Introduction and General Comments

This report contains the results of the tests conducted by Cable Television Laboratories, Inc. (CableLabs) on the *digital* HDTV Grand Alliance system. The tests took place at the Advanced Television Test Center from 1995 June 01 to 1995 June 07. All tests were performed on channel 12 with a moderate input level to the ATV receiver (-53 dBm). The high data rate system (16-VSB) was loaded with one channel of random data and a second channel of high definition system picture, audio, and ancillary data.

The tests consisted of bit error ratio tests with some confirmation checks performed using video signals. The level of impairment was increased to obtain an error ratio as close to the threshold value as possible without exceeding it. Expert comments are shown as submitted. In some instances editorial comments have been added to the expert comments in an attempt to clarify the comments. The editorial comments are enclosed in square brackets.

The cable test bed was tested and calibrated to ensure proper operation and record operational parameters prior to the proponents test. Each morning system levels were re-calibrated. Threshold impairment ratios were measured at the completion of each test.

CableLabs and its staff wish to thank the representatives of the *digital* HDTV Grand Alliance and the Advanced Television Test Center for their efforts in completing the tests of the complete digital ATV transmission system.

The testing was undertaken by CableLabs in support of the work of the Advisory Committee on Advanced Television Service of the Federal Communications Commission.

Cable Television Laboratories, Inc. (CableLabs) is a research and development consortium of cable television operators representing more than 85% of the cable subscribers in the United States and 70% of the subscribers in Canada. Testing the proponent ATV systems for the FCC Advisory Committee is one of many projects undertaken by CableLabs. The tests of the *digital* HDTV Grand Alliance system were carried out in accordance with the "Grand Alliance System Test Procedures" Part IV - Cable Television Tests (Document SSWP/2-1306). A very brief summary of the test plan is included in each section of this report to provide the reader with the general intent of the tests but the test procedure document must be referenced to determine the actual procedures used.

Grand Alliance Comments on Test Results

The Grand Alliance is pleased with the performance of the system in the Cable Television tests. The system met or bettered, most Advisory Committee Target Specifications on both 8-VSB and 16-VSB modes. The few cases in which the system fell short of Target Specifications generally reflect tradeoffs in design and do not represent shortfalls of practical significance. The Alliance believes that the results of the Cable Television tests confirm that the transmission subsystem is capable of reliably delivering ATV services via cable to the home.

Grand Alliance Acknowledgments

The Alliance wishes to express its appreciation to CableLabs for its contributions to the development of the test procedures. We wish to note the thoroughness the tests performed by CableLabs, and the diligence with which accuracy was maintained. We further which to acknowledge the long hours put in by CableLabs staff to assure completion of testing in the most expeditious manner. And, finally, the Alliance wishes to acknowledge the critical contributions of the Expert Observers.

The Alliance feels that the thoroughness with which CableLabs approached the testing is evident in that many of the measurements of threshold (determined by Bit-Error Rates approaching $3x10^{-6}$), which develop comparability to previous tests, were repeated at error-free performance levels for further system characterization and verification.

1 - Second Order Intermodulation Distortion

Background
Composite second order products are created in a cable system by non-linear amplifier characteristics or by lasers in fibre optic links. The industry has significantly reduced the contribution due to RF amplifiers and lasers are now the main contributor of this distortion.

Summary of Test Method (SSWP2-1306 Part IV)
To perform the test the second order products falling in the channel 12 band are generated by the unmodulated carrier outputs of the NTSC channel modulators and amplifier cascade in the test bed. The products falling in channel 12 are selected by a band pass filter and combined with the ATV signal. The level is adjusted to obtain the threshold bit error ratio of 3×10^{-6}.

Test Results - 8-VSB
Test Date: 1995 June 01

Threshold of Visibility - CW Carriers
ATV TP Level: -13.7 dBm CSO Level: -40.8 dBm **CSO Ratio: 27.1 dB**
BER Readings: 0 0 0
Acquisition check: OK
Expert Observer Comments:
TOV within 1 dB of BER threshold.
Acquisition fast and clear.

