CONTROLLED SUBJECTIVE TESTING OF CABLE SYSTEM IMPAIRMENTS TO PICTURE QUALITY USING PSYCHOPHYSICAL METHODS

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ABSTRACT

For the first time, the Cable Industry will take on an organized critical evaluation of the subjective effects of typical impairments to a television picture generated in a CATV system. In the past, this information was gathered from independent sources without verification or firm documentation. This upcoming study is sponsored by Cable Labs under the direction of Tom Elliot, Vice President of Science and Technology. It will be conducted at the Jerrold Communications Applied Media Laboratory in Hatboro, PA. Bronwen Lindsay Jones, an Audio-Video expert in the field of psychophysical testing, has been contracted by Cable Labs to establish this criterion for the subjective measurements and to record all data. The detailed results of this study will be published by Cable Labs.

System Description

The impairments to be measured are:

Video Signal to Noise

Composite Second Order

Third Order Distortions

Chroma/Luma Delay Inequality (Envelope Delay)

Phase Noise

Reflections - (Echoes)

A test system will be set up at the Jerrold facility. There will be a headend with the capability of generating sixty (60) video modulated radio frequency (RF) carriers. These television channels will carry twenty (20) or more clean NTSC signals received off-air , from satellites, and video test pattern generators. The reference channel will be modulated with special pictures chosen to show most readily the various impairments. The reference channel can be assigned to any frequency in the RF. spectrum. Both still and moving scenes will be evaluated. Still scenes will be evaluated in the first set of experiments. The sixty (60 channel headend can be operated in the Standard, the Incremental Related Carrier (IRC), and the Harmonically Related Carrier (HRC) mode. The headend output is connected to the input of a balanced CATV system located in one of Jerrold's temperature control chambers. It includes complete stations with equalizers and the full trunk spans of coaxial cable. Ganged attenuators at the test system input and output allow the system to be driven to various levels of distortion while maintaining a constant RF signal input at the TV set displays. The following displays will be used: a Cable Ready TV set; a TV set or video monitor with a video output port; and an IDTV set to view the impairments in a 525 line progressive scan mode. These displays utilize comb filter technology to produce high resolution pictures while minimizing NTSC artifacts. These subjective tests for distortion will be conducted in the Standard mode and

will be repeated when the headend is phase-locked in the HRC mode and the IRC mode. The IRC mode is best suited to examine Composite Second Order (CSO) distortion. The "System Under Test" will be completely characterized before and throughout the testing period for Carrier to Noise (C/N), Composite Triple Beat (CTB), Cross Modulation (Xmod) and Composite Second Order (CSO) at various RF levels across the system operating range. Test measurements procedures from the NCTA Recommended Practices, second edition, will be used for the above objective measurements.

In addition to the noise and distortion impairments, subjective tests will be made on phase noise and micro reflections. For phase noise we intend to overdrive a headend modulator with noise or low frequency components to the point where phase noise is observable, to allow expert and non-expert viewers to evaluate the annoyance of this distortion. Similarly, the test for micro-reflections will allow us to pick various magnitudes and delays of the resultant echoes to ascertain subjectively the annoynance of the impairment. The phase of the echo will also be adjusted for worst case interference.

It is also our intention to generate Envelope Delay. This is the distortion that occurs when the chroma information is delayed relative to the luminance (or vice-versa). The degree of the delay can cause smear, and when the delay is severe it can cause an "out of register" situation some times seen in the Sunday comics wherein the color of hair, eyes and lips of a character do not line up with the image of the character's face. This delay can be measured by instruments and associated with the subjective evaluation of the impairment. As a first step, expert viewers will establish a threshold level of subjective impairment. This is the level at which the impairment can just barely be seen. Once experts agree on threshold, we will establish levels of impairment in each distortion category to which the non-expert viewers will be tested.

It is seen in the diagram (Figure 1) that the various levels of impairment will be controlled by programmable attenuators and coaxial relays. All these devices are functional to well above one Gigahertz. An extensive software program will be developed by Bronwen Jones' staff to control various levels of impairment, ranging from threshold to significant distortion These will be used to test the response or judgement of non-experts to different degrees of picture impairment. Each person viewing the subjective test will have a control so that they may conveniently register their opinion of the quality of the picture they see. These subjective judgements, as well as the specific level of the distortion for each test, will be automatically recorded. The accumulation of this data from the many non-expert viewers will be analyzed and published in the final report as a group of curves similar to the old TASO study conducted before color TV was available.

The subject matter used will be mostly still scenes chosen to highlight the various impairments. Some moving programs may be presented at a later stage. Each participant will be pretested for color blindness and visual acuity to eliminate those not qualified.

