Positive Trapping Systems For Analog Channels

In the 1st quarter technical report for 2011, I addressed the subject of 'basic FDM', or frequency division multiplexing, with an emphasis on what elements and techniques make for a good FDM design and those that do not.

This has been a hectic year for CSEI, so the 2nd and 3rd quarters have come and gone with no further reports. Now that I'm somewhat caught up, I'd like to address another issue that I often encounter as I conduct semi-annual FCC Proof of Performance testing. My approach will be to make this a fairly brief treatise on this subject; however, the 4th Quarter 2011 technical report is already in progress, and will address the subject of digital (QAM) carrier testing during FCC Proof of Performance testing in more detail.

Introduction.

Positive Trapping Basics

Positive trapping is a technique that was developed years ago for security control of analog pay channels. One or several (usually just one) 'jamming' carrier(s) are introduced into the premium channel, in the spectral area approximately mid-way between the luminance and aural carriers. The frequency of the jamming carrier is chosen such that it is harmonically related to the both (the luminance and aural) carriers, and therefore produces 'maximum' interference to the video and audio signals. Typically, the result is the television cannot lock to the vertical and horizontal sync pulses (picture rolls vertically and horizontally), and aural carrier performance ranges somewhere between an annoying jamming tone to being entirely unintelligible.

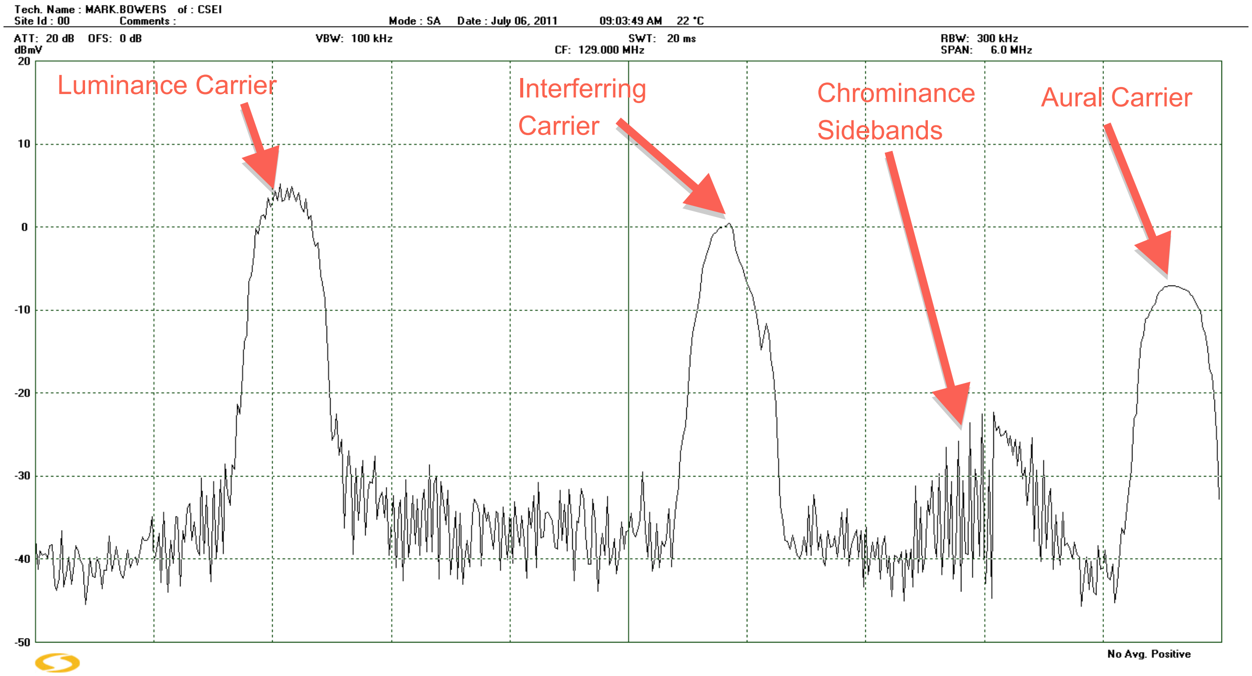
Problems With The Positive Trapping Approach