Threshold of Visibility - NTSC Carriers
ATV TP Level: -13.7 dBm CSO Level: -36.8 dBm **CSO Ratio: 23.1 dB**
BER Readings: 0 0 0
Acquisition check: OK
Expert Observer Comments:
TOV within 1 dB of BER threshold.
Acquisition occurred.

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
Pseudo random data was inserted in the MPEG transport system and received from the Transport decoder with headers removed but otherwise intact.
The System tested slightly worse than the target specification of <25 dB for CW carriers.

Test Results - 16-VSB
Test Date: 1995 June 01

Threshold of Visibility - CW Carriers
ATV TP Level: -13.7 dBm CSO Level: -49.1 dBm **CSO Ratio: 35.4 dB**
BER Readings: 0 1.40×10^{-7} 8.80×10^{-7}
Acquisition check: OK
Expert Observer Comments:
The expert panel confirmed original threshold values.

Threshold of Visibility - NTSC Carriers

ATV TP Level: -13 7 dBm CSO Level: -45.1 dBm **CSO Ratio: 31.4 dB**

BER Readings: 3.42×10^{-7} 1.45×10^{-6} 1.36×10^{-6}

Acquisition check: OK

Expert Observer Comments:

The expert panel confirmed original threshold values.

Test Director: B. James

Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:

The tests were performed with interlaced video on one channel and pseudo random data only on the second channel. The pseudo random data was inserted into the B channel of the Zenith unit and extracted from the B channel of the Zenith receiver. The channel A signal with video and other MPEG format information was sent to the transport decoder. The channel B pseudo random data was not in MPEG transport format

The receiver could not tell which data was for channel A and which was for channel B. During the acquisition tests it was sometimes necessary to attempt it more than once due to the receiver delivering the wrong data stream to the BER test set.

The System tested better than the target specification of <38 dB for CW carriers.

2 - Third Order Intermodulation Distortion

Background
Composite third order or composite triple beat (CTB) products are created in a cable system by non-linear amplifier characteristics. In recent years design improvements in amplifiers has reduced the distortion created in each amplifier thereby allowing more channels to be carried on the cable TV system, however, composite triple beat remains the limiting distortion on cable systems with large numbers of channels.

Summary of Test method (SSWP2-1306 - Part IV)
To perform the test, third order products falling in the channel 12 band are generated by the combined unmodulated carrier outputs of the NTSC channel modulators and amplifier cascade in the test bed. The products falling in channel 12 are selected by a band pass filter and combined with the ATV signal. The level is adjusted to obtain the threshold bit error ratio of 3×10^{-6}.

Test Results - 8-VSB
Test Date: 1995 June 02

Threshold of Visibility - CW Carriers
ATV TP Level: -13.8 dBm CTB Level: -52.8 dBm **CTB Ratio: 39.1 dB**
BER Readings: 0 0 0
Acquisition check: OK
Expert Observer Comments:
TOV is within 1 dB of BER value. Acquired well.

Threshold of Visibility - ATV Modulation
ATV TP Level: -13.8 dBm CTB Level: -39.6 dBm **CTB Ratio: 25.8 dB**
BER Readings: 4.14×10^{-7} 2.38×10^{-6} 1.52×10^{-6}
Acquisition check: OK
Expert Observer Comments:
BER TOV verified. Re-acquired with 2 to 3 seconds.

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested slightly worse than the target specification of <37 dB for CW carriers.

Test Results - 16-VSB
Test Date: 1995 June 02

Threshold of Visibility - CW Carriers
ATV TP Level: 13.7 dBm CTB Level: -60.9 dBm **CTB Ratio: 47.2 dB**
BER Readings: 0 4.90×10^{-8} 0
Acquisition check: OK
Expert Observer Comments:
TOV was at 1 dB less impairment than BER measurement.

