CABLELABS ATV TESTING STATUS REPORT

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Abstract

The Federal Communications Commission (FCC) appointed the Advisory Committee on Advanced Television Service (ACATS) in 1987 to recommend a standard or standards for advanced television in the United States. The committee has developed criteria for the selection of the standard or standards, procedures for the testing of proposed systems to determine whether they will work as proposed and is presently in the middle of the laboratory evaluations of the proposed systems. The laboratory tests are expected to be completed by late summer or early fall of 1992. Follow-up field tests will occur in the winter of 1992/3.

This paper reviews the tests that have been utilized by Cable Television Laboratories, Inc. (CableLabs) in performing the tests for the Advisory Committee. At the time this paper was being written the test results of the first systems had not been released by the committee but were expected to be public at the time of the NCTA convention.

Background

The FCC appointed Richard Wiley as the Chairman of the Advisory Committee. Three subcommittees were organized: Planning Subcommittee, Systems Subcommittee, and Implementation Subcommittee. The Planning Subcommittee was charged with developing the criteria by which the proponent systems would be evaluated. The criteria included technical parameters, spectrum requirements, economical considerations and alternate media capabilities. The Systems Subcommittee was charged with evaluating and testing the systems against the requirements set down by the Planning Subcommittee and recommending a system or systems for adoption by the FCC. The Implementation Subcommittee was responsible for determining the economic, time, and legal implications of introducing the recommended system or systems. Each of the subcommittees was further divided into working parties and task forces as necessary to complete the work of the committee.

The time frame for determining a standard required that the final report be submitted to the FCC in the third quarter of 1992. This due date has been extended from the original date due to delays in the development of a test facility to conduct the tests and changes to digital transmission techniques by the proponents.

The Plan for Laboratory Testing

One of the working parties of the Planning Subcommittee developed criteria for the evaluation of proposed systems but did not specify any minimum requirements for the advanced TV (ATV) system. A second working party developed the test plan to evaluate the systems against the requirements for over-the-air transmission while a third working party developed the test plan for cable television transmission. Other working parties developed the procedures and the test material for the subjective tests, considered spectrum requirements and implications, etc. These criteria and test plans were passed on to the Systems Subcommittee working party responsible for overseeing testing of the proponents' systems.

During the time period that the Planning Subcommittee was developing the test plans, the broadcast and cable industries were determining how to fund the tests, since the government had indicated it was unwilling to underwrite the tests. The broadcast industry, through the networks and trade associations, agreed to create and fund the Advanced Television Test Center (ATTC). They were later joined by the Electronics Industries Association. The cable industry considered joining the ATTC but decided instead, through CableLabs, to fund the cable portion of the tests.

After a lot of discussion, CableLabs and the ATTC entered into an agreement whereby CableLabs would perform the cable portion of the tests at the ATTC and pay the ATTC for lab and office space and access to common equipment. This decision helped reduce the costs for the proponents and ensure that the same system was tested for both broadcast and cable performance.

At the time of the agreement there were two sets of test procedures, a set written for over-the-air transmission and a set written for cable transmission. These two documents were reviewed by CableLabs and the ATTC to eliminate duplicate tests. The final decision called for the ATTC to perform the objective, "broadcast-only" and the joint tests, while CableLabs would perform the "cable-only" tests.

The objective tests are designed to determine the basic system parameters of the proponent systems. These tests include horizontal, vertical, and diagonal resolution, both static and dynamic, and in both the luminance and chrominance channels.

The remaining tests considered the proponent system's ability to operate in the terrestrial and cable environments with the various impairments that are present. Some of the impairments considered for terrestrial transmission were co-channel, adjacent channel and UHF taboo situations, discrete carrier interference, interference to and from NTSC signals, carrier-to-noise performance and multipath considerations.

These are subjective tests which require input from observers looking for the presence of interference in the picture. They are performed in two parts. The first part utilizes expert observers to determine the point at which impairments just become visible. That point is determined by varying the impairment level above and below the threshold point while observers "vote" on whether or not the impairment is visible. The observers then determine the level of impairment that makes the picture unwatchable plus a number of intermediate impairment levels. Video tapes are produced to show the impairment at randomly selected levels in comparison with unimpaired pictures. Non-expert viewers observe the pictures and indicate how annoying they considered a given impairment level to be.

While all "over-the-air" transmission impairments are of interest to the cable industry some are of greater importance and were proposed by the Advisory Committee as cable tests. These include carrier-to-noise performance, discrete carrier interference, and multipath. After the test labs reviewed the requirements of the tests it was decided the tests did not need to be performed twice and the one set of tests would be performed by the ATTC with CableLabs observing.

Cable-Only Tests

The remaining tests, to be performed by CableLabs, were designed to determine how well the proponent systems will operate in a typical cable system. The tests are composite second- and composite third-order intermodulation, the effect of multiple micro-reflections, high-level sweep interference, hum and low frequency noise, phase noise and residual FM. In addition, the proponent signal is passed through an AM fibre system and, if an ancillary data channel is present, the bit error rate in the presence of various impairments is determined.

Composite Triple Beat - Composite triple beat (CTB) is considered to be one of the major limiting factors on current cable television systems. The composite third-order test equipment was designed to test CTB alone and not CTB with other impairments. That requirement was satisfied by designing the computer-controlled test bed so that the CTB products falling in channel 12, the test channel, are generated without using a channel 12 carrier. The channel 12 product is selected by a narrow bandpass filter, amplified as necessary, then combined with the channel 12 ATV signal. The level of the impairment, relative to the desired signal, is varied while the expert viewers observe a received ATV picture.

