DIAGNOSING CABLE SYSTEM FAULTS

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ABSTRACT

There is a lack of technical information within the industry. This is particularly true of material for technician training. The most effective tool with which to ensure the delivery of the highest quality pictures is a well trained technician.

The New York Commission on Cable TV has produced a video tape which simulates system technical problems. The tape does not establish optimum ratios of noise or distortion. It displays distortions at levels that allow easy recognition of specific problems and shows distortion levels at FCC and CRTC standards.

The paper will discuss the tape, its uses in training, and the techniques used in its production.

BACKGROUND

For nearly five years the staff of the New York State Commission on Cable Television has traveled throughout the state utilizing a specially equipped test van in a program of testing and evaluating cable system performance. In that time over 300 tests of operating systems have been conducted. The Commission's Telecommunications Division staff has become acquainted with many cable system technicians and in the process of evaluating system performance has, coincidentally, evaluated many technicians.

The Commission has sponsored three major technical seminars which have attracted more than 350 technicians. Additionally, six regional seminars have been conducted with over 150 technicians attending. After each seminar a critical evaluation of the program has been done to determine the effectiveness of the seminar in terms of technical levels for future seminars.

In filling positions in the Telecommunications Division, the Civil Service Department administered written examinations to determine the abilities of applicants for the positions. One of the positions is equivalent to that of a chief technician in a large cable company; the other, that of a senior technician, capable of headend, trunk and feeder maintenance. Questions for the examination were solicited from the cable industry, manufacturers, and training directors of various companies. Additionally, use was made of questions published as a result of the SCTE 300 Project. In addition to operational and maintenance questions, a section of each examination was devoted to basic electronic theory. The results of these examinations were carefully studied. It was concluded that, despite an entrance requirement for the examination of a minimum of three years experience, many of the candidates earned failing, or near failing, scores.

In June, 1977, at the third annual New York Commission technical seminar in Albany, the Commission exhibited a video tape constructed to graphically display some common cable system faults. The tape was brief and to the point. Many of the technicians who saw it realized that they had not known the difference between cross-modulation and co-channel or inter-modulation.

It was not difficult to conclude that there exists a great need for technical education. Here is an industry utilizing very sophisticated hardware and techniques for signal transmission. In an industry that demands broadband performance that makes baseband video engineering look like childs play, the equipment is often maintained by persons who do not have the slightest idea of how to apply Ohms Law and cannot recognize the most common cable system faults.

The above is not a completely fair assessment of the technical capabilities within our industry. There are many excellent people in cable. Virtually, all of them are self-taught. Fortunately, these

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* The views expressed in this paper are those of the author and do not necessarily represent those of the New York State Commission on Cable Television.

persons share their knowledge with others in seminars, at conventions, and in too few publications. It is unfortunate that, when sharing, the assumption is made that the audience is technically sophisticated. Our experience indicates that such is not the case.

If there is to be an indictment, it should not be of the technical personnel in cable system operation, or those few who are expert but cannot be everywhere. The educational system has not fully recognized the need for technical programs in cable, the industry has not been insistent in demanding good educational programs, and industry management has not been overly enthusiastic in its training efforts.

Having recognized the problem, it became our task to assist in correcting it. It is not the purpose of this paper to fix the blame, but to attempt to fix the problem. Regardless of the existence of technical performance standards at various levels of government and the enforcement thereof, the most effective tool to ensure optimum picture quality is a well trained technician. Having reached that conclusion, the decision was made to produce an audio-visual training aid which could be made available to cable system operators at low cost. Cassette video tapes appeared to be the most viable delivery method.

Industry Support

The production of the tape would have been delayed for many months had it not been for the enthusiastic support of the cable industry and manufacturers of test equipment.1/ The Society of Cable Television Engineers provided a grant to partially defray production costs. Tektronix, Inc. and Hewlett-Packard provided test instrumentation and a precision demodulator. Scientific-Atlanta, Inc. supplied a modulator for the RF television channel used. The New York Network production facilities were used to produce the studio pictures and to record the quad high-band master tapes.

Educational Goal

The video tape has been produced to graphically show various distortions and interferences common to cable television distribution systems. The tape offers suggestions with respect to poysible corrective actions that may be taken to reduce or eliminate the problem. To that end, each section of tape begins with severe distortion. Thus, the technician viewing the tape can clearly see the effects of the distortion on the picture. The various distortions are then reduced to ratios specified in two well known national standards.2, 3/ No effort was made to determine which standard is more appropriate, nor is any attempt made to determine the optimum levels of degradation. A large body of work has been done with respect to subjective picture evaluation and optimum distortion ratios. The thrust of this tape is to show what the distortions are and not what they should be. However, should the reader wish to delve into that subject, a short bibliography is appended to this paper for reference.

The narrative which accompanies the video presentation is not in precise engineering terms. However, it will not mislead the viewer. Having evaluated the technical level at which we find many cable system technicians, we have determined that precise technical terminology must give way to a clear understanding of the problems depicted.