Threshold of Visibility - ATV Modulation

ATV TP Level: -13.7 dBm CTB Level: -50.1 dBm **CTB Ratio: 36.4 dB**

BER Readings: 2.13×10^{-6} 9.31×10^{-7} 8.58×10^{-7}

Acquisition check: OK

Expert Observers Comments:

Re-acquired within 5 seconds.

Test Director: B. James

Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:

The System tested better than the target specification of <49 dB for CW carriers.

8 - Phase Noise Modulation

Background
Phase noise is generated in the frequency synthesizers present in most set top converters and many headend modulators or heterodyne processors.

Summary of Test Method (SSWP2-1306 - Part IV)
The phase modulation is introduced by modulating the local oscillator of the upconverter. The amount of modulation is controlled to determine the threshold of visibility. The phase noise is measured 20 kHz above the visual carrier frequency in a 1 Hz bandwidth.

Test Results - 8-VSB
Test Date: 1995 June 02

Threshold of Visibility
ATV TP Level: -43.5 dBm Ø Noise: -121.8 dBm **C/I: 78.3 dB**
BER Readings: 0 0 0
Acquisition check: OK
Expert Viewers Comments:
TOV found at 1 dB more impairment than BER threshold. Acquisition was fast with sparkly blocking

AML Link BER 0 0 0

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested better than the target specification of <81 dB.

Test Results - 16-VSB
Test Date: 1995 June 02

Threshold of Visibility
ATV TP Level: 5.4 dBm Ø Noise Level: -76.4 dBm **C/I: 81.8 dB**
BER Readings: 4.10×10^{-8} 8.1×10^{-7} 1.0×10^{-7}
Acquisition check: OK
Expert Viewers Comments:
Confirmed TOV. Re-acquired easily.

AML Link BER 0 0 0

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested better than the target specification of <87 dB.

4 - Residual FM

Background
Power supplies in synthesized oscillators used in set top converters or other heterodyne processors add some residual FM to the output signal which the ATV receiver must be able to ignore in order to operate properly.

Summary of Test Method (SSWP2-1306 - Part IV)
The local oscillator is frequency modulated with a 120 Hz sine wave signal to simulate the effect of residual FM.

Test Results - 8-VSB
Test Date: 1995 June 02

Threshold of Visibility

	FM: 8.8 kHz		
BER Readings:	0	0	0

Acquisition check: OK
Expert Viewers Comments:
TOV found at 9.2 kHz. Re-acquired within 5 seconds with a splash and slight hiccup.

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested better than the target specification of >6.5 kHz.

Test Results - 16-VSB
Test Date: 1995 June 05

Threshold of Visibility -

		FM: 6.0 kHz	
ATV TP Level:	-13.66 dBm		
BER Readings:	1.49×10^{-6}	0	0

Acquisition check: OK
Expert Viewers Comments:
TOV found at 7.0 kHz, slightly more that BER threshold. Re-acquired with a splash and slight hiccup.

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested better than the target specification of >4.0 kHz.

5 - Fibre Optics

Background
Cable systems are using amplitude-modulated fibre optic transmission techniques in increasing numbers. The potential for signal degradation must be investigated.

Summary of Test Method (SSWP2-1306 - Part IV)
Two sets of system quality still and motion sequence test scenes are recorded, one through the proponent's equipment and the cable test bed. The second set has the signal passed through the proponent's equipment and the fibre portion of the test bed.

The experts review the tapes and comment on any degradation in picture quality. If no significant degradation is observed on the fibre tape it is not evaluated by the non-experts.

Test Results - 8-VSB
Test Date: 1995 June 05

Threshold of Visibility :
ATV TP Level: -18.1 dBm **Depth of Modulation 7.8 %**
BER Readings: 1.28×10^{-8} 0 0
Acquisition check: OK

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested better than the target specification of >4.5% but fewer carriers were available to load the laser so a direct comparison is not possible.

Test Results - 16-VSB
Test Date: 1995 June 05

Threshold of Visibility -
ATV TP Level: -17.5 dBm **Depth of Modulation: 7.3 %**
BER Readings: Not Recorded
Acquisition check: OK

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested better than the target specification of >4.0 % but fewer carriers were available to load the laser so a direct comparison is not possible.

