INTERCHANNEL AUDIO LEVEL VARIATIONS—A PROGRESS REPORT ON EFFORTS TO SOLVE THIS PROBLEM

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If you ask subscribers and operators, one of the most frequently mentioned "technical irritants" is the variation in audio levels as channels are surfed with the remote control. The problem comes up at city council meetings and other places at the most inappropriate times! When I first began to discuss it at NCTA Engineering Committee meetings, many of my colleagues displayed a look of hopelessness. I have felt for many years that the problem is a series of problems compounded by complex interactions of variables over which you may or not have control! The NCTA Engineering Subcommittee on Quality Sound has been logically analyzing the problem, and we are making progress. The purpose of this paper is to discuss progress toward our goal of reasonable uniformity among channels that can be achieved by head end technicians using test equipment.

LOOKING AT THE "SYSTEM" END TO END

The first step is to look at the entire transmission chain from studio output to the subscriber's speaker. Figure 1 illustrates the various elements of the system, and where the critical adjustments occur. It is important to note (one of the root causes of the problem) that the only part of the link governed by "standards" is the final loop from head end to subscriber. For this portion, the FCC has mandated in rule 73.1570 that television audio shall modulate the FM subcarrier no more that 25kHz PEAK for monaural operation. Note that the FCC has defined a PEAK value, not a "0 VU" value, not an "average" value, not "peak to average ratio," but PEAK modulation. Although technically legal, no cable operator in his right mind would intentionally use any other standard for television sound. So, as a starting point, it is important to realize that most cable modulators have a device to indicate when peaks of 25kHz are occurring. Wouldn't it be nice if one could set the level necessary for 25kHz modulation with TEST EQUIPMENT using a standard reference signal?? This is our goal.

The significance of achieving this goal can be put in perspective by considering the fact that the cable program sources represented by this work represent 184,273 individual audio level controls in cable head ends! (Excluding any stereo!!) I lovingly refer to this as the "AMP" or Audio Misadjustment Potential factor.

FOCUS ON SATELLITE DELIVERY

Data taken by the subcommittee verified that wide audio level variations exist as received at the head end. The subcommittee did some investigation of both the FM subcarrier delivery system as well as VideoCipher. After a series of tests the group unanimously arrived at a recommended practice of 185kHz peak for FM subcarrier transmissions to represent 100% modulation. The old reference of 237kHz is simply too wide for many of today's receivers to handle, while a value of 75kHz does not produce adequate audio signal to noise ratios in many cases.

