is measured before the adaptive equalizer (or in a way that is the equivelent of no equalizer), and equalized MER is measured after the adaptive equalizer. As I noted in last month's column, for the same signal under identical conditions, unequalized MER will always be at least a few decibels less than an equalized value. I've seen differences from as little as a couple decibels to as much as 10 dB or more. This is normal. A good example of the confusion that occasionally crops up is when changing a CMTS (or CMTS line card) from one that reports equalized MER to one that reports unequalized MER. The latter will report somewhat lower upstream "SNR" than before, even though nothing in the outside plant changed. Going the other direction will yield higher "SNR" numbers than before. Both of these conditions are normal, too.

Equalized and unequalized MER are useful parameters, but it's important to distinguish which type of measurement is being reported. Trying to compare an unequalized MER measurement to an equalized MER measurement is like comparing apples and oranges.

Preferences

So which is best? This is also one of those "it depends" questions. My personal preference is unequalized MER because it can be a potential indicator of linear distortions. How? If unequalized MER is low, quickly check CNR and carrier-to-junk (in-channel ingress, common path distortion, etc.). If these are OK, then you likely have linear distortions present, which cannot be seen on a conventional spectrum analyzer.

Another benefit to measuring unequalized MER is the ability to determine how close things are to the crash point. Here are some approximate unequalized MER thresholds where things start to fall apart:

QPSK: 10~13 dB
16-QAM: 17~20 dB

64-QAM: 22~24 dB
256-QAM: 28~30 dB

The actual thresholds may vary a bit, depending on the design of the QAM receiver, its implementation margin, whether forward error correction (FEC) is used, and so on. Good engineering practice says to keep unequalized MER at least 3 to 6 dB or more above the failure threshold for the modulation type in use.

Both equalized and unequalized MER are ideal for tracking long-term trends. But don't try to compare an equalized measurement with an unequalized measurement. Compare like types, or compare a given value to itself over time.

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