6 - Channel Change and Channel Acquisition

Background
The ability of a viewer to change channels and immediately observe the new video is very important. Viewers become frustrated if there is a significant delay between the selection of a TV channel and its display on the screen.

Summary of Test Method (SSWP2-1306 - Part IV)
The ATV receiver was switched from channel 11 to channel 12 and the time required to display a picture was determined. The signal is impaired with either phase noise, ghosts, and random noise to determine if these impairments increase the acquisition time.

Test Results - 8-VSB
Test Date: 1995 June 06

Acquisition Time with no impairments: **0.7 sec**
Expert Viewers Comments:
clean and without impairment

Acquisition Time with 300 Ns, -18 dB Echo: 0.6 sec.
Expert Viewers Comments:
rough changes picture freezes but does not blank

Acquisition Time with 2500 ns -120 dB echo: 0.6 sec
Expert Viewers Comments:
not clean, picture blanks and freezes

Acquisition Time with phase noise: 0.6 sec
Expert Viewers Comments:
rough changes, picture blanks and freezes.

Acquisition Time with 600 ns -3 dB echo: 1.1 sec
Expert Viewers Comments:
picture blanked out on all channel switches, moderately clean come-back.

Acquisition Time with 2500 ns -3 dB echo: 1.5 sec
Expert Viewers Comments:
blanks on all channel switches, did not reacquire on channel 12 one time, occasional hang-ups.

Average Acquisition Time with various impairments: **0.9 sec.**

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested at the target specification of 0.7 seconds without impairments and slightly slower than the target specification of 0.75 seconds with impairments.

Test Results - 16-VSB
Test Date: 1995 June 06

Acquisition Time with no impairments: **1.1 sec**
Expert Viewers Comments:
fairly clean, some hits infrequently upon restoration

Acquisition Time with 300 Ns - 18 dB Echo: 1.2 sec.
Expert Viewers Comments:
fairly clean

Acquisition Time with 2500 ns -20 dB echo: 1.3 sec
Expert Viewers Comments:
freezes picture, lots of impairment, but it did perform reacquisition. The switch from channel 11 to 12 had more hits than to channel 13.

Acquisition Time with phase noise: 1.3 sec
Expert Viewers Comments:
very clean

Acquisition Time with 600 ns in phase -3 dB echo: 1.2 sec
Expert Viewers Comments:
fairly clean

Acquisition Time with 2500 ns in phase -3 dB echo: 1.3 sec
Expert Viewers Comments:
clean

Average Acquisition time with various impairments: **1.2 sec.**

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
The System tested slower than the target specification of 0.7 seconds without impairments and 0.75 seconds with impairments.

7 - Multiple Impairment - Second Order vs. Noise

Background
ATV systems will normally operate with multiple impairments present. Preliminary information on the ability to handle multiple impairments is obtained by this test.

Summary of Test Method (SSWP2-1306 - Part IV)
The CSO threshold of visibility is re-determined then the CSO interference is set 3 dB below the threshold of visibility found in the single impairment test. Random noise is increased until a new TOV is obtained. The test is repeated for various levels of CSO impairment.

Test Results - 8-VSB
Test Date: 1995 June 01
ATV TP Level: -13.7 dBm CSO @ Threshold - 40.8 dBm

CSO Ratio	C/N_6	BER Readings		
27 dB(TOV)	None added	0	0	0
30 dB(-3 dB)	15.5 dB	1.8×10^{-7}	1.6×10^{-7}	2.1×10^{-7}
33 dB(-6 dB)	15.1 dB	1.4×10^{-7}	0	5.3×10^{-8}
none added	15.0	4.16×10^{-7}	9.40×10^{-7}	6.16×10^{-7}

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
The System tested better than the random noise target specification of <15.6 dB.
No target specifications were specified for the noise vs. other impairment trade-offs.

