11.2.4.3. Presentation of Data-IMD

For each audio channel at each input level, obtain a graph of SMPTE IMD versus input signal level at the specified input levels.

11.2.5. Procedure-DIM

Terminate all video inputs in 75 ohms and continue to supply H and V drive to the proponent's apparatus. Load all ancillary data inputs with PN sequences.

Perform the following procedure for each audio channel:

11.2.5.1. Setup-DIM

Set the proponent encoder/decoder for 0 db gain as measured at 400 hz.

Attach the DIM signal generator to the input of the channel under test. Attach the frequency selective voltmeter to the output of the channel under test.

11.2.5.2. Measurement Technique-DIM

Using the true RMS audio voltmeter set the DIM squarewave/tone combination to +4 dBNTL at the encoder input. Using the ffequency selective voltmeter measure the level of the 750 hertz and 2.4 kHz components at the decoder output.

Perform the DIM measurement at input levels of -50 dBNTL, -30 dBNTL, -10 dBNTL, +4 dBNTL, and +14 dBNTL. The DIM is the dB amount the RSS sum of the 750 Hz and 2.4 kHz products are below the RMS value of the squarewave/tone combination.

11.2.5.3. Presentation of Data-DIM

For each audio channel at each input level, obtain a graph of DIM versus input signal level at the specified input levels.

.2. AUDIO/VIDEO DELAY

12.1. Introduction

Any ATV system that incorporates storage of lines, fields, or frames of video for vertical and temporal filtering may introduce significant delay of the video signal with respect to the corresponding audio. The design of such a system must provide matching delay for the audio signal in order to avoid the effect that is commonly referred to as "lip-sync error."

12.1.1. Definition-AVD

Audio/video delay is the difference in time between audio and video signals delivered to the output ports of the system under test, when those signals are presented simultaneously to the inputs of the proponent-furnished encoders.

12.1.2. General Description of Method-AVD

A video signal having an obvious and instantaneous transition is presented to the input of the encoder, along with a simultaneous presentation of a tone burst to all audio channels. Vertical-interval timing of the input transition shall be used. A dual-trace oscilloscope is used to measure the timing difference between the video output and each of the audio outputs. The measurements are performed first with the ATV video output and then, if the system provides NTSC compatibility, with an NTSC demodulator. It is assumed that the timing at the Green ATV output is identical to that at the Red and Blue outputs, so that only the Green ATV output need be measured.

12.2. Test and Measuring Equipment-AVD

12.2.1. Signal Sources-AVD

A flat-field video test signal is used. This signal is gated on and off with an active video gate, as used for temporal video transient response measurement. The active video gate provides a trigger output coincident with the gating of the video signal.

The audio tone burst is obtained from the audio generator described above, in Section 4.2, and used for audio/audio/dynamic crosstalk measurement. The test set must accept an external gating signal.

12.2.2. Monitoring-AVD

A dual-trace oscilloscope that features a single-sweep mode, and variable delay from an external trigger, is needed for comparison of the output video and audio waveforms. On-screen readout of the relative timing between the displayed signals is a recommended feature.

12.3. Procedure-AVD

12.3.1. Setup-AVD

Connect the output of the video test generator, through the active video gate, to the Red, Green, and Blue inputs of the system under test. Use a wideband video

distribution amplifier driving equal lengths of identical coaxial cable into 75-ohm terminations at the encoder input. Select a 700-mV flat-field test signal.

Connect the logic output of the active video gate to the gate input of the audio signal generator and to a trigger input of the oscilloscope.

For measurement of ATV audio/video delay, connect the Green output of the system under test to one input of the oscilloscope. Terminate the cable in 75 ohms.

For measurement of Enhanced NTSC audio/video delay, connect an NTSC demodulator video output to one input of the oscilloscope. Terminate the cable in 75 ohms.

Feed the tone burst to all of the audio inputs of the system under test. Select a tone frequency of 1 kHz. This will permit measurement to within 1 millisecond of error when the tone is gated on or off at zero crossings. Set the output level of the generator to +4 dBNTL at the proponent encoder input.

Use an input switcher on the audio test set to select each of the audio outputs of the proponent system, in turn, for testing. Connect the monitoring output of the audio analyzer to another input of the oscilloscope.

12.3.2. Measurement Technique-AVD

Adjust the timing of the sync supplied to the active video gate so that the video and audio are gated on and off near the beginning of the active field period.