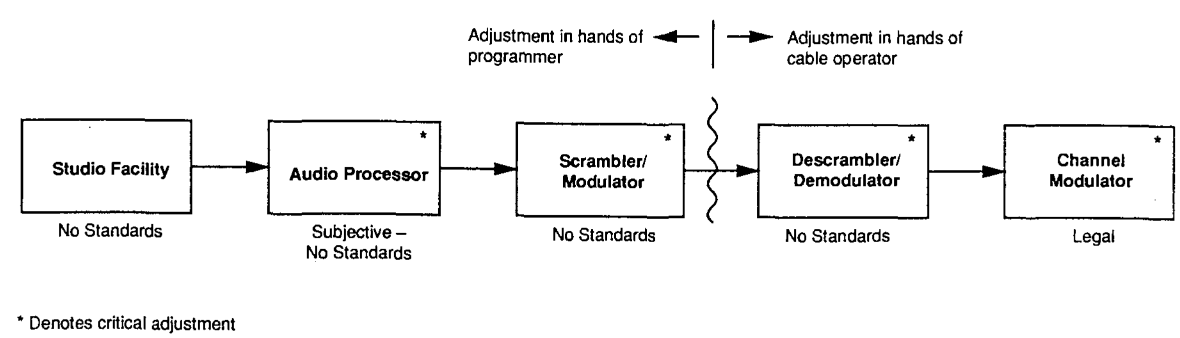

Figure 1. Cable TV Sound Block Diagram—a Program/Operator Team

In the case of VideoCipher, the "reference" system defines maximum audio level as approximately +16dBm just prior to clipping. Note that a "reference" system as defined by the manufacturer includes a 6dB pad on the input to the scrambler. Since there are no standards, the next best thing (we thought) was to ask the programmers to tell us what they considered to represent 100% peak modulation, as defined by FCC rule 73.1570. For FM subcarrier transmissions programmers were asked to provide a deviation value. For VideoCipher transmissions, programmers were asked to provide a value in dBm relative to the GI reference system that represents 100% peak modulation. Responses from programmers representing 29 satellite delivered sources were received. As we suspected, the answers confirmed an amazing variation. There are FM subcarrier transmission with peak deviations ranging from 75kHz to 237 kHz, a 10 dB spread! In the VideoCipher world, the range is from 0 dBm to +16 dBm, a 16 dB variation! A considerable amount of time was spent reviewing each response to make sure that the answer was indeed correct. This was time well spent! As you can see from figures 2 and 3, there is indeed a wide variation in admitted peak levels among programmers.

As an editorial comment, we as an industry should have insisted on defining recommended practices in this area 15 years ago instead of letting it go. The subcommittee encourages developers of the next satellite delivery systems to help set the practices up front.

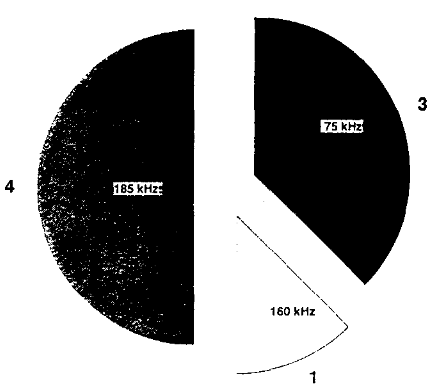

Figure 2. Reported FM Subcarrier TV Sound Peak Deviation

THE BIG HEAD END EXPERIMENT

Armed with peak program level knowledge as provided by the programmers, the next logical step was to set up a head end using these values, good test equipment, and procedures. The head end at CableLabs was volunteered for this experiment. In May of 1992, a technical team from the ranks of programmers, MSO's, and vendors spent 2 full days calibrating the head end. Each IRD was calibrated using a GI furnished scrambler to produce unity gain throughout the system. Each FM subcarrier demodulator was set for unity gain with respect to the recommended deviation of 185kHz. Seals were then placed on all audio adjustments on all IRD's. So, at this point, we had a rack of precisely calibrated receivers and descramblers.

The modulators for each cable channel were then adjusted to produce precisely 25kHz deviation when driven with a signal exactly equal to the level each programmer said should equal 100% modulation. This was done using Bessel Null techniques to insure high accuracy. (At the end of the experiment, we dubbed ourselves the Bessel Null Boys.) Calibration was verified using a precision modulation monitor. It was interesting to note that the little red "peak" indicators on the modulators were consistently within 1dB of being totally correct.

The calibration process of our reference head end also emphasized the need for a regular calibration source available by satellite so that technicians can duplicate our efforts without the

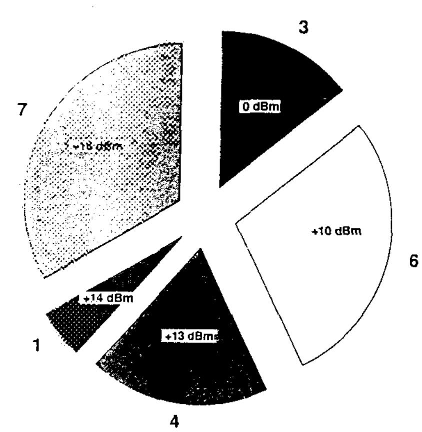

Figure 3. Reported VideoCipher Peak Program Levels

need for exotic test equipment. To that end, our subcommittee is working to establish a weekly precision audio reference test signal that will be available via satellite at a civilized hour of the day. We hope to have this in place and operating this year.