Test Results - 16-VSB
Test Date: 1995 June 01
ATV TP Level: -13.7 dBm CSO @ Threshold -48 dBm

CSO Ratio	C/N_6	BER Readings		
35.4 dB(TOV)	None added	0	1.4×10^{-7}	8.8×10^{-7}
38.4 dB(-3 dB)	32.2 dB	5.39×10^{-7}	3.50×10^{-7}	2.60×10^{-7}
41.4 dB(-6 dB)	30.1 dB	1.73×10^{-6}	2.06×10^{-6}	2.30×10^{-6}
44.4 dB(-12 dB)	29.5 dB	1.44×10^{-6}	1.59×10^{-6}	1.83×10^{-6}
47.4 dB(-15 dB)	29.4 dB	9.07×10^{-7}	9.64×10^{-7}	8.50×10^{-7}
none added	29.1	8.79×10^{-7}	1.26×10^{-6}	1.62×10^{-6}

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
The System tested slightly worse than the random noise target specification of 29.1 dB but that is believed to be due to the moderate input level being reduced to -53 dBm for these tests. With an input level to the receiver of -33 dBm (20 dB higher than moderate) the random noise BER threshold value was 28.4 dB.
No target specifications were specified for the noise vs. other impairment trade-offs.

8 - Multiple Impairment - Third Order vs. Noise

Background
ATV systems will normally operate with multiple impairments present. Preliminary information on the ability to handle multiple impairments is obtained by this test.

Summary of Test Method (SSWP2-1306 - Part IV)
The CTB threshold of visibility is re-determined then CTB interference is set 3 dB below the threshold of visibility found in the single impairment test. Random noise is increased until a new TOV is obtained. The test is repeated for various levels of CTB impairment.

The channel was offset up in frequency by 35.84 kHz to take advantage of the precision offset impairment improvement. Expert observers commented on the effects of no offset and offset but measurements were only made with the offset.

Test Results - 8-VSB
Test Date: 1995 June 02

ATV TP Level: -13.7 dBm CTB @ Threshold -52.8 dBm

CTB Ratio	C/N_6	BER Readings		
39 dB(TOV)	None added	0	0	0
42 dB(-3 dB)	15.1 dB	5.22×10^{-7}	4.27×10^{-7}	7.2×10^{-7}

Test Director: B. James
Test Engineers : C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

Test Results - 16-VSB
Test Date: 1995 June 02

ATV TP Level: -13.7 dBm CTB @ Threshold -60.9 dBm

CTB Ratio	C/N_6	BER Readings		
47 dB(TOV)	None added	0	4.90×10^{-8}	0
50 dB(-3 dB)	29.4 dB	2.59×10^{-7}	4.59×10^{-7}	4.51×10^{-7}
53 dB(-6 dB)	29.0 dB	2.36×10^{-6}	1.87×10^{-6}	1.90×10^{-6}

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

9 - Multiple Impairment - Phase Noise vs. Noise

Background
ATV systems will normally operate with multiple impairments present. Preliminary information on the ability to handle multiple impairments is obtained by this test.

Summary of Test Method (SSWP2-1306 - Part IV)
The phase noise threshold of visibility is re-determined then the phase noise interference is set 3 dB below the threshold of visibility found in the single impairment test. Random noise is increased until a new TOV is obtained. The test is repeated for various levels of phase noise impairment.

Test Results - 8-VSB
Test Date: 1995 June 02

ATV TP Level: -43.5 dBm Ø Noise @ Threshold -121.8 dBm

C/I Ratio	C/N_6	BER Readings		
77.3 dB(TOV)	None added	0	0	0
80.3 dB(-3 dB)	16.7 dB	1.09×10^{-6}	1.34×10^{-6}	6.57×10^{-7}
83.3 dB(-6 dB)	15.6 dB	7.72×10^{-7}	1.39×10^{-6}	1.31×10^{-6}
86.3 dB(-9 dB)	15.4 dB	1.95×10^{-6}	1.95×10^{-6}	1.11×10^{-6}
89.3 dB(-15)	15.1 dB	4.40×10^{-7}	1.30×10^{-7}	2.60×10^{-7}