12.3.2.1. ATV Audio/Video Delay-AVD

For each ATV audio output, with respect to the Green video output, measure the time interval between the 50-percent amplitude point of the first half-cycle of the audio waveform and the 50-percent amplitude point on the rising edge of the video waveform. Then, measure the corresponding points of the last half-cycle of the audio waveform and the falling edge of the video waveform. Note whether the audio or the video is leading.

12.3.2.2. Compatible NTSC Audio/Video Delay-AVD

Perform the following procedure with an NTSC demodulator for any system the proponent identifies as "NTSC-compatible":

For each audio output, measure the time interval between the 50-percent amplitude point of the first half-cycle of the audio waveform and the 50-percent amplitude point on the rising edge of the video waveform. Then, measure the corresponding points of the last half-cycle of the audio waveform and the falling edge of the video waveform. Note whether the audio or the video is leading.

12.3.3. Presentation of Data-AVD

Record the relative audio/video delay for each ATV audio channel with respect to the Green video output, for both transition edges.

For each of the three timing conditions, record the relative audio/video delay for each NTSC-compatible audio channel with respect to the NTSC-compatible video output, for both transition edges.

Express all delays in milliseconds, and indicate whether audio or video is ahead in each case.

13. AUDIO FREQUENCY RESPONSE

13.1. Introduction-AFR

The frequency response of each audio channel shall have been specified by the proponent. The procedure below verifies the specified performance.

13.1.1. Definition-AFR

Audio frequency response is defined as the difference in dB between the output amplitude of a single frequency 400 Hz reference and a range of frequencies which fall within the specified performance range of the system under test when the system is fed all tones at a constant level.

13.1.2. General Description of Method-AFR

Frequency response is measured with either a pure sine-wave sweep from 20 Hz to 20 kHz at -16 dBNTL or with a series of discrete CW tones at -16 dBNTL. The output of each channel is measured. The response is plotted as the difference between the measured signal and the reference output level. The measurement is then repeated at input levels of +4 dBNTL and then at -36 dBNTL.

13.2. Test and Measuring Equipment-AFR

An audio tone generator (or sweep generator), 600Ω terminations, and an audio voltmeter are required.

13.3. Procedure-AFR

Terminate all video inputs in 75 ohms, and continue to supply H and V drive to the proponent's apparatus. Load all ancillary data inputs with PN sequences.

Perform the following procedure for each audio channel:

13.3.1. Setup-AFR

Apply a 20-Hz to 20-kHz sweep or the discrete frequencies, at a level of -16 dBNTL, from the signal generator to the input of the channel being tested. Connect the audio voltmeter to the output of that channel. Adjust the gain of the audio channel to unity, as measured at 400 Hz.

13.3.2. Measurement Technique-AFR

Measure the signal amplitude at the output of the channel being tested.

These measurements are then repeated at an input level of +4 dBNTL and then at a -36 dBNTL input level.

13.3.3. Presentation of Data-AFR

Obtain a graph of output amplitude versus frequency at each of three input levels, for each audio channel. Express the amplitude in dB, relative to the output level obtained at a frequency of 400 Hz.

14. SINE WAVE OVERLOAD VERSUS FREQUENCY

14.1. Introduction-SWOF

This procedure measures the overload point of the system under test across the audio frequency range so as to determine the maximum safe audio program levels and headroom margins at the various frequencies.

14.1.1. Definition-SWOF

Overload is defined as the system input amplitude at a given frequency at which the system under test gain falls by 0.2 dB from its normal gain.

14.1.2. General Description of Method-SWOF

After establishing unity gain through the system under test at Nominal Test Level, the input signal level is increased while measuring system gain. When the measured gain drops from the nominal value by 0.2 dB, the input generator level is recorded as the system overload level for that frequency. This procedure is repeated at many frequencies across the audio range of the proponent's system.

14.2. Test and Measuring Equipment-SWOF

A two channel audio voltmeter capable of measuring the ratio between two audio signals is used. One channel is connected to the system under test input (audio generator output) and the second channel is connected across the system under test output. The ratio between the input and output is the system gain.

14.3. Procedure-SWOF

Terminate all video inputs in 75 ohms, and continue to supply H and V drive to the Proponent's apparatus. Load all ancillary data channels with PN sequences.

