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UNDERSTANDING CONSTANT POWER-PER-CARRIER

By RON HRANAC

“Constant power-per-carrier operation causes a fair amount of confusion, largely because of the observed change in the upstream signal’s ‘haystack’ height.”

Many cable modem termination systems (CMTSs) are configured for what is known as “constant power-per-carrier operation” in the upstream. This mode of operation ensures that upstream digital channel power remains the same value when symbol rate and channel bandwidth are changed.

Constant power-per-carrier is in contrast to another supported mode of operation — constant power-per-hertz — which maintains a constant carrier-to-noise ratio (CNR) when the channel bandwidth changes. Note that constant power-per-carrier and constant power-per-hertz operation are not the same as long loop automatic level control (ALC), which is a CMTS cable-modem interaction mechanism to maintain the desired RF signal level — the commanded nominal receive power — at the CMTS upstream port as the return path’s attenuation changes because of temperature variations and other factors. The default commanded nominal receive power is 0 dBmV in most, if not all, CMTSs.

Constant power-per-carrier operation causes a fair amount of confusion, largely because of the observed change in the upstream signal’s “haystack” height as seen on a spectrum analyzer when channel bandwidth is changed. The haystack height change means CNR also changes, accompanied by a change in the CMTS’s reported upstream “SNR” — actually modulation error ratio or MER. What the heck is all of this change if constant power-per-carrier operation is supposed to maintain the same digital channel power when channel bandwidth is changed?

The following example might help to clear up some of the confusion: Let’s say an existing upstream signal is configured for a symbol rate of 2.56 million symbols per second (Msym/sec), which yields a channel bandwidth of 3.2 megahertz. Connect a spectrum analyzer to a suitable test point near the CMTS’s upstream port so you can observe the received signal’s haystack. Note the displayed height of that haystack on the spectrum analyzer. Now switch the upstream signal’s symbol rate to 5.12 Msym/sec (6.4-megahertz channel bandwidth). For a brief amount of time, the height of the haystack will remain as before. At this instant, the now-wider signal’s digital channel power is 3 dB greater than the narrower bandwidth signal’s was, even though the displayed haystack height has not changed. Double the haystack bandwidth means double the digital channel power!

Because of constant power-per-carrier operation, after the channel bandwidth is doubled to 6.4 megahertz, the CMTS will command cable modems to reduce their transmit power by 3 dB in order to maintain the same digital channel power that existed when the upstream signal’s bandwidth was 3.2 megahertz. The haystack’s displayed height on the spectrum analyzer will drop 3 dB, which indicates the CNR also has dropped 3 dB. Remember, a quadrature amplitude modulation (QAM) signal’s CNR is the haystack height in dB above the displayed system noise floor as seen on a spectrum analyzer; just make sure the displayed noise floor is system noise and not test-equipment noise.

In a pure additive white Gaussian noise (AWGN) environment with no other impairments, the MER will drop 3 dB because of the 3 dB CNR drop. However, in a typical real-world upstream, the MER often is seen to go down more than 3 dB (and sometimes a lot more) because of linear distortions in the channel. The 6.4-



megahertz-bandwidth QAM signal is somewhat more susceptible to linear distortions than was the 3.2-megahertz-bandwidth signal, causing the MER to drop more than just the 3 dB CNR-related reduction.

All right. With constant power-per-carrier operation, a doubling of channel bandwidth causes the CNR to drop 3 dB and the MER to drop at least 3 dB but probably more. What to do?

One can make up for the 3 dB CNR reduction by changing the CMTS's commanded nominal receive power from the default 0 dBmV to +3 dBmV or by installing a 3 dB pad as closely as possible to the input of the CMTS's upstream port. Either will force the cable modems to transmit 3 dB higher than before, making up for the CNR hit and the CNR-related MER degradation. This may not be necessary in a properly designed and well-maintained plant. After all, modern HFC networks easily are capable of producing upstream CNR 30 dB or higher. If the upstream CNR already was high enough, there may be no need to tweak cable-modem transmit levels when switching upstream channel bandwidth, at least to compensate for the CNR reduction.

FIGURE 1: The 6.4 MHz bandwidth QAM signal on the right has 3 dB greater digital channel power than the 3.2 MHz bandwidth QAM signal on the left, even though the displayed heights of the two signals are the same.

FIGURE 2: Both of these QAM signals have the same digital channel power. The 6.4 MHz bandwidth QAM signal's carrier-to-noise ratio is 3 dB lower than the 3.2 MHz bandwidth QAM signal's.

A word of caution when forcing cable modems to transmit at higher levels: If there are cable modems in the field already operating at their maximum transmit levels, those cable modems won't be able to increase their transmit levels the desired 3 dB. They're already maxed out. Here you may see a couple "gotchas." The affected cable modems' upstream signals will be received at the CMTS at least 3 dB lower than other cable-modem signals, and they will have per-modem CNR and MER values that also are lower than other cable modems. The affected cable modems may not be able to stay on line if their signal levels hit the CMTS too low, depending on CMTS configuration. The latter may have to be tweaked to allow low-upstream-receive-level cable modems to remain online. The vast majority of high-transmit-level cable modems are that way because of subscriber drop problems, so you should identify the culprit modems and sort out what's causing them to be maxed out in the first place.

If the upstream MER dropped more than 3 dB when doubling channel bandwidth, changing cable-modem transmit levels won't compensate for MER degradation related to the presence of linear distortions in the channel. Two options exist here. One is to turn on cable-modem upstream pre-equalization, which is quite effective at dealing with upstream in-channel linear distortions. DOCSIS 2.0-and-later cable modems support 24-tap adaptive pre-equalization, which is superior to DOCSIS 1.1's 8-tap adaptive pre-equalization. DOCSIS 1.0 cable modems generally do not support any pre-equalization.

The other option is to troubleshoot the linear distortions and fix what is causing them. For this, you'll need specialized test equipment because conventional spectrum analyzers and signal-level meters can't display linear distortions. Several manufacturers offer QAM analyzers, combination QAM/spectrum analyzers and even spectrum-monitoring platforms suitable for troubleshooting upstream linear distortions.

Alternatively, if your company has deployed an internal tool based on CableLabs' Pro-Active Network Maintenance best practices guidelines (see my October 2010 column, "A Novel Way to Troubleshoot Linear Distortions," at <http://www.cable360.net/ct/sections/columns/broadband/43310.html>), you can troubleshoot them with that tool.

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