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

Test Results - 16-VSB
Test Date: 1995 June 02

ATV TP Level: 5.4 dBm Ø Noise @ Threshold -76.4 dBm

C/I Ratio	C/N_6	BER Readings		
81.8 dB(TOV)	None added	7.23×10^{-7}	4.41×10^{-7}	2.04×10^{-6}
84.8 dB(-3 dB)	29.9 dB	4.10×10^{-8}	$8.10 \times 10^{--7}$	1.90×10^{-7}
87.8 dB(-6 dB)	29.2 dB	9.20×10^{-7}	1.02×10^{-6}	7.28×10^{-7}
90.8 dB(-9 dB)	29.0 dB	2.15×10^{-6}	2.72×10^{-6}	2.61×10^{-6}

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

10 - Multiple Impairment - Residual FM vs. Noise

Background
ATV systems will normally operate with multiple impairments present. Preliminary information on the ability to handle multiple impairments is obtained by this test.

Summary of Test Method (SSWP2-1306 - Part IV)
The residual FM threshold of interference is re-determined then the residual FM interference is set at 75% of the modulation found to be the threshold of visibility found in the single impairment test. Random noise is increased until a new TOV is obtained. The test is repeated for various levels of residual FM impairment.

Test Results - 8-VSB
Test Date: 1995 June 02

FM @ TOV: 8.8 kHz

FM %	C/N_6	BER Readings		
8.8 kHz(TOV)	None added	0	0	0
6.6 kHz(75%)	24.5 dB	0	0	0
4.4 kHz(50%)	23.9 dB	0	0	0
2.2 kHz(25%)	16.7 dB	2.85×10^{-6}	1.46×10^{-6}	1.30×10^{-6}

Test Director B. James
Test Engineers C. Chamberlain, R. Prodan, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

Test Results - 16-VSB
Test Date: 1995 June 05

ATV TP Level: -13.7 dBm FM @ TOV: 6.0 kHz

FM %	C/N_6	BER Readings		
6.0 kHz(TOV)	None added	1.09×10^{-6}	0	0
4.5 kHz(75%)	29.4 dB	2.29×10^{-6}	2.00×10^{-6}	2.53×10^{-6}
3.0 kHz(50%)	29.1 dB	1.53×10^{-6}	1.46×10^{-6}	1.81×10^{-6}
1.5 kHz(25%)	29.0 dB	2.58×10^{-6}	2.84×10^{-6}	2.15×10^{-6}

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
No target specifications were specified for the noise vs. other impairment trade-offs.

11 - Local Oscillator Instability

Background
The ability of an ATV receiver to operate when the carrier frequency is offset is determined by this test. This is not instability in the normal sense but rather ability to tune channels offset from nominal allocations.

Summary of Test Method (SSWP2-1306 - Part IV)
The signal is offset +100 kHz and applied to the ATV receiver. If the receiver tunes the signal it is then offset -100 kHz and the test repeated. If the receiver is unable to tune the offset channel the offset is reduced until the system can tune the offset signal.

Test Results - 8-VSB
Test Date: 1995 June 05

Threshold of Visibility -
ATV TP Level: -13 dBm
Acquisition check: OK

Positive offset: >100 kHz

Negative offset: > 100 kHz

Acquisition check: OK

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested better than the target specification of ±89 kHz.

Test Results - 16-VSB
Test Date: 1995 June 06

Threshold of Visibility -
ATV TP Level: -14.0 dBm
Acquisition check: OK

Positive offset: > 100 kHz

Negative offset: >100 kHz

Acquisition check: OK

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested better than the target specification of 89 kHz.

12 - Burst Error Measurement

Background
An ATV system should be capable of operating in the presence of bursts of interference such as impulse noise. This test investigates widths of pulses and repetition rates that can be handled by the ATV system. The results are not intended to provide a direct comparison with burst errors but provide the capability of comparing systems with known widths and repetition rates of interference.