14.3.1. Setup-SWOF

Connect the audio generator output and the "B" channel input of the audio voltmeter to the input of the channel under test. Connect the audio voltmeter "A" channel to the output of the channel under test. Set the audio generator output for 1 kHz at +4 dBNTL. Adjust the channel gain to unity ±0.1 dB.

14.3.2. Measurement Technique-SWOF

Set the audio generator to give a series of frequencies in nominally logarithmic sequence between the upper and lower boundaries of the proponent's audio bandwidth. At each frequency increase the generator output until a 0.2 dB decrease in gain is noted. Record the absolute generator output level. This is the overload point at the frequency being tested.

14.3.3. Presentation of Data-SWOF

For each audio channel, obtain a graph of the overload point amplitude versus frequency.

15. RF BANDWIDTH AND RF SPECTRUM

This section only applies to ATV systems which use a separate carrier (or carriers) for the transmission of audio and/or data.

15.1. Introduction-RFB

15.1.1. Definitions-RFB

RF Bandwidth is either the 3 dB power bandwidth or the 30 dB power bandwidth of a signal. The 3 or 30 dB number is usually indicated by a subscript, *e.g.*, bandwidth_{30} for 30 db bandwidth.

RF Spectrum is the actual occupied spectrum of a transmitted signal. Normally it is characterized by a spectrum photograph or plot.

15.1.2. General Description of Method-RFB

The RF spectrum around the proponent's aural/data carrier is examined with a spectrum analyzer. The 3 and 30 db bandwidths are measured graphically from the spectrum display. Also a spectrum photograph is taken. Measurements are made with and without audio modulation. If possible, any other carriers near the aural/data carrier are turned off to make the aural/data carrier easy to see and measure.

15.2. Test and Measuring Equipment-RFB

A spectrum analyzer, several 600Ω terminations, a source of typical audio program, *e.g.*, a CD player, and an audio-frequency pink noise generator are used.

15.3. Procedure-RFB

15.3.1. Setup-RFB

The spectrum analyzer is set-up to monitor the RF spectrum around the aural/data carrier. The input to each audio channel is set up so that quiet termination, pink noise, or program may be fed into the channel. If possible any carriers near the aural/data carrier are turned off.

15.3.2. Measurement Technique-RFB

Spectrum photographs are taken with no audio modulation, pink noise as modulation, and music as modulation. The spectrum analyzer is set so that there is at least 60 db of dynamic range displayed and at least 0.5 MHz of bandwidth shown on either side of the carrier center.

15.3.3. Presentation of Data-RFB

The spectrum photographs are displayed. For each photograph the 3 and 30 dB bandwidths are measured.

6. STEREO INTERCHANNEL AMPLITUDE AND PHASING

16.1. Introduction-SIAP

Certain channel characteristics are necessary for audio channel pairs to properly reproduce stereophonic programming. This procedure measures two important such characteristics, interchannel amplitude and interchannel phase shift. The proponent shall indicate which audio channels are suitable for use as a stereo pair.

16.1.1. Definitions-SIAP

Interchannel Amplitude is the difference in gain between the two channels of a stereo pair as measured over the useful frequency range of the stereo pair.

Interchannel Phase Shift is the difference is phase between the two channels of a stereo pair as measured over the useful frequency range of the stereo pair.

16.1.2. General Description of Method-SIAP

For interchannel amplitude and phase shift, a tone generator feeds both channels of the stereo pair at a level of -10 dBNTL. A audio phase meter and an audio power meter switchable between channels are attached to the output of the stereo pair. The input tone frequency is varied from one end of the useful frequency range of the stereo pair to the other. The interchannel phase and the difference in audio signal power are recorded.

16.2. Test and Measuring Equipment-SIAP

An audio tone generator, an audio phasemeter, a frequency selective voltmeter, and an audio power meter with a 2x1 input switcher are required.

16.3. Procedure-SIAP

16.3.1. Setup-SIAP

For interchannel amplitude and phase shift, the tone generator is fed into the two channels of the stereo pair under test. The tone generator is set so that the level going into each channel is -10 dBNTL. The outputs of the channels under test are terminated in 600Ω. The audio phasemeter is set up to read the phase between the two channels. The inputs to the 2 x 1 of the audio power meter are attached to the two channels under test.

16.3.2. Measurement Technique-SIAP

For interchannel amplitude and phase shift, the frequency of the tone generator is varied slowly from one end of the useful range of the stereo pair to the other. The phase and amplitude differences are recorded at each frequency. At least ten different frequencies are used, such frequencies to be chosen spread out over the useful range of the channels.