Starting with the basics, any positively trapped analog channel cannot pass several FCC specifications, as defined under FCC Part 76, so it's always been a bit of a mystery for me as to how these systems were initially approved. A fairly narrow bandwidth trap is employed at the home/premise of a customer desiring to purchase the service, however the traps still notch much of the fine detail (sideband information) in the luminance portion of the NTSC-M signal along with the interfering carrier, thus the picture takes on a distinctive 'mushy' look. The trap also typically has considerable insertion loss, usually on the order of several dB, in the channels adjacent to the + trapped signal. Pre-emphasis (a peaking of the video response at the interfering carrier frequency) is employed in the positive trapping encoder to assist with trap loss within that channel, but this does not help with the loss in adjacent channels, and cannot replace the fine picture detail lost in the process. This pre-emphasis (measured with or without the trap in place) causes failure of ICR; the 'in-channel response' specification. Typical peak-to-valley ICR measurements for a positively trapped NTSC-M carrier are 12 to 13 dB, with the FCC limit at 4 dB. And with the trap in place, considerable group delay is introduced within the encoded channel and thus CLDI, or 'chrominance to luminance group delay' also fails FCC specifications. Finally, depending on the system in place (brand/model) and whether it is adjusted properly, a somewhat viewable picture may still be present that customers are willing to put up with if it's free, and often yields viewable pictures for those that wish to block the programming from young children when the signal is absolutely not desired.

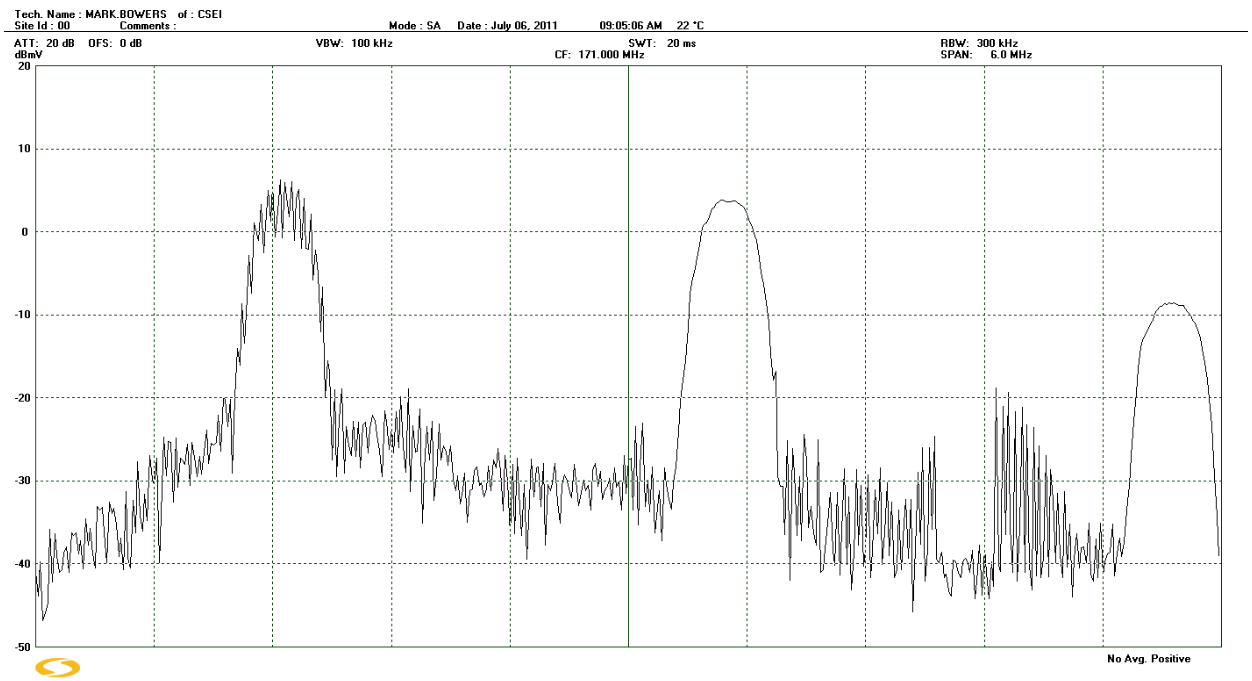
My advice to all systems still employing this technique is to abandon it as soon as is possible; yet often they are kept in place as it does offer a method by which the cable operator can deliver a premium channel without the requirement for a set-top box.