Summary of Test Method (SSWP2-1306 - Part IV)
Gated broadband noise is injected into the ATV signal. The pulse width of the interference at a 10 Hz repetition rate is increased until errors occur then reduced for no errors. The pulse width is increased until the threshold BER is obtained. The test is repeated by increasing the repetition rate while the pulse width is kept constant at 75% of the width at which errors just started.

Test Results - 8-VSB
Test Date: 1995 June 06

Threshold of Visibility -
ATV TP Level: -13.9 dBm

Repetition Rate	Pulse Width	BER		
10 Hz	157 µsec	0	0	0
10 Hz	**180 µsec**	1.20×10^{-7}	4.20×10^{-7}	1.31×10^{-6}
240 Hz	118 µsec	0	0	0

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested better than the target specification of 169 µsec @ 10 Hz.

Test Results - 16-VSB
Test Date: 1995 June 06

Threshold of Visibility -
ATV TP Level: -13 dBm

Repetition Rate	Pulse Width	BER		
10 Hz	90 µsec	0	0	0
10 Hz	**120 µsec**	2.42×10^{-6}	2.28×10^{-6}	2.88×10^{-6}
480 Hz	68 µsec	0	0	0

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams

Comments:
The System tested slightly worse than the target specification of 129 µsec @ 10 Hz.

13 - Minimum Isolation Between Receivers

Background
Television sets normally have a poor match except for the channel they are tuned to. Changing channels , switching the set on and off will result in a change in the match of the TV set at some frequencies. This change in response can change the frequency response of TV sets connected to other ports of a multi-tap or splitter resulting in a need for the ATV receiver to re-equalize. Data may be lost during the re-equalization period. This tests is to help determine the receivers susceptibility to these changes in response

Summary of Test Method (SSWP2-1306 - Part IV)
A 150 nsec. echo is switched on or off every 5 seconds. The level of the echo is adjusted until the highest level for which no errors occurs is reached. The level of the ghost is increased 6 dB and the BER measured. The level is then re-adjusted until the threshold BER is reached.

Test Results - 8-VSB
Test Date: 1995 June 05

Threshold of Visibility :
ATV TP Level: 13 dBm

Test	C/Echo			BER
No Errors	**17 dB**	0	0	0
+6 dB	11 dB	1.77×10^{-3}	1.52×10^{-3}	1.63×10^{-3}
Threshold	16 dB	9.4×10^{-7}	0	0

Expert Viewers Comments:
TOV was within 1 dB of original value. Reacquisition was OK (fast & clean).

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Test Results - 16-VSB
Test Date: 1995 June 06

Threshold of Visibility :
ATV TP Level: 13.9 dBm

Test	C/Echo			BER
No Errors	**28 dB**	0	0	0
+6 dB	22 dB	6.29×10^{-4}	6.11×10^{-4}	5.90×10^{-4}
Threshold	26 dB	8.50×10^{-7}	2.60×10^{-6}	2.05×10^{-6}

Expert Viewers Comments:
TOV was within 1 dB of original value. Reacquisition was OK (fast & clean).

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
No target specifications were specified for these tests.

14 - Effect of High Level Sweep

Background
Many cable TV systems use high level sweep systems to perform preventative and corrective maintenance on their systems. There are two major types of high level sweep in use. The traditional type sweeps across the cable system spectrum with an RF signal about 10 dB above the visual carrier level in about 10 milliseconds. The high level signal triggers an oscilloscope which displays the frequency response of the cable system. The NTSC receiver normally displays one or more white lines when the sweep passes through the TV channel. A second type of sweep periodically transmits individual carriers at a level 10 dB below the visual carrier level. The receiver integrates the individual carriers to display the system frequency response. The NTSC set normally displays a short white burst during a part of a TV line when the signal is transmitted.

Summary of Test Method (SSWP2-1306 - Part IV)
Inject the Wavetek sweep signal into the ATV signal path 10 dB above the ATV level at a rep rate of 5 seconds and record the BER. Replace the Wavetek sweep with a lower level Calan sweep at 10 dB below the ATV carrier level and record the BER.