Application of motion and "busy" scenes in the tape was deliberately limited. While it is true that few still pictures are broadcast, for purposes of clearly showing the effects of the various distortions, it was decided to concentrate on showing the distortions without a background which might interfere with the learning process.

The brief discussion of probable causes for the distortions depicted in each section of the tape does not include all possible sources of operational problems. To do so would require many hours of tape. The more common causes are briefly discussed with the view towards initiating some thinking in the troubleshooting process that will soon discover the problem source.

The tape may be used for enforcement in formal training sessions, or it may be offered to technicians for individual study. Of course, it would be best to have a knowledgeable person available to answer any questions which may arise as a result of viewing the tape.

1/ The use of various manufacturers products in the production of the video tape does not constitute an endorsement of those products by the New York State Commission on Cable Television.

2/ Federal Communications Commission Rules and Regulations, Sub-part K, Section 76.605.

3/ Canadian Radio and Telecommunications Commission, BP-24, Broadcast Procedures for Cable Systems with Augmented Channel Capacity.

The tape, in cassette form, will be available at reasonable cost from the Society of Cable Television Engineers.

Video Tape Program Sections

The video tape is segmented for ease in identifying various distortions and to provide the viewer with a standard test signal with which to adjust his television receiver for optimum performance. The segments are as follows:

a) Introduction and instruction on receiver adjustments using monochrome gray scale and NTSC color bars.

b) The broadcast television signal.

c) The baseband video signal.

d) Carrier-to-noise presentation.

e) Co-channel Interference.

f) Electrical Interference.

g) Hum modulation.

h) Intermodulation interference.

i) Ghosting and reflections.

j) Cross-modulation interference.

k) Video baseband distortions.

How we made the tape

The television baseband signals, whether from the live studio cameras or from a film chain, were split at the respective camera output; one signal being fed to the studio switcher through a video delay line, the other through the mod/demodulator combination. Figure I shows the interconnection of the various devices. Of course, the devices were not simultaneously connected to the signal path.

Receiver Set-up

The first two sections of the tape deal with the proper set-up of the viewers television receiver. The user is "talked" through the monochrome set-up utilizing a standard five step gray scale. We chose to leave nothing to chance in the color section. The correct color name of each bar was keyed over its respective bar. The user is then "talked" through the appropriate adjustment of the color controls on the receiver.

Broadcast Television Signal

The television broadcast channel bandwidth is displayed as the ideal curve from the FCC broadcast rules. A brief discussion of the method of broadcasting the signal follows. The channel is then presented as it is seen on a spectrum analyzer.

The baseband video waveform is depicted showing the video waveform contained in the FCC broadcast rules. This is followed by a view of a waveform monitor. A brief discussion follows regarding what the synchronizing pulses are intended to accomplish.

Signal-to-Noise Ratios

Noise at various ratios was added at RF at the output of the modulator. This simulates a single channel being added to a broadband system. The noise added was essentially "white" over the frequency range of 40 to 300 MHz. The noise generator output was fed through a step attenuator to control injection levels.