Sample Waveforms

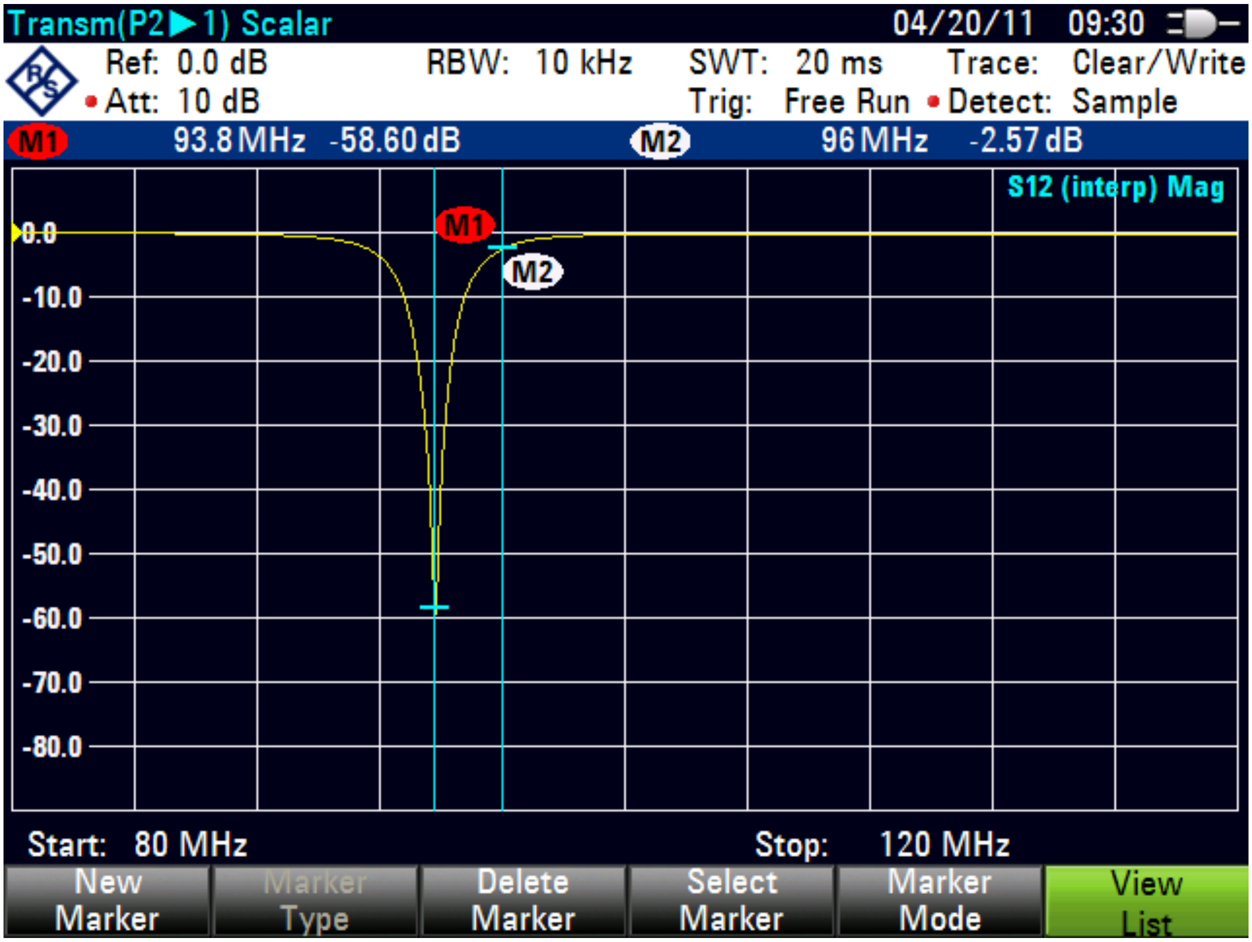
The following waveforms are intended to provide further illustration of the positive trapping ‘technique’, along with trap response and problems thus introduced.