MONITORING THE RESULTS

One channel on the system was used as a continuous reference with a precisely calibrated 400Hz tone at 25kHz deviation. This would serve as a benchmark to insure credibility of results. The entire CableLabs head end was then carefully monitored using a portion of an "AudioRider" system. This system looks at all channels sequentially and records the audio level data in memory. Both peak level as well as "opinionated loudness" information are recorded. One full month of data was taken on the entire system.

Figure 4 is a print out of out reference channel that produced a deviation of precisely 25kHz. Having a print out of this channel for each of the 30 days of the test insured that nothing in the monitoring set up had drifted.

Figures 5 and 6 represent two of the Denver off air channels. These are interesting in that we did not have anything to do with modulation level since heterodyne processors were used. It is also interesting to note the consistency within the channels and between the channels. This same comparison can be made for 4 of the 5 available off air sources.

Now for the cable channels.....

Figure 7 represents a cable programmer who produced a "signature" of the correct peak deviation on a consistent basis. Figure 8 represents a cable programmer who in consistent, but slightly higher in level that he thought he was. Figure 9 represents a cable programmer who is consistent, but lower than he thought he was. Figure 10 represents one of several cable sources with somewhat inconsistent peak level control. It should be noted that Figures 4 thru 10 are from the exact same day.

The identity of channels is deliberately confidential at this point at the request of programmers, of whom several have diligently contributed to this effort. It should be pointed out that there is a sincere desire on the part of many in the programming community to understand the issues and contribute to the solutions where it can be done in a manner consistent with their corporate goals.

The data collected on all 29 channels fills 3 huge binders. As of this date (Mid April, 1993) we are in the process of sharing the data with each programmer along with initial interpretations of the data. The easy issues to solve will involve those programmers who are consistent, but obviously not "peaking" at the level they initially thought. Harder issues to deal with involve the subjective arena of audio processing. Our subcommittee will be sponsoring a processing seminar for the satellite programming community later this year.

Spot checking of the monitoring system reveals that all remains precisely calibrated over one year after the initial data was collected. One interesting observation was the apparent significant (4dB) increase in level of a major well respected programmer. When brought to their attention, the level increase was verified, but there was no obvious reason. This points out the obvious need as a part of the long term process of a central Cable Quality monitoring service to alert programmers when their technical parameters are beyond established limits.

This subcommittee work is rewarding in that the subject seems so simple, yet there are so many subtle variables to make the task nearly impossible. Precise knowledge of peak levels is just the beginning. Issues such as processing, local commercial insertion, etc. are also very complex and will require continuous effort to understand and quantify. Our work will continue until such time as we can provide technicians with a written accurate guide to enable them to perform head end audio adjustments using test equipment and industry accepted calibration methods.

ACKNOWLEDGMENTS

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The staff at General Instrument VideoCipher Division also deserves a special thanks for their contribution to the effort.

