Originally appeared in the **March 2004** issue of *Communications Technology*.

MICROREFLECTIONS AND 16-QAM

By RON HRANAC

You cleaned up the reverse, getting the carrier-to-junk ratio to a manageable 25~30 dB or better. Ingress and impulse noise are under control. The forward and reverse amps have been balanced. You moved the cable modem upstream digitally modulated carrier to a center frequency in the 20 to 35 MHz range, so diplex filter-related group delay isn't an issue.

Your data folks tweaked your cable modem termination system's (CMTS) modulation profiles. Then you pulled the switch and made the jump from quadrature phase shift keying (QPSK) to 16-QAM (quadrature amplitude modulation). Things are working well, but modems in some parts of the system are having problems. One possible culprit? Microreflections, reflections or echoes-call them what you will, they must be taken seriously. Find and fix the cause, and your modems and customers will be happier.

Mismatched impedance

Let's go back to basic transmission line theory for a moment. Ideally, the signal source, transmission medium and load ought to have the same characteristic impedance. When this condition exists, all incident energy from the source is absorbed by the load-excluding energy lost by attenuation in the transmission medium, of course. In the real world of cable networks, impedance can at best be considered nominal. Impedance mismatches are everywhere: connectors, amplifier inputs and outputs, passive device inputs and outputs, and even the cable itself.

Anywhere an impedance mismatch exists, some of the incident energy is reflected back to the source. The reflected energy interacts with the incident energy to produce standing waves, which manifest themselves as the standing wave ripple one sometimes sees in sweep receiver displays.

Long echoes in the time domain-that is, those that are offset from the incident signal by an amount greater than the affected data's symbol period-mean more closely-spaced amplitude ripple in the frequency domain. Put another way: If the amplitude ripple peaks are widely separated, the impedance mismatch is nearby. If the ripple peaks are close together, the distance to the fault is farther away.

Not only do echoes cause amplitude ripple, they also cause phase ripple. Group delay-an impairment that can wreak havoc with 16-QAM-is defined as the rate of change of phase with respect to frequency. Fine-grained (closely spaced) amplitude ripple produces fine-grained phase ripple, which in turn may result in large group delay ripple. This phenomenon is generally worse for long echoes.

Sweep, sweep, sweep

Just how does one track these things down? Remember the sweep equipment that's collecting dust on the shelf? "Our newly upgraded HFC plant has only amps in cascade after the node, so we don't need to sweep anymore." Yeah, right.

You might want to reconsider that decision, dust off the old sweep gear, and get its firmware updated. One way to look for problems is to use the highest sweep resolution (maximum number of sweep points) possible when sweeping the upstream. Calan's 3010H/R (http://sunrisetelecom.com/broadband/) supports up to 401 data points, and Acterna's SDA-5000 (http://www.acterna.com/global/Products/Cable/index_gbl.html) offers 250 kHz maximum sweep resolution.

Greater sweep resolution will allow techs to see more closely spaced amplitude ripple. The sweep update may take a little longer when operating in a finer resolution, but it will help when it comes to troubleshooting microreflections.

If you want to get down to the nitty-gritty, Holtzman, Inc.'s Cable Scope (http://www.holtzmaninc.com/cscope.htm) displays impulse response (great for seeing an echo's time offset), amplitude vs. frequency response, phase vs. frequency, and group delay vs. frequency.

Troubleshooting tips

Another tool in the battle against microreflections is adaptive equalization. DOCSIS 1.1 supports 8-tap adaptive equalization, and DOCSIS 2.0 supports 24-tap adaptive equalization. Unfortunately, the large installed base of DOCSIS 1.0 modems won't benefit from either, because DOCSIS 1.1 and 2.0-specified adaptive equalization is done using pre-equalization in the modem. DOCSIS 1.0 modems generally don't support adaptive equalization.

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