Four sources of CTB can be used for the test. Two types, unmodulated NTSC carriers or carriers modulated with an NTSC signal, are the normal sources of CTB for the tests. Some of the proponents had proposed non-standard carriers for their ATV systems in order to minimize interference to existing services. The effect of these non-standard carriers had to be tested. The test bed was designed with two modes for testing the CTB generated by the ATV signal. The first mode tested the effect when half the signals were NTSC and half were ATV, a situation that will occur some time after the introduction of ATV services. The second mode used all ATV signals to generate the CTB product, representing a future situation when NTSC is no longer broadcast.

Composite Second-Order - Composite second-order (CSO) interference is generated in the same manner as the third-order products and similar tests are performed to determine the threshold levels for various combinations of NTSC and ATV signals. The CSO test was added to the procedures to account for the second-order distortion of current lasers being used in fibre optic links.

Summation Sweep - Two types of high-level sweep signals are tested. The first type is the typical sweep signal operating at a higher than visual carrier level and swept across the band periodically. The second type of sweep tested uses short bursts of carriers located lower in level than the visual carriers and at frequencies selected to produce the minimum amount of interference. The proposed ATV signals make extensive use of digital compression and, in some instances, digital transmission techniques. The impact of a high-level signal sweeping through the band may have a very detrimental effect on some systems and but little effect on other systems. It is desirable to have a transmission system which is not affected by the sweep signal.

Hum and Low Frequency Noise - Long cascades of amplifiers, poorly designed systems or poorly regulated power supplies can amplitude modulate TV signals with power line frequency signals. NTSC sets are designed to be very tolerant of hum modulation and only show the effect when it exceeds a few percent. ATV signals will be subjected to the same environment and must be capable of tolerating this interference at least as well as the NTSC signal. Low frequency noise can be created in the switching power supplies in common use on cable systems. The test equipment amplitude-modulates the ATV signal by passing it through a voltage-controlled attenuator. This attenuator is driven by a 120 Hz source or a low frequency noise source.

Phase Noise - Phase noise is the result of slight instability in oscillators used to heterodyne signals both at the cable headend and in the subscriber's home. Frequency synthesizers have been a significant source of phase modulation and their use has been increasing in recent years. The ATV receiver must be capable of receiving and decoding a signal with phase noise present. In test, the phase noise is introduced by phase modulating the local oscillator used in the ATV signal upconverter.

Residual Frequency Modulation - Residual FM has been be introduced by power supply ripple in a frequency synthesizer. Only a small amount of ripple was necessary to introduce a significant amount of frequency modulation in the output signal. The residual FM signal is introduced into the ATV signal by frequency modulating the local oscillator with a 120 Hz sine wave signal. The maximum modulation possible is 99 kHz and, if desired phase modulation could be introduced at the same time to observe the combined effect.

Channel Change Time - The length of time necessary to change channels and produce a picture on the next channel has been a major concern to cable operators. The wide availability of remote controls has produced consumers who demand the ability to quickly flip through channels to find a program of interest. If it were necessary to pause at a channel for any length of time to determine the program, the consumer might become very frustrated. Many of the ATV proponents are proposing very complex compression schemes which could possible take an excessive amount of time to tune the channel, decode it, and produce a picture. The test is performed by switching channels and determining the length of time required to produce a picture.

Multiple Micro-reflections - Cable distribution systems by necessity, are composed of many active and passive devices located at fairly close spacings. The input and output matches of the devices plus the return loss of the cable itself are never perfect and produce many low level reflections. The effect of these reflections is sometimes a slight smearing of the NTSC picture. The reflections are normally not long enough to produce an visible ghost. The effect of the micro-reflections could be the production of a visible ghost if a time compression technique is used, or the effect could be the creation of sufficient group delay in the band to upset a digital signal via inter-symbol interference. The test bed includes a sample distribution system which consists of twelve multitaps spaced 60 feet apart and includes two line extenders. The taps have drops attached with lengths varying randomly from 50 to 150 feet and which are terminated in either a short or a three dB pad and a short. The ATV signals are passed through the distribution system and recorded. Non-expert viewers compare the pictures which are passed through the distribution plant with reference pictures and indicate any differences observed.

Fiber Optic - Many cable operators have been introducing fiber optic transmission paths into their plant. It is considered to be imperative that the ATV signal pass through the AM fiber system without degradation. In test, the ATV signal is passed through a 20 km AM fiber system. Expert observers compared the received signals with reference signals to determine if there is any signal degradation. If any degradation is observed the signals are rated by non-experts to determine the amount of degradation the average observer notices.

Bit-Error Rate - Ancillary data channels, proposed by some of the proponents, could be used to transmit decoding information, text, or other data services. The data channel should be designed to be capable of operation to the point that the video channel became unusable. In test, the bit-error rate is observed while impairments such as CTB, CSO, Phase Noise and Residual FM are increased.

System Selection

At the conclusion of the tests, the results of all the proponents will be compared to determine the best compromise between picture and audio quality and the ability to operate in the presence of the various impairments, both on cable and over the air. The best system will be recommended for field tests, scheduled to take place in Charlotte, NC. The second-best system will be identified as a backup in case of the failure of the first system to succeed in field testing.

Based on the output of the lab and the field tests, the Advisory Committee will recommend an ATV standard to the FCC. After reviewing the recommendation the FCC will begin the rule-making process necessary to adopt an ATV standard. Expected decision date for the standard is late Spring 1993.