In-Service Measurement of Composite Triple Beat and Other Proof-of-Performance Enhancements

Robert V.C. Dickinson
Edwin L. Dickinson
Dovetail Surveys Inc.

Abstract

This paper covers some innovations developed to streamline the execution of proof-of-performance testing and the generation of the required reports. These include automated cyclic test signal application and in-service testing techniques for measuring CTB, CSO, C/N and in-band spurs without producing visible disruption of subscriber viewing.

Background

Proof-of-performance testing has become another of those necessary but annoying parts of the cable operator's life and business. Having done many proofs since the inception of this requirement we have struggled to improve the procedure for better measurements, quicker execution and less disruption of the cable system especially in terms of customer dissatisfaction. The memory of the first series of proofs still lingers. Data was taken laboriously with available equipment and recorded with pencil and paper. This just couldn't last very long. Then computer programs were developed to capture the data and ultimately to direct the spectrum analyzer and other equipment to do their functions semi-automatically. These improvements were welcomed and helped to systematize the procedure and reduce the time required, but still proofs are a burden sopping up man hours and communications channels while interfering with subscriber viewing.

The Traditional Way

The proof-of-performance requires the following measurements to prove compliance with Part 76.

1) To be measured on all analog channels
   - Visual carrier levels both absolute and relative
   - Visual carrier level stability
   - Aural carrier levels relative to the associated visual carrier
   - Aural carrier frequencies relative to the associated visual carrier

2) To be measured on channels designated as test channels;
   - In-band flatness
   - Visual carrier to noise ratio
   - Visual carrier to composite triple beat, composite second order and spurs
   - Low frequency disturbances
   - Terminal isolation (usually derived from manufacturer's specs.)

3) To be measured at the headend every three years on the designated test channels;
   - Differential gain
   - Differential phase
   - Chrominance-luminance delay

The measurements under 1) above are accomplished manually or automatically employing standard test equipment and procedures. Those listed under 2) are measured at the headend and at each test point and are normally those which require special test signals and procedures which can be the most labor intensive and disruptive to CATV viewing. The items under 3), although required only triennially and only at the headend, are easily performed along with the tests in 2).

The traditional way to make the measurements listed under 2 & 3, is to insert and remove test signals at the headend. To measure C/N, CTB, CSO and spurs without interference from the visual carrier and the program material on the test channel requires that the test channel be turned OFF while the field measurement is executed. Measurement of in-band flatness may be done with a non-intrusive vertical interval test signal. Some remove the video modulation to measure low frequency disturbances.

The tests requiring synchronized operations between the field and the headend represent an area where the most time and aggravation is experienced. When a test signal must be inserted or removed or a channel turned ON or OFF, a person must be present at the headend and communication must be carried on between the field and the headend to coordinate the action with the commensurate measurement. In addition to the personnel needs, a radio or telephone channel is required. The availability of a communication channel is taken for granted until the regular system operational traffic loads the channel to where the testing procedure is slowed down waiting for openings to make the required transmissions. To make matters worse, there are spots where radio communications are poor and extra time is required to make up for this deficiency.

A More Efficient Way

One approach at a "more efficient way" is to automate the testing cycle at the headend. This amounts to permanently installing programmable equipment which does the test signal insertion, switching, etc. in a preset sequence with adjustable timing to match the field data recording needs. This "permanent" feature eliminates setup and knock down time after the initial installation. With such a system in place no personnel are required at the headend and the cyclic operation of the headend tasks continues without reference to the operations in the field. This arrangement immediately eliminates the requirement for at least one person (at the headend) and for any type of field/headend communications. The field task then resolves to moving to the next test point, plugging in and waiting for the next testing sequence to begin and then taking the required data. There is some time lost (about one half of the period of one sequence on average) but this is often less than that lost due to communication problems, etc.