16.3.3. Presentation of Data-SIAP

A frequency versus interchannel amplitude difference and interchannel phase shift shall be made for each stereo pair.

17. NOISE DEGRADATION OF COMPATIBLE NTSC AUDIO

This parameter only applies to Enhanced NTSC ATV systems which claim compatibility with NTSC. This procedure assumes a BTSC compatible signal with SAP. If the proponent's system does not provide this full capability, then whatever compatible capacity is claimed will be tested.

17.1. Introduction-ND

17.1.1. Definition-ND

Noise Degradation of Compatible NTSC Audio is defined as the added audio noise degradation caused by the Enhanced NTSC system under test as compared with an NTSC system under the same test circumstances.

17.1.2. General Description of Method-ND

Using two different television channels, an NTSC signal and the enhanced NTSC signal are fed to the bank of 24 NTSC receivers. Each signal has the same audio modulation, and each is transmitting 75% color bars. The expert observers tune each receiver to the NTSC and then Enhanced NTSC signal and compare the audio quality. Nominally two minutes is spent listening to each NTSC receiver switching back and forth between NTSC and the Enhanced NTSC system under test. If the experts can hear no difference, then the Enhanced NTSC system is judged fully compatible.

17.2. Test and Measuring Equipment-ND

24 NTSC receivers and an NTSC modulator with BTSC and SAP capability are required.

17.3. Procedure-ND

17.3.1. Setup-ND

Using the RF Test Bed put the Enhanced NTSC signal on TV channel 11 and an NTSC signal on channel 13. Feed 75% color bars to both the NTSC and Enhanced NTSC modulators at visual carrier levels of -35 dBm. Apply the same audio program material to both modulators. If the enhanced NTSC system claims BTSC stereo and SAP compatibility, then the NTSC modulator should be set to provide these signals as well.

17.3.2. Measurement Technique-ND

Using the tuner on each NTSC receiver, allow the expert observers nominally two minutes to tune back and forth between channels 11 and 13 and listen.

17.3.3. Presentation of Data-ND

The consensus of the group of expert observers is recorded.

18. CONFIRMATION OF PROVISIONS FOR ANCILLARY DATA SIGNALS

This procedure only applies to a system that claim the capability to transmit ancillary data as part of its capability.

18.1. Introduction-ANS

This section provides a means of verifying the capacity of an ATV system for transmitting ancillary data along with the program audio and video. Prior to testing the proponent must supply the data transmission rate of his system.

18.1.1. Definition-ANS

Ancillary Data capacity refers to the ability of an ATV system to "piggy-back" a one way data channel from the broadcaster to the home receiver.

18.1.2. General Description of Method-ANS

Bit error rate measurements are made of the ancillary data capacity of the system under test at various levels of Carrier-to-Noise of the carrier conveying the data.

18.2. Test and Measuring Equipment-ANS

A bit error rate test set is required.

18.3. Procedure-ANS

During the testing audio tones are placed on all program audio channels and a test pattern is placed on the video channel. Normal H and V drive is maintained to the proponent's encoder.

18.3.1. Setup-ANS

The RF Test Bed is set to inject random noise into the proponent's signal(s). The level of the proponent's signal shall be high enough that any noise contribution of the proponent's front end shall be negligible. All noise shall, in effect, come from the injected noise of the RF Test Bed.

A bit error rate test set is attached to the proponent's encoder and decoder so as to send and receive data via the ancillary data channel.

18.3.2. Measurement Technique-ANS

For each level of carrier-to-noise three PN blocks of 10^7 length are sent. The BER for each block is measured. The results of the three measurements are averaged. C/N vs. BER measurements are taken so that there are at least 6 sets of BER vs. C/N measurements between BER's of 10^{-1} and 10^{-5}.

18.3.3. Presentation of Data-ANS

The average BER is recorded for each level of C/N taken.

19. LABORATORY TESTING OF TERRESTRIAL TRANSMISSION ISSUES

Transmission issues are divided into two categories -- impairments and interferences. Impairment testing determines the susceptibility of a "desired" signal, provided by the system under test, to various transmission impairments that are simulated by the RF Test Bed. These include random noise, impulse noise, multipath, and airplane flutter. Interference testing involves two RF signals -- a "desired" signal and an "undesired" signal. The signal provided by the proponent system is tested as both desired and undesired, with respect to both an NTSC signal and another, identical, ATV signal. In addition, interference from radio services (discrete frequencies) is simulated by the RF Test Bed.