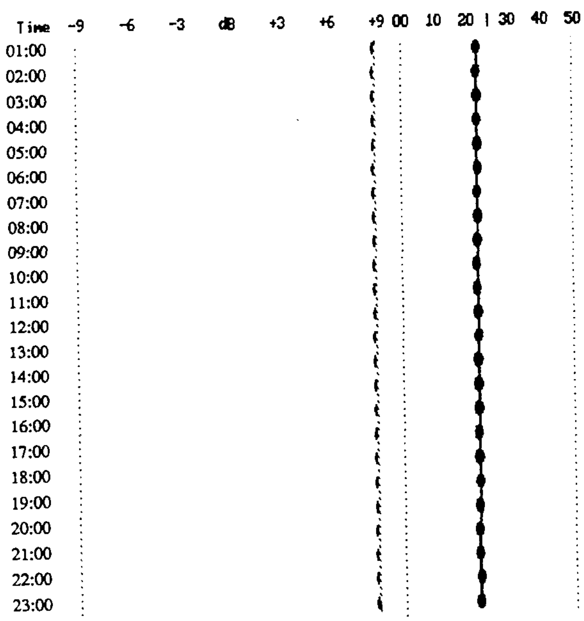

Figure 4. Reference Channel with 400Hz Tone at 25 kHz Deviation

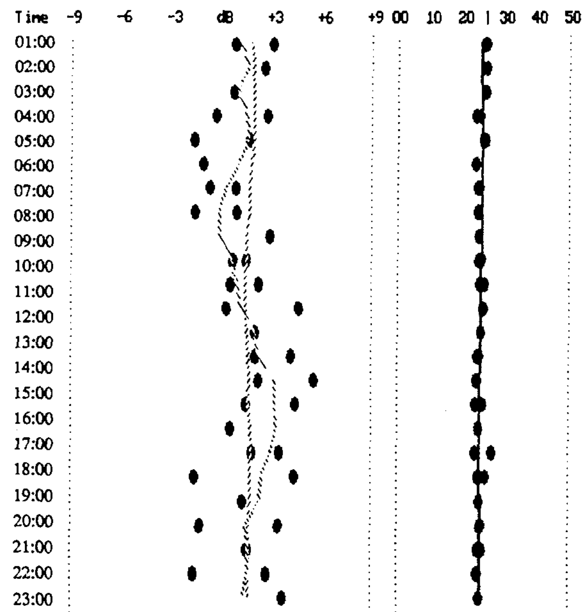

Figure 5. Off-Air Broadcast Station #1

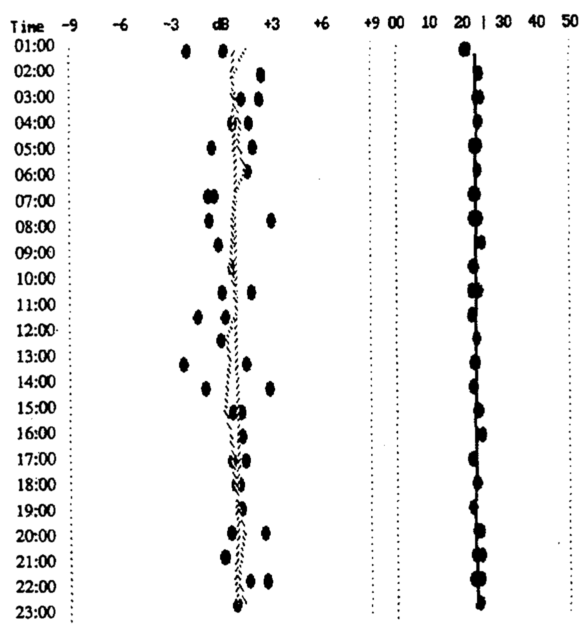

Figure 6. Off-Air Broadcast Station #2

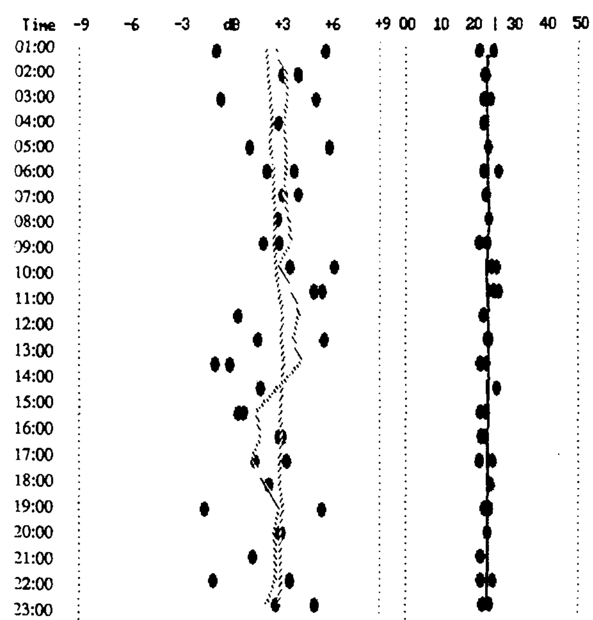