Test Results - 8-VSB
Test Date: 1995 June 01

Threshold of Visibility -
ATV TP Level: 13.6 dBm

Sweep Generator	BER		
Wavetek	3.22×10^{-5}	1.7×10^{-7}	7.8×10^{-8}
Calan	0	0	0

Expert Viewers Comments:
No degradation with Calan sweep and acquisition was good. Wavetek sweep resulted in about 1 hit pet minute. Acquisition was good.

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
No target specifications were specified for this test.

Test Results - 16-VSB
Test Date: 1995 June 01

Threshold of Visibility -
ATV TP Level: -13.5 dBm

Sweep Generator	BER		
Wavetek	2.51×10^{-5}	1.98×10^{-5}	3.24×10^{-5}
Calan	0	0	0

Expert Viewers Comments:
No degradation with Calan sweep and acquisition was good. Wavetek sweep resulted in 5 to 6 hits pet minute. Acquisition was within 2 - 3 seconds.

Test Director: B. James
Test Engineers: C. Chamberlain, M. Chelehmal, R. Prodan, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
No target specifications were specified for this test.

15 - Hum Modulation

Background
Cable TV systems are normally powered by a 60 volt, quasi-rectangular, supply. The contribution to hum modulation by any amplifier is normally small but a long cascade of amplifiers can result in a buildup of hum to the point that it is visible in the NTSC picture.

Summary of Test Method (SSWP2-1306 - Part IV)
The ATV signal is amplitude modulated with a "quasi-rectangular" 120 Hz signal to simulate typical hum on a cable system. The level of the modulation is varied while the experts determine the threshold point.

Test Results - 8-VSB
Test Date: 1995 June 05

Threshold of Visibility -
ATV TP Level: -13.6 dBm

Hum Modulation	BER		
7.6 %	0	0	0

Acquisition OK
Expert Viewer Comments:
TOV verified at original level. Acquired in good shape.

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris. T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
No target specifications were specified for this test.

Test Results - 16-VSB
Test Date: 1995 June 06

Threshold of Visibility -
ATV TP Level: 13.9 dBm

Hum Modulation	BER		
6 %	1.32×10^{-7}	2.13×10^{-7}	3.95×10^{-7}

Acquisition OK
Expert Viewer Comments:
TOV verified at original level. Acquired in 3 to 5 seconds.

Test Director: B. James
Test Engineers: C. Chamberlain, T. Williams
Expert Viewers: R. Harris, T. Blakeman, R. Dickinson, M. Lovelock, E. Poulin

Comments:
No target specifications were specified for this test.

Part V

Record of Test Results

for

digital HDTV Grand Alliance System

from

Multichannel Audio Subjective Tests

Conducted by

FCC ACATS SS/WP-2
Audio Task Force
(May 8-18, 1995)

This report has been compiled with the support of:

Cable Television Laboratories

National Cable Television Association

The Grand Alliance

Snell Acoustics

PREFACE

This document presents the results of formal listening tests carried out at the National Cable Television Association in Washington DC, May 8-18, 1995.

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~ all listeners who participated in the tests

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~ Brian James for electronic support and assistance with the written report;

GRAND ALLIANCE COMMENTS

The Audio Subjective Test Plan, which calls for judgments by experts, is intended to provide data on audio system performance of the Dolby AC-w audio system fully integrated into the Grand Alliance hardware. The goal of the test was to verify that the integrated audio system performed as well as the stand-alone audio system, which was tested in 1993. In addition to the 5.1 channel quality, stereo quality and stereo mixdown quality were evaluated as well.

We are pleased with the performance on the audio coder, which shows clear improvement over the 1993 implementation and provides transparent or near transparent performance on difficult and challenging test material in all modes tested. At most, only one of ten selections was rated as impaired and the differences from the references were small (-0.4 or less, where 1 is the difference between "imperceptible impairment" and perceptible, but not annoying").

We appreciate all the effort by the test centers, the industry participants, and the Advisory Committee, with special thanks for Bronwen Jones for the test administration.

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