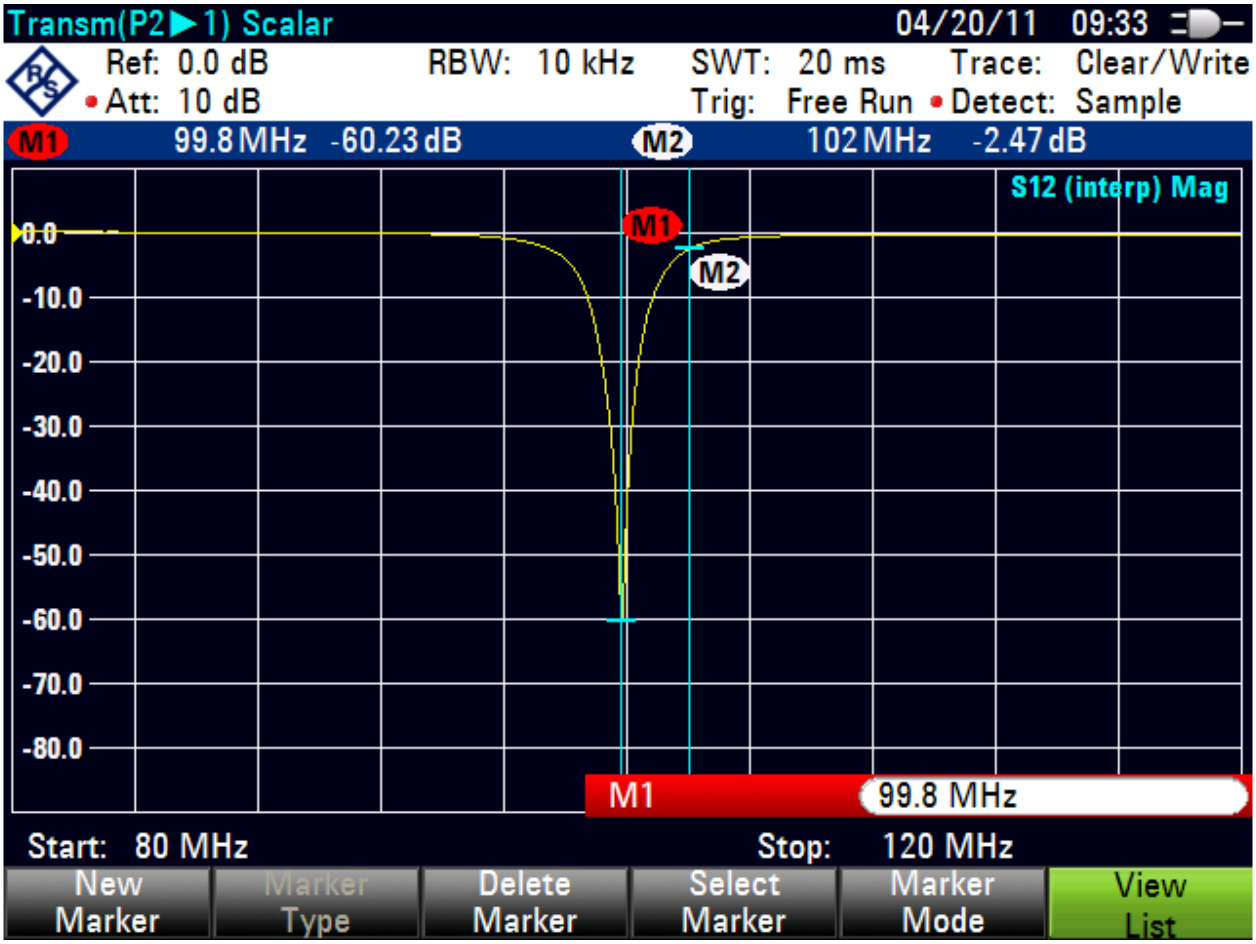
CH15 downstream signal with positive trapping



