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DIGITAL PROOFS OR NOT (PART 1)

By RON HRANAC

Did you know the Federal Communications Commission (FCC) has required digital signals carried on most cable networks to meet certain technical performance parameters, and that this requirement has been on the books for several years? I thought that might get your attention. But it's true; §76.640(b)(1)(i) is where you'll find the rules for digital signals:

"(1) Digital cable systems with an activated channel capacity of 750 MHz or greater shall comply with the following technical standards and requirements:

"(i) SCTE 40 2003 (formerly DVS 313): "Digital Cable Network Interface Standard" (incorporated by reference, see §76.602), provided however that with respect to Table B.11, the Phase Noise requirement shall be −86 dB/Hz, and also provided that the "transit delay for most distant customer" requirement in Table B.3 is not mandatory."

This causes a fair amount of confusion along the lines of "what do you mean there are rules for digital signals in Part 76?" A lot of folks are unaware of §76.640, which states that digital signals in 750 MHz and greater plants MUST meet the technical parameters in SCTE-40. The FCC rules don't say when, how or how often to verify that digital signals are in compliance, nor do the rules say how to document that compliance. But those signals must comply — that part is clear.

The good news is that most of the quadrature amplitude modulation (QAM) signal technical parameters in SCTE-40 can be measured with commonly available QAM analyzers, spectrum analyzers and signal-level meters (SLMs). Grab a cup of coffee and read along as I take a look at the parameters applicable to digital signal performance in cable networks with an upper bandwidth limit of 750 MHz or greater. You'll notice that some of the requirements in SCTE-40 apply to analog TV channels. For the most part, those parameters mirror what long has been required in §76.605 and other sections of the FCC rules.

"Believe it or not, measuring a QAM signal's CNR generally is easier than measuring analog-TV-channel CNR and can be done using a spectrum analyzer."
Section 6.4, "Downstream Transmission Characteristics," of ANSI/SCTE 40 2004, the current version of SCTE-40 available online, states the following:

"The Downstream Transmission Characteristics are contained in Table B. Analog and FAT Channel: RF Transmission Characteristics and Table C. FDC Channel: RF Transmission Characteristics as provided below. Analog and FAT signals shall meet the characteristics specified in Table B when measured on the subscriber's premises at the end of a properly terminated drop cable and OOB FDC signals shall meet the characteristics specified in Table C when measured on the subscriber's premises at the end of a properly terminated drop cable."

Here's a quick translation of a couple of the terms used in the previous paragraph. "FAT Channel" is a forward application transport channel, which we know as a 64- or 256-QAM signal that complies with ITU-T J.83 Annex B and is carried in the 54 MHz-864 MHz range. "OOB FDC" channels are out-of-band forward data channels defined as quadrature phase shift keying (QPSK) signals located between 70 MHz and 130 MHz.

SCTE-40's Table B includes 15 technical parame-ters. The FCC rules in §76.640 relaxed the phase noise spec in Table B's requirement #11 from -88 dBc/Hz to -86 dBc/Hz, and the transit delay spec in requirement #3 is not a mandatory requirement. Let's look at the first four of the 15 specs in Table B (others will be covered next month):

1. RF Channel Spacing: 6 megahertz

This is pretty much a yes or no requirement. If in doubt, channel spacing is easily determined using a spectrum analyzer.

2. RF Frequency Range: 54 MHz to 864 MHz, IRC/HRC/Standard Channel Plans

The first portion of this requirement is largely a fill-in-the-blanks question. Specify the frequency range used for downstream transmission. The second portion of this requirement can be fulfilled by stating the CEA 542-C channel plan — STD, IRC or HRC — in use for downstream operation. If you're unfamiliar with CEA 542-C, it's the standard that defines North American cable channel plans, and it formerly was known as the NCTA/EIA channel plan.

3. Transit delay from headend to most distant customer: ≤0.800 msec (typically much less)

The SCTE-40 one-way transit delay specification (that is, the time it takes for an electromagnetic signal to travel from the headend to the most distant subscriber) is the aforementioned ≤0.800 millisecond (ms or msec). Even though this particular spec isn't mandatory in §76.640, I'd like to discuss it for those who may be interested in how to figure it out. To calculate the approximate one-way transit delay in a cable network, this information is required: The length of transmission medium (fiber and/or coax) through which the signals travel and the velocity of propagation of the transmission medium.

Typical velocity of propagation for hardline coaxial cable is about 87 percent. The free-space value of the speed of light is 299,792,458 meters per second (983,571,056.43 feet per second). RF travels through hardline feeder cable at 87 percent of the free space value of the speed of light, or 983,571,056.43 x 0.87 = 855,706,819.09 feet per second. The time it takes for RF to travel through 1 foot of cable is 1.17x10-9 second (1.17 nanosecond).

Surprisingly, light travels through single-mode optical fiber slower than RF travels through coax! For example, the published effective group index of refraction for Corning's SMF-28e+ optical fiber is 1.4676 at 1310 nanometers. That puts the velocity factor at 1/1.4676 = 0.6814, and the velocity of propagation at a touch more than 68 percent. The light makes its way through the fiber at the leisurely pace of 670,190,144.75 feet per second or through 1 foot of fiber in 1.49x10-9 second (1.49 nanosecond).

It takes signals about 92 microseconds (µs or µsec) to travel one way from the headend to the subscriber through, say, 18 kilometers (59,055 feet) of fiber and 1 kilometer (3,281 feet) of coax. This is the same as 0.092 msec, which is well-within SCTE-40's ≤0.800 msec spec.

4. Carrier-to-noise ratio, C/(N+I), in a 6-megahertz band where C/(N+I) includes the simultaneous presence of all additive impairments in the 6-megahertz channel bandwidth including CTB, CSO, other discrete interference: Not less than 27 dB for 64 QAM; 33 dB for 256 QAM; C/N (analog channels): 43 dB for AM-VSB analog

The first part of this requirement applies to downstream QAM signals. The second part of this requirement applies to downstream analog TV channels and is the same as what is specified in §76.605(a)(7) of the FCC's rules.

Believe it or not, measuring a QAM signal's CNR generally is easier than measuring analog-TV-channel CNR and can be done using a spectrum analyzer. The CNR simply is the height of the QAM signal's haystack above the noise floor in decibels — no bandwidth or detector-correction factors needed. One note of caution: Make certain the spectrum analyzer is displaying the cable system's noise floor and not the test equipment's noise floor. The easiest way to confirm the latter is to temporarily disconnect the RF input from the spectrum analyzer; the displayed noise floor should drop at least 10 dB. If it doesn't, you're seeing mostly test equipment noise, not system noise. Find a test point with higher signal level.

Next month I'll continue this discussion, starting with the SCTE-40 specs for composite triple-beat and composite second-order-distortion measurements.

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