Originally appeared in the **January 2010** issue of *Communications Technology*.

IS MER OVERRATED?

By RON HRANAC

Tough question. Read on for more about why I think we as an industry put way too much emphasis on modulation error ratio (MER).

As you know, MER is a parameter that is computed in pretty much every quadrature amplitude modulation (QAM) receiver, whether that QAM receiver is in a digital set-top, cable modem or embedded multimedia terminal adapter (eMTA), QAM analyzer, or the upstream receiver of a cable modem termination system (CMTS). In a nutshell, MER is the ratio of average signal constellation power to average constellation error power — that is, digital complex baseband signal-to-noise ratio (SNR). Indeed, MER is often called SNR.

Another way to look at it is to consider MER a measure of the fuzziness of the symbol landings in a constellation display. For a two-cups-of-coffee-deep-dive into the subject, see the paper coauthored by Broadcom's Bruce Currivan and yours truly, "Digital Transmission: Carrier-to-Noise Ratio, Signal-to-Noise Ratio, and Modulation Error Ratio," available at www.cisco.com/en/US/prod/collateral/video/ps8806/ps5684/ps2209/prod_white_paper0900aecd805738f5.html.

"Why doesn't each piece of test equipment show the same number?"

Despite the widespread use of MER as an often critical performance metric in cable networks carrying digitally modulated signals, there is widespread misunderstanding of MER. First, it's important to know that because MER is a digital computation performed on digital quantities in a QAM receiver, MER is by nature extremely accurate in itself.

The MER picture starts to get muddy when one considers the many factors that can affect the reported value.

In the lab

Here's an example. Let's say we're evaluating a high quality QAM signal in a lab environment, and there are no impairments in the signal path between the QAM modulator and the input to our test equipment except for inserted additive white Gaussian noise (AWGN) to vary the carrier-to-noise ratio (CNR). Assume for this example that the QAM signal's CNR is initially 49 dB. What MER value will our test equipment report?

The answer definitely falls into the "it depends" camp, but to narrow things down a bit let's measure equalized MER. In a perfect world, CNR and equalized MER are numerically the same. For an explanation of why this is true, refer to the previously mentioned paper.

If we use a very expensive lab grade vector signal analyzer such as an Agilent N9030A with all the bells and whistles, the reported equalized MER will be 49 dB. Measure that same signal with a Rohde & Schwarz EFA73, and the reported equalized MER might be in the low to mid 40s. A Sunrise Telecom AT2500RQv will report >40 dB, and an old Hukk CR-1200 will report about 36 or 37 dB. Which of the reported MER values is accurate?

All of them!

When the CNR is reduced to, say, 35 dB, the differences among reported values will be less, with each instrument's equalized MER somewhere near the mid-30s.

Why doesn't each piece of test equipment show the same number? One reason is implementation loss, a parameter that is somewhat analogous to noise figure in an RF amplifier. Think of implementation loss this way. Theory might predict the bit error rate (BER) will be 1.0E-06 at, say, 21 dB CNR for a given constellation, but in practice we find that a QAM receiver actually needs 25 dB CNR to achieve that same BER. The difference between theoretical and real-world — 4 dB in this case — is the implementation loss.

Even when the input CNR is high, as in our earlier example with 49 dB, every QAM receiver has an implementation loss MER ceiling. That means the MER reading will saturate at a value that is in part related to the implementation loss! The QAM receiver will contribute noise to the MER measurement because of such things as the equipment's front-end noise figure. Other gotchas include imperfect time, frequency, or phase tracking; round-off effects; in-channel ripple inside the instrument; and imperfect adaptive equalization.

Not simple

Still other factors that affect a QAM receiver's reported MER include statistical variation (the number of samples over which the MER is averaged), unequal occurrence of symbols, linkage of carrier loop bandwidth to capture length, symbol error MER floor, phase noise in the QAM receiver or signal source, burst noise, suboptimal modulation profiles, whether the measurement is equalized or unequalized (in the real world, unequalized MER will almost always be at least a few dB lower than equalized MER on the same signal under identical conditions), and even the presence of signals in adjacent channels (this is related to the QAM receiver's selectivity). Toss in various outside plant gremlins, and things get even more interesting.

All of the following affect MER: the QAM signal's CNR, the presence and severity of linear distortions (micro-reflections, amplitude ripple, group delay), nonlinear distortions (common path distortion, composite triple beat, etc.), in-channel ingress, and data collisions. To further add to the confusion, a low reported MER tells us nothing about what's causing it to be low in the first place!

As you can see, this thing called MER is far from simple.

Rather than target a specific MER value in our networks, we should instead look for relative changes on a given QAM signal from point-to-point when using the same piece of test equipment for all measurements. For instance, check MER in the headend, at the node's downstream output, at various points in the amplifier cascade after the node, and at the customer premises, then determine whether the observed MER degradation as the signal makes its way through the plant is acceptable. When performing these measurements, ensure that the signal level at the QAM analyzer input is within the manufacturer's specs, and is as close to the same value as possible at every test point.

You should know the lower ES/N0 (energy per symbol-to-noise density ratio) threshold — effectively the MER crash point — for each constellation type carried in your system. The lower ES/N0 threshold is defined as the unequalized MER where the symbol error rate is 1.0E-02 to 1.0E-03. Here are the approximate MER failure thresholds for popular constellations in cable networks: QPSK, 7 to 10 dB; 16-QAM, 15 to 18 dB; 64-QAM, 22 to 24 dB; and 256-QAM, 28 to 30 dB. Good engineering practice suggests that unequalized MER be maintained 3 to 6 dB or more above these failure thresholds.

Another tool

Despite the realities and limitations of MER, many insist on having specific minimum MER values at various locations in the network. To maintain consistency, one should specify the make/model QAM analyzer used for the measurement, the general measurement conditions (analyzer input signal level, CNR, etc.) and whether the measurement is equalized or unequalized.

Does all of this mean we should toss MER out the window?

Of course not. Look at it this way: If your household finance department gave you the go-ahead to drive to the nearest Sears store and buy that 1468-piece Craftsman tool set, could you name the most important tool in the set? The answer is that the tool set is what's most important, not any individual tool. Likewise, MER should be considered nothing more than one tool out of many that we use when maintaining and troubleshooting digitally modulated signals.

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