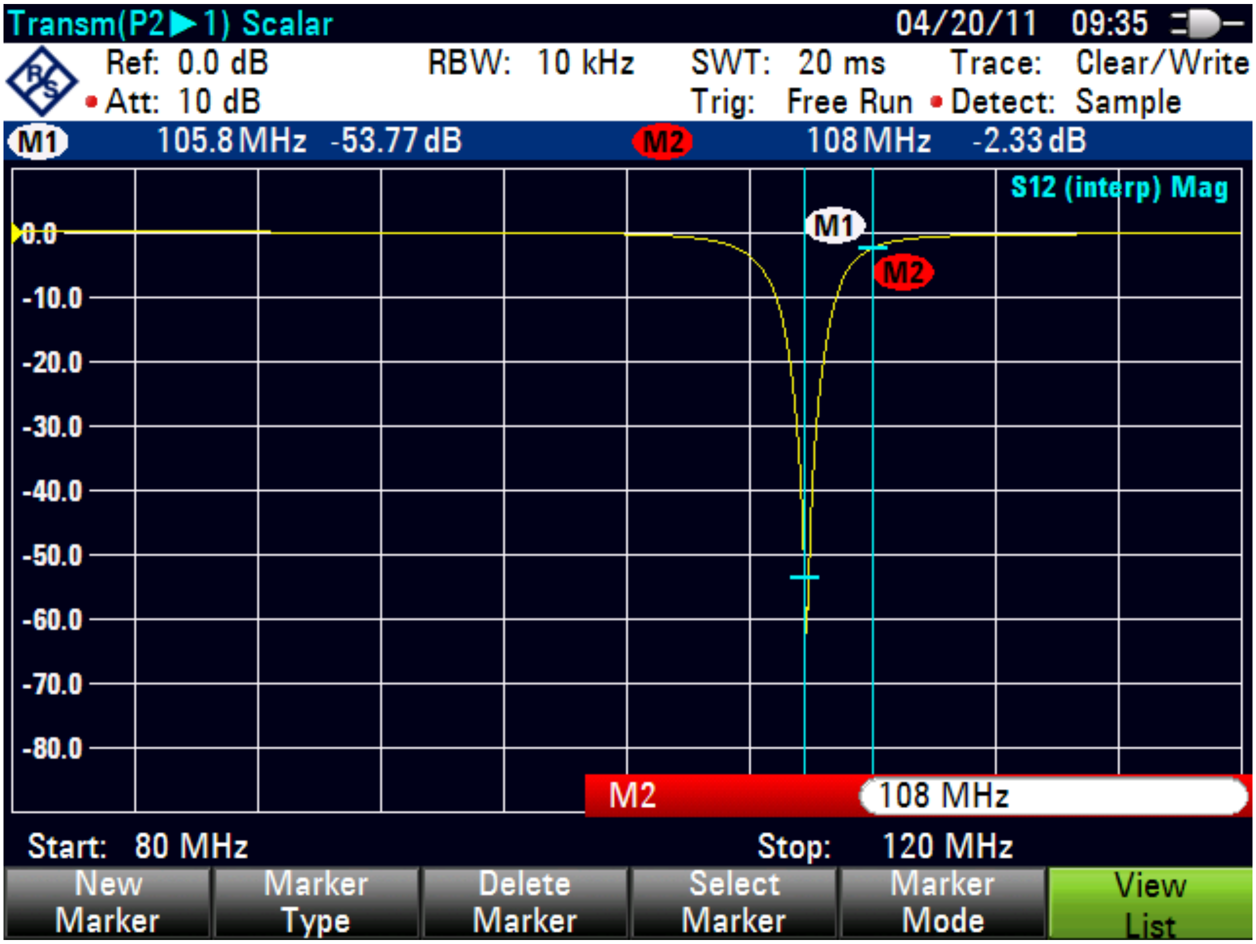
CH22 downstream signal with positive trapping