The above is a great improvement on the traditional way but still requires the repeated removal of test channels to accomplish the C/N, CTB, CSO, and spur measurements. This is perhaps the most onerous problem since it causes subscriber dissatisfaction due to viewing interruptions. Not only are the subscribers unhappy but the CSRs must be alerted and given the proper responses for the call-ins and, of course, the volume of traffic increases substantially. This problem has been ameliorated by announcements and other cable operator innovations but certainly is still a problem that we could all do without.

In-Service Testing

The first approach to in-service testing is the normal use of vertical interval test signals, which is often employed. In-band flatness has long been tested by use of the Multiburst signal where the amplitudes of the bursts are compared to indicate the flatness of the channel. This is a good and acceptable test but suffers from the specific frequency nature of the packets and sometimes from the addition of noise in remote locations making the results less accurate. A variation on this approach is offered by use of the "Line Sweep" signal. The Line Sweep signal is not available from all video test signal generators. It is a video signal on a single line where a full amplitude sine wave signal is swept from 500KHz to 5 MHz linearly over the active video portion of the single video line. This signal can be applied in the vertical interval in one or both fields. Since this signal is full amplitude it is always as great or greater than any normal video component and therefore produces a maximum response. This signal appears 60 times per second if inserted in both even and odd TV fields. To detect this the spectrum analyzer is set to sweep slowly across the 6 MHz channel (usually about 10 seconds) in a peak detection mode. This displays a solid line indicating the response across the channel. A typical in-band-flatness display is shown in Figure 1. The preferred way of quantifying the result is to capture the spectrum analyzer screen picture on a computer and later submit it to computer analysis. A faster sweep may be employed but this can cause narrow dropouts between the peaks although the peaks will still indicate the in-band flatness. These dropouts may be detrimental to the computer analysis.

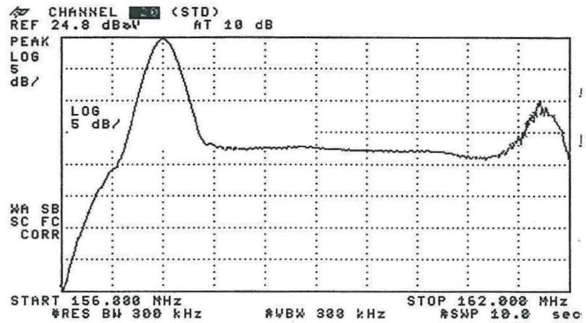

Figure 1 - In-band Flatness

Insertion of vertical interval test signals is also useful in performing the triennial video measurements non-intrusively. In this case the images are captured through a calibrated demodulator and mathematically processed to determine Differential Gain, Differential Phase and Group Delay. This measurement is required to be made only at the headend. Figure 2 illustrates the capture of FCC Composite and Multiburst signals from which differential gain, differential phase and group delay parameters may be calculated.

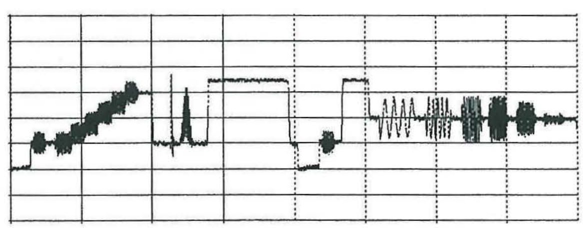

Figure 2 – Detected FCC Composite & Multiburst Signals

The real killer test is to see the composite third order products that lie beneath the visual carrier. Some methods have been developed to extrapolate the desired CTB results from out of band measurements but direct observation is to be desired. Tests for C/N, CSO and spurs may be made on a quiet line in the vertical interval although these measurements are vulnerable to small disturbances on the visual carrier which sometimes degrade or obscure the desired information.

Tests indicate that modern TV receivers are tolerant to loss of visual carrier for up to several vertical interval lines without picture disturbances or loss of sync. This fact suggests a technique of turning the visual (or visual and aural) carrier(s) OFF for short periods of time and observing what is underneath. Based upon this method, "looking underneath" the visual carrier has been pursued coupled with a sampling type of measurement of CTB, C/N, CSO and spurs during this OFF period. This technique makes use of work done by John Huff [1] and Francis Edgington [2] with the addition of the transmitted signal gating.

