Originally appeared in the **April 2009** issue of *Communications Technology*.

ANOTHER LOOK AT UPSTREAM 64-QAM

By RON HRANAC

My April 2007 column highlighted the efforts of Midcontinent Communications, a Midwestern cable operator, to deploy upstream 64-QAM (quadrature amplitude modulation) in a half-dozen nodes (www.cable360.net/ct/operations/bestpractices/22839.html). As of late 2008, the company had rolled out 6.4 MHz bandwidth 64-QAM in more than 60 nodes, largely problem-free.

During the past couple years, a number of other operators have rolled it out in their networks, too. What does it take?

Obvious factors

The obvious factors include a DOCSIS 2.0 cable modem termination system (CMTS) and modems running the latest software and firmware respectively, plus proper CMTS and modem configuration.

The folks at Midcontinent found much of their success in good ol' Cable 101: a comprehensive and effective preventive maintenance program, aggressive leakage and ingress control, tracking down high-transmit level modems, manageable node sizes, and placing their 64-QAM signal at 21.6 MHz center frequency. Interestingly, the latter has enabled Midcontinent to operate its DOCSIS 2.0 modems without upstream adaptive pre-equalization enabled.

What kind of lasers?

One question that comes up is whether return path Fabry-Perot (F-P) lasers will work with 64-QAM. The short answer is yes, but a little "it depends" applies. Last year, I teamed up with Cisco colleagues Frank Eichenlaub and Don Sorenson to speak in Cable-Tec Expo's technical workshops. The subject of our presentation was return path optimization, with one area of focus being the preparation for denser constellations such as 64-QAM and migrating to multiple channels under a DOCSIS 3.0 channel bonding scenario. Earlier in the year, we conducted lab tests to characterize F-P and distributed feedback (DFB) lasers with four 64-QAM and one 16-QAM signal in the RF payload. What we found was no surprise.

First, properly set up F-P links will support one or two 64-QAM channels in the real world, but much more than that really requires DFB or digital return links. F-P lasers simply don't have the bit error rate (BER) dynamic range to handle a bunch of channels. Second, the downstream and upstream network must be properly aligned. Think forward and return sweep!

Frequency choice

Assuming the plant has been properly tweaked, then what?

Pick an appropriate center frequency. My suggestion? Keep your wide bandwidth 64-QAM signals below 30 MHz, and place your narrower bandwidth 16-QAM and/or quadrature phase shift keying (QPSK) signals at higher frequencies. Why? Diplex filter-related group delay. Those less dense constellations are a little more forgiving of group delay and other impairments than 64-QAM is.

We tend to think of diplex filter-related group delay as being confined to frequencies above about 35 MHz or so. Diplex filter-related group delay is cumulative, so the more return amplifiers a given signal passes through, the more diplex filters, too. Each amplifier has two filters, and group delay is much worse through six cascaded amps than it is for one or two amps. Signals from modems near the ends-of-line of a six-amp cascade have to pass through 12 diplex filters before reaching the node! The more diplex filters in the signal path, the worse the overall group delay, and the lower in frequency it starts to degrade. What does that mean? Group delay might be acceptable at 33 MHz in a two-amp cascade, but unacceptable in a five- or six-amp cascade.

Think back to the Midcontinent example. Its upstream 6.4 MHz bandwidth 64-QAM signal is carried at 21.6 MHz, well away from diplex filter-related group delay problems.

Plant testing

Once the operating frequency has been chosen, you should evaluate the plant using a test signal configured to the same symbol rate and constellation that you plan to deploy. For instance, if your intent is to launch a 6.4 MHz bandwidth 64-QAM based service, use a 6.4 MHz bandwidth 64-QAM test signal. Do the tests on the same frequency as the intended operating frequency. Inject the test signal at various points in the system, including end-of-line locations.

Using suitable test equipment in the headend, look at the test signal's carrier-to-noise ratio (CNR). Even though DOCSIS assumes a minimum of 25 dB, you should strive to achieve higher numbers. I've evaluated hundreds of upstreams over the years, and the vast majority of cable networks have no problem meeting or exceeding 30 dB or more. Also look at in-channel flatness and group delay; the constellation; modulation error ratio (my preference is unequalized rather than equalized MER - a good place to be is 25 to 27 dB or higher); the adaptive equalizer graph (good for identifying micro-reflection problems); and if your test gear supports it, pre- and post-forward error correction (FEC) BER. Check the upstream spectrum for ingress and common path distortion (CPD). Be sure to look at the spectrum below 5 MHz for lower frequency ingress and above 42 MHz (all the way to 200 MHz) for evidence of laser clipping distortion. Check packet loss during your tests, too.

If you identify service-impacting issues, they need to be fixed before rolling out 64-QAM. Once problems have been taken care of, it may make sense to initially limit the rollout to a few nodes at a time. This will make it easier to deal with the inevitable gremlins that crop up. As your comfort level with the 64-QAM deployment increases, add more nodes to the mix.

Checklist

The previously discussed information and my April 2007 column, plus the following checklist, will help smooth out some of the bumps in the upstream 64-QAM road.

• DOCSIS 2.0-capable CMTS and modems

• Entire cable network - headend, distribution network and subscriber drops - DOCSIS-compliant or better

• Proper upconverter setup, IF input/RF output levels

• Correct downstream laser input levels

• Avoid downstream frequencies near band edges or rolloff areas

• Avoid downstream frequencies that may be susceptible to ingress from strong over-the-air signals

• Forward and reverse properly aligned (coax and fiber)

• Signal leakage management (<5 µV/m at 3 meters)

• Good installation practices

• Modulation profiles optimized for constellation in use - for instance, upstream 64-QAM

• Identify high transmit-level modems (greater than +54 dBmV); fix problems causing high transmit levels

• Select upstream frequency that avoids diplex filter roll-off area

• Upstream packet loss not more than 1 percent for data, or not more than 0.1 percent to 0.5 percent for voice

• Upstream unequalized MER 25~27 dB or higher for 64-QAM

• Consider using upstream pre-equalization to deal with linear distortions

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