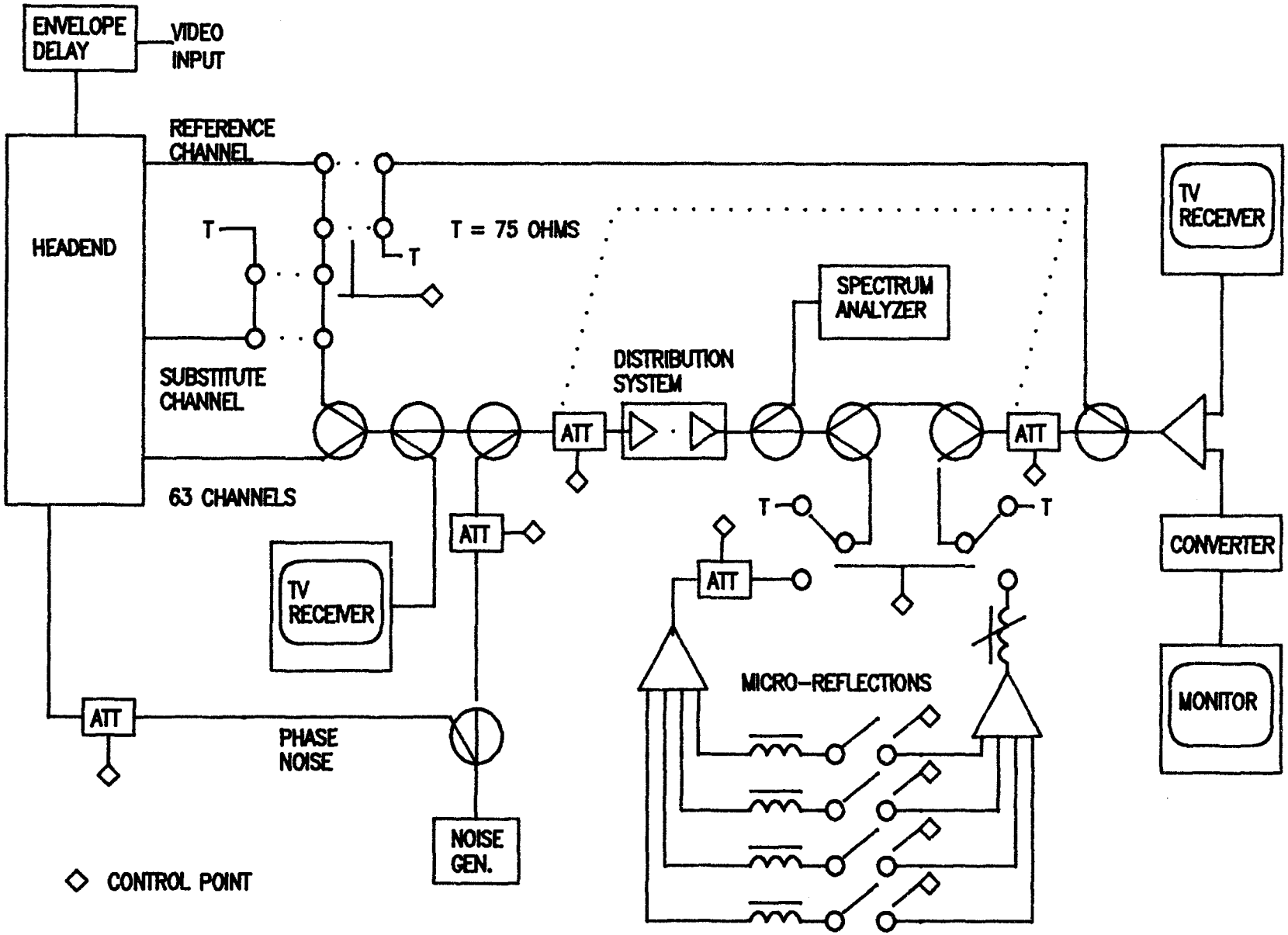

FIG. 1 – TEST SYSTEM BLOCK DIAGRAM

Conclusion:

The true conclusion of this effort will be the final report to be published by Cable Labs. This is estimated for the last quarter of 1990. We expect the results of the impairments that CATV has established by trial and error over the years to give no surprises. These are Carrier-Noise, Cross Modulation and Second and Third Order Intermodulation. The remaining impairments have not been thoroughly tested before and we should be able to establish meaningful data on thresholds. In all cases the subjective results of non-expert viewers should establish for the first time the picture quality levels acceptable by Cable TV subscribers. The goal is to give to the cable operator a cross reference between acceptable picture quality and the objective measurements made on cable television systems using standard instruments.

It might appear to some that this testing can be completed more expeditiously. It is to Tom Elliot's credit that he insisted on the automatic testing and recording of the data to insure accurate and sustaining results. We feel the time and money spent to achieve this goal is well worth it.