There are several precautions to be observed in applying this approach.

First, the rise time of the gating signal for the visual carrier must be properly controlled or else spurious products will be generated outside of the channel of interest. What happens inside of the test channel is of less importance since it is in an unviewed time (vertical interval) of the picture format. If the gate has a rise time similar to the TV sync pulse its products will remain within the channel. Figure 3 shows a typical gating signal as seen in a received video waveform.

Second, the detection equipment must provide a similar gating function except that it must be turned ON only during the time that the modulator is turned OFF. The timing for the received sample may be derived from counting TV lines or by sensing the instant of full carrier turn OFF of the test channel.

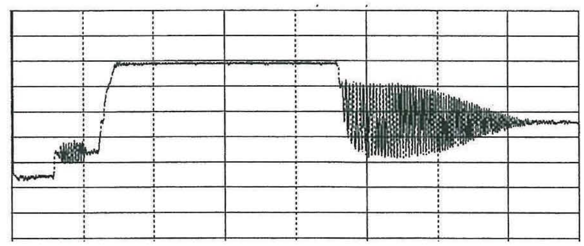

Figure 3 – Detected Video Waveform with Gating Pulse

In order to view the spurious signals, a spectrum analyzer following (or including) the receiving sampling gate, is employed. The spectrum analyzer must be operated in the peak detection mode since data is received for a period of microseconds and therefore have a very low average value. Since the gating of the visual carrier occurs only 60 times per second (when gating both fields of the TV picture) the analyzer sweep must be slow enough to receive at least one sample per horizontal pixel of the display. Typically there are about 500 pixels horizontally in the spectrum analyzer display so the sweep must be no faster than $500/60 \cong 9$ seconds to assure that there is data in each pixel interval. Sweeping for 20 seconds provides at least 2 samples per pixel of which the maximum sample amplitude will be recorded.

The analyzer resolution bandwidth setting will determine the shape of the indicated response. In the case of a CW signal the amplitude will be less than without sampling by an amount determined by the impulse response of the analyzer due to its bandwidth and filter settings. The rise time of the indication on the spectrum analyzer is governed largely by the resolution bandwidth. For instance, the rise time (RT) of a pulse is in the order of the inverse of the bandwidth, i.e., the RT in a 30 KHz bandwidth is about 33 microseconds and reaches 63% (-4 dB) of its full value in this time while a 60 KHz bandwidth would reach 86% (-1.3 dB) in the same time. A more complete discussion is given in Reference 2. Due to this effect a video filter narrower than the resolution bandwidth should not be used since it will increase the rise time of the instrument and thereby attenuate the signal peaks. Figure 4 shows a CW signal lying beneath the channel video in the gated mode.

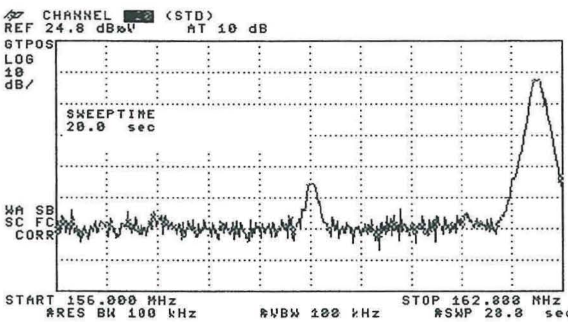

Figure 4 - CW Carrier under Video Signal in Gated Mode

For a "noise-like" signal this technique records the amplitude peaks. The peaks bear a relation to the average noise (which is what we are trying to measure) which has been determined [3] and is a result of the instrument settings. For example using a sampling pulse width of 40 microseconds and a 30 KHz resolution bandwidth, the average of a noise-like signal (C/N, CTB, CSO) is about 4.3 dB less than the indicated peak value. A typical spectrum analyzer display with CTB and CSO products within the test channel is shown in Figure 5. To obtain the numerical result the peak value is recorded and then the correction factor is applied. Since there are many complex variables in the real life situation the simplified model may need some correction. Therefore it is suggested that the system be calibrated by measurement of known amounts of injected CW and noise signals.