Figure 7. Cable Service with Correct Deviation

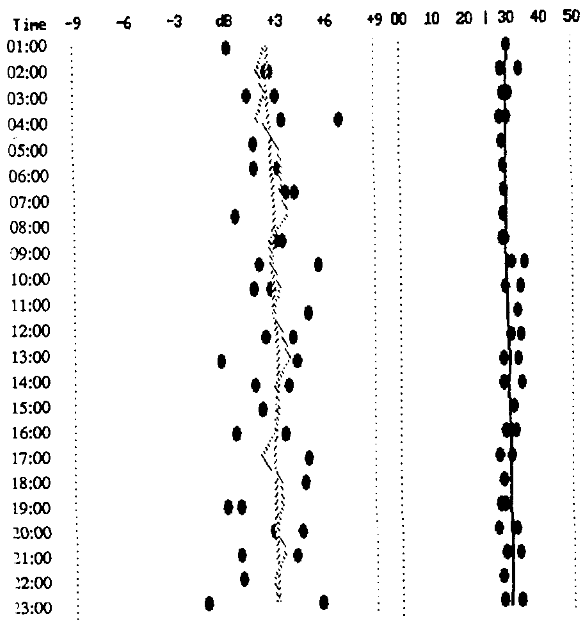

Figure 8. Cable Service with High Deviation

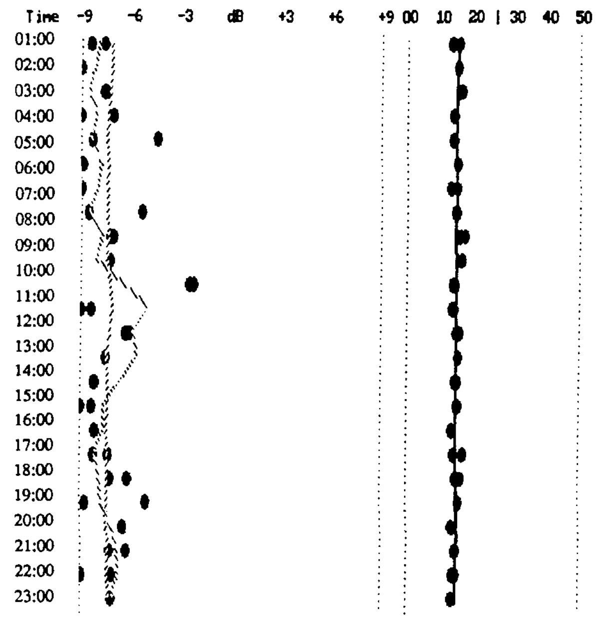

Figure 9. Cable Service with Low Deviation

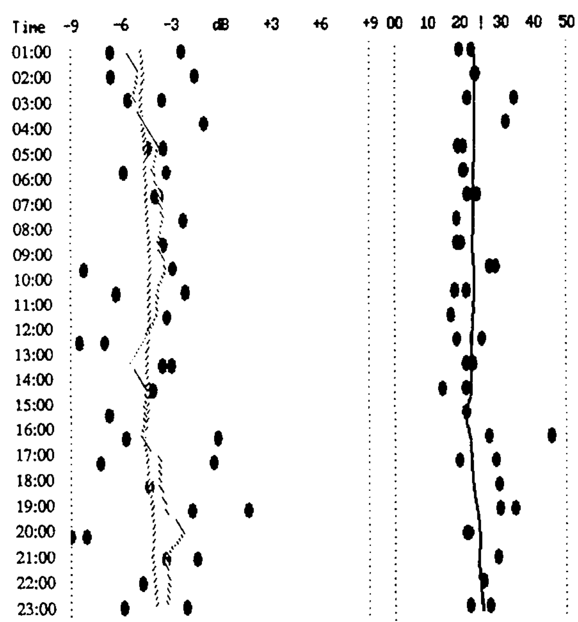

Figure 10. Cable Service with Inconsistent Peak Deviation