The interference performance of both ATV and NTSC systems depends to a large extent on four factors: (1) the level and spectral power density of the RF signal; (2) the scene content of the interfering signal; (3) the selectivity of the receiver; and (4) the signal processing in the receiver. For testing Enhanced-NTSC systems, since the level and spectral density of the Enhanced-NTSC signal resemble those of an NTSC signal, the same reference power levels (-15 dBm, -35 dBm, -55 dBm) used for testing the interference performance of NTSC are appropriate. The existing measurement procedure, i.e., measuring the peak power of the visual carrier during sync tips, is suitable. Section 19.1. describes the method for setting RF power levels to test Simulcast systems.

In selected (as indicated in the Audio Subjective Test Procedures) impairment or interference tests, the audio channel performance of the desired signal shall be monitored, measured, and, as appropriate, recorded. When NTSC is the desired signal, the aural carrier power shall be set at ten percent of (10 dB below) the visual peak power. The BTSC audio quality will be monitored and recorded. The point at which it degrades or fails will be logged with comments. When NTSC is the undesired signal, aural power shall be set at twenty percent of (7 dB below) the visual peak power.

For Enhanced-NTSC systems under test, the power levels specified above apply to the aural FM carrier. The relative power level of any digital aural subcarrier, and the frequency of the subcarrier with respect to the visual carrier, are as specified by the proponent. These parameter values shall be logged. If the proponent has specified a range of power for the digital subcarrier, then the maximum power shall be used when the ATV signal is the undesired signal; the minimum power shall be used when it is the desired signal. All audio inputs, analog and digital, shall be loaded so that normal modulation is achieved.

The RF Test Bed permits carrier offsets to be resolved to 1 Hz, so that tests can be conducted in a highly repeatable manner. Inasmuch as the worst case offset, for NTSC-into-NTSC interference, differs from the best case by only 30 Hz, the tests will be run using the worst case offsets. Accordingly, the carrier offset to be employed for NTSC-into-NTSC tests (for reference purposes) shall be 10,040 Hz, which is the worst case for ±10 kHz offsets under present FCC rules.

For testing interference of ATV into ATV, NTSC into ATV, and ATV into NTSC, the offset will be that specified by the proponent at the time of final certification. The offset frequency will be specified to 1 Hz resolution.

A panel of expert observers shall determine the range of Undesired signal levels over which each test is conducted. As specified in the Subjective Test Procedures Manual, expert observers must have had recent extensive experience in observing picture quality or impairment, particularly of the type under study. Additionally, they must have calibrated or known, rather than declared, normal color vision. The viewing studio conditions are summarized in the Video Subjective Test Procedures Manual, and diagrammed in Figure 19-1, General Design and Layout of the Viewing Studio.

Using methods detailed in the Video Subjective Test Procedures, expert observers shall determine the threshold of visibility (TOV) and, as required, the point of unusability (POU) and intermediate ranging levels to be videotaped for non-expert subjective assessment.

Recordings required by the Video Subjective Test Procedures manual shall be made, on an appropriate digital videotape recorder (DVTR), from the ATV receiver output of Simulcast and Enhanced-NTSC systems. For Enhanced-NTSC systems, recordings shall be made, on an NTSC D2-VTR, of a representative NTSC receiver output.

The ATV video outputs (RGB), from the proponent-supplied Demodulator and Decoder, shall be viewed on the reference large screen display, adjusted for the scanning standards and aspect ratio of the system under test.

For viewing of NTSC signals, an assortment of receivers will be furnished by the EIA Consumer Electronics Group (EIA/CEG). These units shall represent the current state of the art, but shall not be hand-picked or tweaked by the manufacturer. Performance shall be verified by the suppliers to be within all production specifications, and copies of measurement data shall accompany the units if possible. Additional receivers, representing 5 to 10 year old designs, may be available. Further, all NTSC signals will be applied to a professional-quality television demodulator, and the baseband video will be viewed on a studio-quality NTSC color monitor. The performance of the BTSC audio channels will be monitored and evaluated according to procedures specified in Section 17.

Two DVTRs, one HD and one NTSC, shall be connected to capture the video outputs for any subsequent subjective analysis called for by the Video Subjective Test Procedures manual, and for any desired archival purposes.