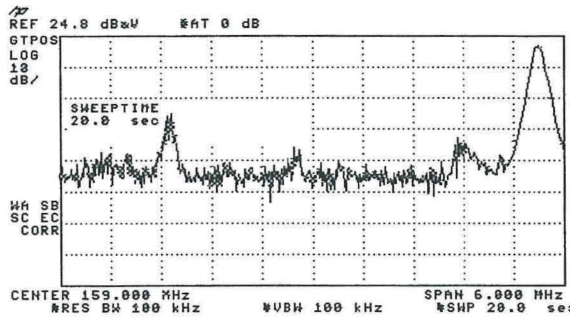

Figure 5 – CTB, CSO, Spurious Signals and Noise under Test Channel in Gated Mode

Putting It All Together

With all of the above in mind, the system would be something like the following including a rack mounted controller, permanently installed in the headend, plus a small encoder module for the modulator of each test channel and special considerations and possibly equipment for the field measurements.

The controller needs to intercept the video signals going to each respective modulator and insert the required vertical interval test signals at the proper times. In addition, it must control the gating time and duration to the encoding gates that interrupt the rf TV signal. The controller must also provide means for configuration of the test parameters such as start and stop dates and times, vertical interval test signals to be used, test signal insertion fields and lines and indicators to show the present status in the testing cycle. Test modes are valuable to check setup conditions and to perform the headend tests that may be done manually while the tester is in the headend.

The encoder module is required to interrupt the rf TV signal. This is preferably the visual IF signal in the modulator. Using the IF signal requires high isolation gating of rf only at relatively low frequencies (IF) which do not necessitate UHF design of the circuits as would be required with VHF and UHF modulator outputs. In addition, not interrupting the aural carrier makes interference with the TV audio less likely. Configuration of both the controller and the encoders must stress precise timing and amplitude control to create "glitchless" switching for high quality in-service testing.

At the receiving end a sampling gate, which has high OFF isolation at all CATV system frequencies, is needed to avoid corruption of the data due to leakage from the ever-present full amplitude system signals. Some analyzers include a time gating function that may be used in this connection. The sampling gate must be triggered in a way to sample only when the modulator gate is OFF. This also is provided in some analyzers which include TV demods and TV line finders. It is also possible to trigger on the no signal condition that occurs when the carrier is gated. This generally requires some kind of receiving device to separate the test channel from the other channels. Whatever analyzer and supporting equipment is used must be fully understood in order to be properly configured and thereby correctly capture and ultimately analyze the data.

A side benefit of the above permanently installed system, beyond the ability effortlessly execute proof-of-performance testing, is that it may be employed for incidental testing without a great deal of setup and knock down a normally experienced.

This system has been employed in the performance of numerous proofs with dramatic improvements in measurement efficiency and without disruption of program delivery. The equipment and techniques described in this paper are the subject of a current patent application.

References:

1) Huff, John L. – "Time Selective Spectrum Analysis – Extending Spectrum Analyzer's Usefulness", NCTA 1983

2) Edgington, Francis M. - "Time-Selective Spectrum Analysis: Non-Intrusive Analysis of a Cable System", NCTA 1992

3) Hewlett Packard Application Note 1303 – "Spectrum Analyzer Measurements and Noise"

Contact info: Bob or Ed Dickinson
Dovetail Surveys Inc. - 961 Marcon Blvd., Suite 450, Allentown, PA 18103
Tel: 610-264-0100, Fax: 610-264-8901
web site http://www.dovetailsci.com
e-mail info@dovetailsci.com