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SPECTRUM ANALYZER CNR VERSUS CMTS SNR

By RON HRANAC

There are many ways to characterize the upstream performance of a two-way cable network and how it may impact the performance of a digitally modulated carrier. One time-tested method is to measure carrier-to-noise ratio (CNR) with a spectrum analyzer.

Not only will the spectrum analyzer allow one to measure carrier-to-additive white Gaussian noise (AWGN, or good ol' thermal noise), but it's also useful for taking a look at carrier-to-ingress and carrier-to-interference ratios. In the case of a Data Over Cable Service Interface Specification (DOCSIS) upstream digitally modulated carrier, the recommended minimum for all of these parameters is 25 dB.

CMTS measurements

Another useful tool for tracking upstream performance is incorporated in Broadcom's 3137 burst demodulator, an upstream receiver chip used in several makes and models of cable modem termination systems (CMTSs) available today. A 3137-equipped CMTS is capable of providing an upstream signal-to-noise ratio (SNR) estimate. It's important to understand that a 3137-equipped CMTS's upstream SNR estimate is not the same thing as CNR that one would measure with a spectrum analyzer or similar test equipment. More on this in a moment.

In my March 2003 column, I discussed CNR versus SNR (http://www.broadband-pbimedia.com/archives/ct/0303/0303_broadband.html). I emphasized the fact that in cable industry vernacular, CNR is a pre-detection measurement—that is, one made at RF—while SNR is a pre-modulation or post-detection measurement made on a baseband analog signal such as video or audio. From that perspective, there is no easy way to measure baseband data SNR. A more meaningful measurement for data is modulation error ratio (MER), a direct measure of modulation quality. Mathematically, MER is 10log(average symbol power/average error power).

MER is somewhat analogous to SNR, and in the data world the terms are often used interchangeably. Quadrature phase shift keying (QPSK) digitally modulated carriers like to see a minimum MER of ~13 dB, and 16-QAM (quadrature amplitude modulation) does well when MER is ~20 dB or more.

Understanding SNR

Let me backtrack a bit and talk about SNR. SNR is a useful metric with which to quantify the performance of a baseband signal—say, the video quality seen on a TV set. Even more important, SNR is a way to characterize the end-to-end performance of the video signal. It includes the contributions of the original video signal quality (for instance, the SNR from a studio camera, videotape or disk); satellite and/or microwave link performance; headend modulator; the cable network's CNR; set-top box; and even the TV set's tuner and video circuits.

In the data world, MER is a useful metric with which to quantify the end-to-end performance of a data signal. MER includes the contributions of CMTS, transmitter or upconverter phase noise; impairments such as second and third order distortions; group delay; in-channel frequency response problems (amplitude tilt or

ripple); and microreflections. Other factors that impact MER include the effect of quantization in A/D conversion involving a limited number of bits, rounding errors, D/A conversion in the modulator, and phase jitter of the converter clock. One class of impairments that MER generally won't show is fast transients such as impulse noise. For this, tracking BER or uncorrectable forward error correction (FEC) errors is better.

And CNR? It's a measurement of carrier power to noise power in the RF transmission path only, say, a coaxial cable distribution network or a standalone device such as a set-top box or headend heterodyne processor.

The point of this discussion is to show that CNR is not the same thing as SNR or MER. As mentioned earlier, a CMTS's SNR estimate is not a CNR measurement, but the SNR estimate is a valuable tool for tracking long-term average trends.

It may be helpful to understand that the Broadcom 3137's SNR estimate is derived from the demodulated upstream data signal. I can't get into the specifics of how the Broadcom chip comes up with its SNR estimate (the details of that process are the company's intellectual property), but suffice it to say the SNR value reported by the 3137 is similar to MER.

If we go back to baseband video SNR, there are circumstances in which an NTSC TV channel's SNR will be numerically almost the same as a CNR measurement. One must start in the headend with "perfect" video at the modulator input—say, 70 dB or greater baseband SNR. Out in the field the demodulated video SNR will be numerically within about 0.2 dB of measured CNR. In the real world, of course, the baseband video at the headend is far from perfect, so the measured SNR in the field often will be numerically somewhat less than CNR.

SNR meets CNR

What about a CMTS's upstream SNR estimate and its relationship to CNR? Because of differences in the algorithms for CMTS-reported SNR versus a spectrum analyzer CNR measurement, there can be differences between the two values—especially if the CNR is extremely low or high. However, for the range of 15~25 dB CNR, and where AWGN is the primary impairment, the two values should agree to within less than 2 dB.

In a well-designed and maintained cable system, upstream performance is seldom limited by AWGN. Impairments that cause the most grief are ingress, impulse noise and common path distortion (CPD), all of which are easily measured on a spectrum analyzer. Ingress and CPD can degrade MER, but impulse noise usually won't.

There are other upstream impairments that will affect MER or a CMTS's SNR estimate, though. They include in-channel frequency response problems, group delay and microreflections. As such, it's possible to have very good CNR numbers on a spectrum analyzer, but low MER or SNR numbers. With regard to the latter, group delay or microreflections could be severe enough to impact MER or SNR, yet the CNR would be just fine.

So, given the differences in how they are measured and the less than one-to-one correlation between them, how do you use all of these signal quality metrics in plant monitoring and maintenance? If you like to track CMTS-reported SNR, then use it as a long-term trend indicator and as part of a comprehensive troubleshooting arsenal which includes other features available in today's CMTSs, and of course the tried and true spectrum analyzer. But because some of the plant impairments won't show up in an RF CNR measurement, don't forget to include specialized upstream test equipment and third-party upstream monitoring technology in your arsenal.

Ron Hranac is technical leader, HFC Network Architectures, for Cisco Systems, and former senior technology editor for *Communications Technology*. Reach him at rhranac@aol.com.