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TOTAL POWER, PART 2

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If the goal is to combine carrier-to-noise ratios (CNRs), we have to tweak the formulas discussed in last month's column slightly. For example, when combining multiple identical CNRs, the first formula's plus sign is changed to a minus sign.

CNRt = x - 10log(n)

where x is the CNR, and n is the number of identical CNRs being combined. Here's an example. Let's say the standalone CNR of a downstream fiber link is 53 dB, and the standalone CNR of the coax plant also is 53 dB. What's the combined CNR of these two portions of the plant?

CNRt = 53 - 10log(2)
CNRt = 53 - 10 * log(2)
CNRt = 53 - 10 * 0.301
CNRt = 53 - 3.01
CNRt = 49.99 dB

When combining different CNRs, use the following formula (note that this formula also has been tweaked somewhat from the one in last month's column):

CNRt = -10log[10(-CNR1/10) + 10(-CNR2/10) … 10(-CNRn/10)]

Here, let's assume a scenario in which the headend's combined CNR is 55 dB, the fiber link's standalone CNR is 53 dB, and the coax plant's standalone CNR is 49 dB. What's the end-of-line CNR?

CNRt = -10log[10(-55/10) + 10(-53/10) + 10(-49/10)]
CNRt = -10log[10(-5.50) + 10(-5.30) + 10(-4.90)]
CNRt = -10log[0.00000316 + 0.00000501 + 0.0000126]
CNRt = -10 * log[0.0000208]
CNRt = -10 * -4.68
CNRt = 46.83 dB

Last month I commented that power addition with quadrature amplitude modulation (QAM) channels is a bit trickier than what has been discussed so far. For routine power addition in the outside plant, the same formulas that I used last month for unmodulated carriers will work fine. Where things get interesting is when calculating per-channel power levels of QAM channels at the common output port of a QAM modulator. (Per-channel power has to drop when multiple channels are present to maintain more or less the same total output power.) According to the DOCSIS Downstream RF Interface Specification - commonly referred to as DRFI - the following formula is used to calculate per-channel power.

Pc = x - ceil[3.6 * log2(n)]

where x is the power of a single QAM channel, and n is the total number of QAM channels - assuming identical per-channel levels. This formula uses a base 2 logarithm function (log2) rather than the more common base 10 logarithm function (log10 or more commonly just log). It also uses a mathematical ceil (ceiling) function, which returns the first integer that is greater than or equal to a given value.

Here's an example. Let's say a QAM modulator that supports one to four channels per output port is going to be set up for four QAM channels on one port. When configured for one QAM channel, the maximum output is +60 dBmV. What should the port's per-channel power be when the configuration is changed to four channels? If you used a traditional 10log10 approach, you'd assume the answer is ~6 dB lower than the power of a single QAM channel, or 60 - 10log(4) = +53.98 dBmV per channel.

But this isn't the correct way to sort out the four QAM channels' per-channel power! We have to use the new formula.

Pc = 60 - ceil[3.6 * log2(4)]
Pc = 60 - ceil[3.6 * 2]
Pc = 60 - ceil[7.2]
Pc = 60 - 8
Pc = +52 dBmV

What the above example shows is the base 2 logarithm of 4 equals 2, and the ceil function of 7.2 equals 8. With respect to the ceil function, it basically means to round up the answer to the next whole number, unless the given value already is a whole number. So, 7.2 is rounded up to 8.

If your calculator doesn't support log2 functions - most support log10 and loge (natural logarithm) functions - there is a workaround. To find a logarithm with base b, using any base k, the formula logb(x) = logk(x)/logk(b) will do the trick. In the previous example, here's how to calculate the base 2 logarithm of the number 4:

log2(4) = log10(4)/log10(2)
log2(4) = 0.602/0.301
log2(4) = 2

I suspect you're wondering why the traditional 10log10 function can't be used here. I checked with a couple colleagues who were involved with the development of the DRFI spec and was told that it has to do with scaling the QAM modulator's internal "combining" loss, accounting for the peak-to-average power ratio of multiple QAM channels at the modulator output connector, ultimately ensuring signal peaks avoid clipping.

Troubleshooting tips

Let's get back to total power. Last month I showed one way to "guesstimate" total power at the input to a cable modem or set-top box if test equipment that supports total power measurements is not available.

Recall that there are two RF power parameters of concern: The signal level on the channel of interest - the DOCSIS channel in the case of high-speed data - and the total downstream power at the modem input. For the former, ensure that the level is in the -15 to +15 dBmV range, although -10 to +5 dBmV or even -5 to +5 dBmV are common specs among many cable operators. For the latter, ensure that total power is less than +30 dBmV. If either of these is exceeded, it's possible to overload the modem or set-top, resulting in bit errors and/or packet loss.

The fix? Attenuate the input as required, keeping in mind that an in-line pad or a splitter/coupler also will attenuate a modem's transmitted upstream signal (unless you're using a device that attenuates the downstream but not the upstream), forcing the cable modem termination system (CMTS) to command the modem to transmit at a higher level! This is not necessarily bad, as long as the modem has adequate RF output power range to accommodate the additional attenuation.

Another potential gotcha occurs when the DOCSIS channel's level is OK, for instance, when it's carried at a fairly high frequency, but there is significant reverse tilt across the spectrum. That is, the lower frequency channels have much greater signal level than the higher frequency channels. Depending on the number of channels, amount of tilt, and actual levels, a modem or set-top could be easily overloaded - another example of too much total power. Assuming outside plant alignment is correct, one effective fix is to install an in-line drop equalizer. These are drop passives available from several sources, and they come in a variety of values to accommodate different amounts of reverse tilt. Low pass-type drop equalizers also are available for situations requiring minimal insertion loss in the upstream spectrum while still equalizing downstream levels.

So, if you've ever pulled your hair out trying to sort out gremlins such as intermittent tiling on digital channels or downstream packet loss in a modem, don't rule out incorrect signal levels as a possible cause. While the level on the channel you're measuring might be fine, total power could be out of whack!

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