Response (scalar) of a CH95 sample trap (all cable and connector loss is normalized, so the top zero dB line accounts for all loss and response characteristics except for the device under test). Several measurements are noteworthy. The first is that the total notch depth at the interfering carrier frequency is -58.6 dBc; the second is that at the band-edge frequency for CH95 (beginning of CH96 spectrum), insertion loss is 2.57 dB! So at the very least, spectral portions of adjacent channels, where encoder pre-emphasis offers no help, insertion loss is almost 2.6 dB; and if traps have to be cascaded (multiple positively trapped channels), the insertion loss only becomes worse.

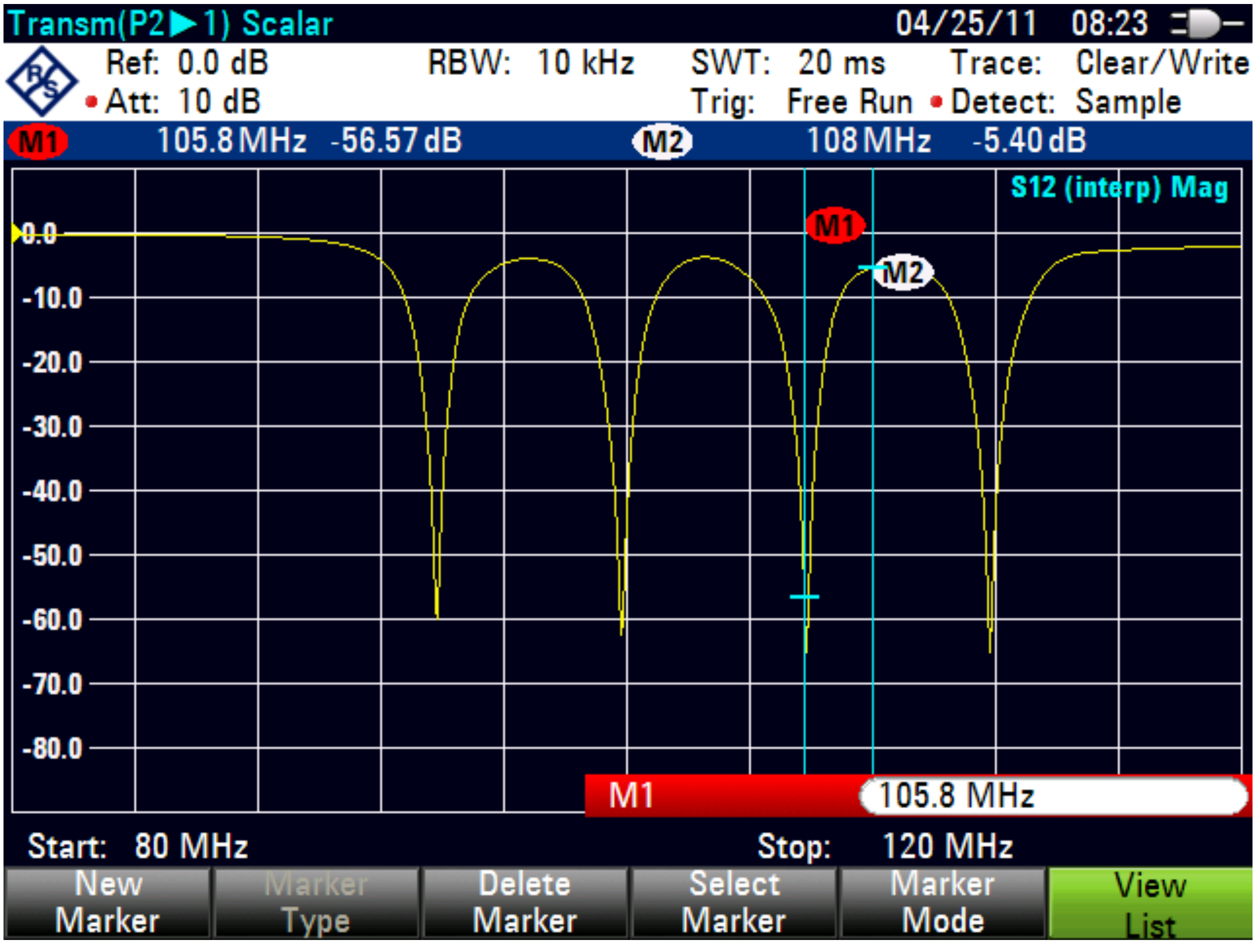


Response (scalar) of a CH96 sample trap. Notch depth at the interfering carrier is -60.23 dBc, and insertion loss at the adjacent carrier band edge is 2.47 dB.



Response (scalar) of a CH97 sample trap. Notch depth at the interfering carrier is -53.7 dBc, and insertion loss at the adjacent carrier band edge is 2.33 dB. Note that the notch depth for the other traps is typically close to or exceeds 60 dB; whereas the response of this sample trap (notch depth) is approx. 5 dB less. 'Stability' for these traps is an additional long-term issue.

Response (scalar) of a CH98 sample trap. Notch depth at the interfering carrier is -60.7 dBc, and insertion loss at the adjacent carrier band edge is 3.8 dB (much greater than others)!



This waveform measures the combined scalar response of all four sample traps in cascade; channels 95 through 98. The system in which these were measured does indeed offer positively trapped analog premium services on all of these channels. If the customer subscribes to a package