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TOTAL POWER

By RON HRANAC

The DOCSIS Radio Frequency Interface Specification includes a summary of assumed downstream and upstream RF channel transmission characteristics, parameters that effectively define what a DOCSIS-compliant cable network is. That same document includes other performance parameters for the cable modem termination system (CMTS) output, as well as cable modem electrical (RF) input and output.

Parameters

A table titled "Electrical Input to CM" includes two items of particular interest: "Level Range (one channel)" and "Total Input Power (40-900 MHz)." If either of these specs is exceeded, it's possible to overload the cable modem with too much RF and cause bit errors to be generated in the modem. The same concept applies to digital set-tops, which fall under ANSI/SCTE 40 2004, Digital Cable Network Interface Standard.

The first parameter is straightforward, stating that a cable modem's downstream RF input level on the DOCSIS channel is to be in the -15 to +15 dBmV range. In practice, most cable operators prefer to maintain a somewhat tighter range of modem input levels, generally something like -10 to +5 dBmV, or -5 to +5 dBmV. The total power parameter is not quite as easy to understand, stating a spec of <+30 dBmV. What the heck does that mean?

Meaning

In a nutshell, the combined RF power of all downstream signals at the cable modem input is supposed to be less than +30 dBmV. How can one ensure that the total power spec is not exceeded? If you have access to test equipment that can automatically measure total power, no problem. But most signal level meters (SLMs) and QAM (quadrature amplitude modulation) analyzers don't support total power measurements. Not to worry. There are ways to guesstimate what the total power is, to within a few decibels.

Methods

One technique is to use an SLM to measure three or four channels - say, Ch. 2, something at the high end, and one or two channels somewhere in the middle of the downstream. Assuming there isn't a bunch of tilt across the spectrum, use the previous measurements to come up with an approximate average per-channel level. Let's say you measure +2 dBmV on Ch. 2, 0 dBmV on Ch. 52, and -2 dBmV on Ch. 116. From this we can deduce the average per-channel level is about 0 dBmV.

If you were dealing with just one channel at 0 dBmV, the total power would be 0 dBmV (I'm assuming that the carrier-to-noise ratio, CNR, is high enough so the noise does not adversely affect the carrier power measurement). Doubling the channel count to two, each at 0 dBmV, brings the total power up to +3 dBmV. Four channels, each at 0 dBmV, is +6 dBmV total power; eight channels, each at 0 dBmV, is +9 dBmV total power; 16 channels, each at 0 dBmV, is +12 dBmV total power; and so on. Assuming that each channel has the same level, every time the number of channels is doubled, the total power goes up about 3 dB. So, if your system has 128 channels, each at 0 dBmV, the total power is about +21 dBmV.

This exercise tells us a couple things. First, it's fairly easy to figure out the approximate total power at the cable modem input, assuming the spectrum is fairly flat. If there is too much tilt, one cannot use this guesstimate method. Second, with typical drop levels of around 0 dBmV per channel, there is little likelihood of exceeding the total power spec. Where things get messy is when per-channel levels are on the high side.

The high side

For example, if the per-channel levels are +10 dBmV, total power with 128 channels would be +31 dBmV. That exceeds the DOCSIS total power spec and is likely to result in overloading the modem. Does your system have hot taps feeding duplexes or other small multiple dwelling units (MDUs)? If the per-channel level is on the order of +20 dBmV at the modem or set-top box input, the total power with 128 channels would be about +41 dBmV. Yikes!

If you're interested in the math behind power addition, here's a quick overview. This applies to RF carriers as well as additive white Gaussian noise (AWGN, or thermal noise).

Let's look at an example with 128 unmodulated carriers, each at 0 dBmV. The formula to calculate total power is Pt = x + 10log(n), where x is the RF power of a single carrier in dBmV and n is the number of carriers. Keep in mind that all carriers must have the same amplitude for this formula to work.

Pt = 0 dBmV + 10log(128)
Pt = 0 + [10 * log(128)]
Pt = 0 + [10 * 2.11]
Pt = 0 + [21.07]
Pt = +21.07 dBmV

Another way to combine power levels is with the following formula. This can be used when per-carrier levels are different.

Pt = 10log[10(p1/10) + 10(p2/10) ... 10(pn/10)]

Here, p1 is the level of the first carrier, p2 is the level of the second carrier and so on. Let's say we have three carriers, the first at +11 dBmV, the second +13 dBmV, and the third +18 dBmV. The total power of the three carriers is:

Pt = 10log[10(11/10) + 10(13/10) + 10(18/10)]
Pt = 10log[10(1.10) + 10(1.30) + 10(1.80)]
Pt = 10log[12.59 + 19.95 + 63.10]
Pt = 10 * log[95.64]
Pt = 10 * 1.98
Pt = +19.81 dBmV

So far, we've seen that when doing power addition with unmodulated carriers, the basis is a 10log, or more accurately, 10log10 function. In other words, if you have two unmodulated carriers with the same power level - for instance, +15 dBmV each - the total power of the two carriers is about 3 dB greater: +18.01 dBmV. The same is true of AWGN. For instance, one can combine CNRs. More on that next month.

QAM

When dealing with QAM signals, power addition is a bit trickier. They're not the same as unmodulated carriers, and even though QAM signals are noise-like, they don't behave exactly like AWGN. A different mathematical approach is necessary. I'll look at that next month, too, along with some tips on sorting out situations where too much signal level - whether single channel or total power - may be overloading a modem or set-top.

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