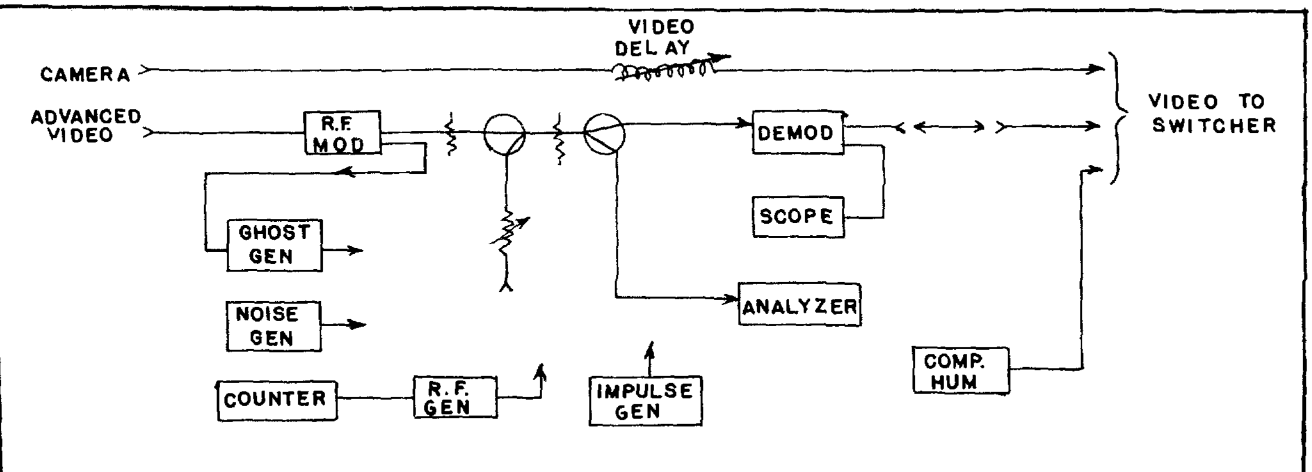


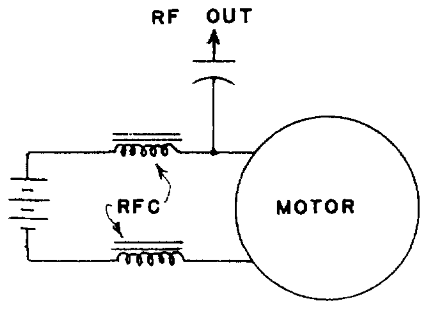
FIGURE I - EQUIPMENT LAYOUT

Co-channel Interference

The generation of co-channel interference required both a stable TV channel modulator and a precise, stable and easily controlled sine wave generator. The generator was expected to maintain 10 to 20 kHz off-sets for the period required to show both the effect on a TV picture of the interference and on a spectrum analyzer display. The purpose of showing both plus and minus co-channel was to alert the technician that the width of the interfering co-channel bars and the direction of movement through the picture was a clear key to the identification of the interfering station, without the use of a spectrum analyzer.

Electrical Interference

Display of electrical impulse noise required that a special circuit be devised to generate fast rise-time random electrical pulses. The circuit of Figure II solved the problem. No attempt was made to specify the absolute levels of interference, since noise of this type is very difficult to measure. In any event, the test equipment owned by the average cable system cannot measure the peak power of these pulses.



IMPULSE NOISE GENERATOR

FIGURE 2

Hum Modulation

Depicting hum modulation presented a unique problem. Present production video switchers are not designed to accommodate non-composite video inputs. Therefore, adding hum to the camera output would be meaningless, since the clamping circuits in the switcher would remove much of the added hum. Any residual hum would effectively be removed by the quad video recorder. Thus, any hum added at the switcher input, or camera output, would not be present in any tape copies.

The solution appeared in the form of a sync and blanking adder commonly used in television broadcasting for the addition of composite sync and blanking to sweep generators in sweeping transmitter circuits.

Hum was introduced to the sync and blanking adder as a video signal. After addition of composite sync and blanking, the hum signal was mixed with a camera signal in the switcher. Since the sync contains no hum, the switcher clamp circuits and the video recorder correction circuits see clean sync and the hum on the picture remains untouched.

Intermodulation

The section on intermodulation does not attempt to show composite triple-beats. The single frequency discrete interfering signal has been defined and specified in FCC and CRTC regulations and in some state regulations. It is a discernable and measurable interference, thus it was chosen to be shown. The tape narrative discusses composite beats, but the complexity of the topic is beyond the scope of this tape.

The interfering signal is injected at RF as shown in Figure I and the demodulated pictures are then recorded. Several frequencies and levels are shown.

Ghosting

The Ghosting Generator shown in figure I is a simple RF delay line to which is fed an output of the modulator. A level of insertion of the delayed signal is chosen to clearly show the ghost. The narrative discusses various causes of ghosting and direct pick-up and the difference in appearance.

Cross-Modulation

Modern cable systems do not display cross-modulation until other severe intermodulation distortions have effectively taken the system out of service. The difficulty of producing cross-modulation in an amplifier without generating other spurious signals led us to simulate the effect.

Two video signals were introduced at the video switcher input. One was locked to studio sync, the other was a "wild track". The wild track was mixed with the locked signal to produce the cross-modulation effect. Thus the tape shows video cross-talk rather than cross-modulation.

Video Distortions

The video tape shows the effects of two baseband video related problems which can be caused by signal processor design or alignment, and by filters, i.e.: bandpass, bandstop or cross-over filters in bi-directional systems.

Poor frequency response at the processor or antenna, or "suck-outs" on cable, may reduce the color carrier to a point where the color on receivers is low or "washed-out". The effect on the received picture is shown by introducing a baseband processing amplifier into the video from the demodulator and reducing the chroma information.

Chroma/liminance delay distortion, or "funny paper" effect, is generated and displayed on a receiver. No attempt is made to show measured chroma/luminance delay distortions.

A Tektronix Chrominance/Luminance Delay Corrector was inserted in the baseband video path, then misadjusted to show the effects of such delay distortions on the received picture.

A third form of baseband video distortion also can occur at RF in the signal processors. Should the RF visual carrier envelope be clipped or limited, the sync pulses will be distorted. Sync level reduction and ringing are the result of RF clipping of the visual carrier. This, in turn, causes receiver picture instability. The effects are discussed on the tape. However, the distortions are not shown.

Summary

The New York State Commission on Cable Television and the Society of Cable Television Engineers, in recognizing the need for technical education and training, have produced a video tape which is designed to assist the cable technician in recognizing the various distortions which may occur in cable distribution systems. The tape is designed to permit the trouble-shooting of a distribution system utilizing a very common and very sensitive test instrument-a television receiver.

The tape is intended to be used in formal training sessions, either as the primary topic or as a re-enforcement tool in structured lectures. It also may be used for individual study. Because it is in cassette video tape format, it is inexpensive and very portable. It represents a first step in what is hoped will be a major effort to train technicians. Distribution of the cassette tapes will be handled by the Society of Cable Television Engineers.

For in-depth discussions of the various topics discussed in this paper, the reader is referred to the bibliography which follows.

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