of all four channels, insertion loss really becomes problematic! In this waveform, the notch depth of CH98 was measured at -56.7 dB, and insertion loss at the band edge for CH98 is 5.4 dB! And as mentioned earlier, group delay (chrominance to luminance) through this cascade would be very high.

Conclusions

As stated earlier, this technical letter is not intended to be a dissertation on positive trapping techniques, but rather a ‘quick’ examination of basic techniques and problems that arise. Positive trapping was developed during the era of analog only channels, and as a fairly effective but simple technique for offering premium services where the system either could not afford or chose not to employ more sophisticated analog ‘sync suppression scrambling’ techniques with accompanying set top boxes. The advent of digital QAM signal delivery and the multitude of advantages offered (superior signal quality, multiple program streams per 6 MHz spectral slot, superior access control, PPV, IPPV, etc.) make this technology obsolete; however, it’s amazing how many systems I visit where I still find it in use.

Given it’s inability to pass several FCC Proof of Performance specifications, it’s poor use of valuable RF spectrum, the poor picture quality delivered to the subscriber, and it’s impact on adjacent channels; it's a technique that really should be abandoned as soon as possible by modern cable television systems.

A 4th Quarter 2011 Technical Letter will be issued in the next several weeks addressing the subject of "Increased Testing Requirements for Downstream QAM Carriers", if the activated HFC system bandwidth is 750 MHz or greater.

Take care and best regards.

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