19.1. Power Level Calibration for Simulcast Systems

19.1.1. Introduction

The first task to be carried out by the testing laboratory is to determine the power levels to be used to test a given proponent's system. Simulcast systems employ a wide range of modulation techniques in which there may be no convenient peak power reference, independent of scene content and/or motion. The average power may be dependent upon scene content and/or motion. For such systems, a new method for power measurement must be employed.

The testing laboratory must be able to re-establish, daily and on demand, a reference power level to the ATV receiver for each system. The methodology to be used to establish the reference power level must be readily applied to all ATV systems and be scientific and readily executable with the available instrumentation. A laboratory procedure for establishing such a reference condition is presented below.

The fundamental limit to reception of television signals is random noise. If we chose as our reference level the minimum signal power level at which the ATV receiver under test operates reliably, we would have to measure the Noise Factor of each ATV receiver in order to compare the performance of ATV systems, as we cannot expect the same Noise Factor in the various ATV receivers. To remove this variable, a known RF noise power will be added to the ATV signal provided to the antenna terminals of the ATV receiver. This noise power is chosen on the basis that it exceeds by 10 dB the noise power due to the Noise Factor of the tuner, which is

assumed to be 10 dB. This tuner noise in a 6 MHz channel is -96 dBm, as calculated below:

Noise Power or	P_n	=	KTB
	K	=	Boltzman's Constant
	T	=	Temperature (290°)
	B	=	Bandwidth in Hz
	P_n	=	-174 dBm/Hz
or	P_n	=	114 dBm/MHz
in 6 MHz;	P_n	=	-106 dBm

Assuming a Noise Factor of 10 dB typical of present art,

Noise = -96 dBm referred to input.

Under these conditions, the injected noise masks the tuner noise. With the noise level at -86 dBm, signal power is increased until a noise threshold condition obtains. In the case of analog ATV systems, this is defined as the point at which the effect of random noise is just perceptible to a panel of expert observers under the viewing conditions established in the Video Subjective Test Procedures Manual. In a digital system, it is expected that reception does not occur below the noise threshold. At threshold, reception becomes usable and remains stable with no further improvement in quality for signal power levels higher than threshold. In a hybrid (analog and digital) system, there may be different thresholds for the analog signals from those transmitted digitally. The higher of the two thresholds is taken as the significant threshold.

By injecting noise at -86 dBm, the threshold signal power determined for each system is higher by 10 dB than would have been measured otherwise, but the Noise Factor variable has been eliminated and the different ATV systems can be compared in terms of noise thresholds. Since these are experimental receivers, operating them at their maximum sensitivity may prove impractical. By injecting noise at -86 dBm, and by using greater signal power, the sensitivity of the ATV receiver will be backed off. This will reduce any tendency for instability or pickup of local noise, from such sources as digital clocks and their harmonics.

The range of Simulcast systems to be tested includes all-analog, hybrid analog-digital, and all-digital systems. For at least some of these, the signal power at the noise threshold will be dependent upon scene content and motion. What must be found experimentally is the signal power at the noise threshold for the most critical kind of scene; *i.e.*, the scene most affected by noise. This will be done by adjusting the calibrated RF attenuator feeding the antenna terminals of the ATV receiver. When the attenuator provides the threshold signal level for the critical scene, a suitable test pattern can be substituted for the critical scene and the RF power measured. Several means to measure RF power are available; *e.g.*, average power and peak power. Which power measurement is best suited to a specific ATV signal remains to be determined. If not determined by the FCC Advisory Committee (SS/WP-1) prior to system certification, the determination will be made by the testing laboratory and the rationale of such determination attached to the test results.

19.1.2. Test and Measuring Equipment

The following special test equipment is required:

(1) A broadband noise source, covering the high-band VHF test channels. This source must have a flat noise energy distribution per unit bandwidth.

(2) An RF step attenuator, having at least 1-dB resolution, to be applied to the output of the noise source.

(3) A spectrum analyzer.

(4) An average-reading power meter, to measure this noise power in a nominal 6 MHz bandwidth.

19.1.3. Procedure

19.1.3.1. Setup

Refer to the Functional Diagram for the test center facility, Figure 6-1. The output of the proponent-supplied ATV Modulator is connected to the RF Test Bed.

Connect the output of the noise source, through an attenuator and calibrated noise bandwidth filter to one input of an RF Combiner. Connect the output of the ATV Modulator, heterodyned to Channel 12, to the other input of the Combiner. Connect the output of the Combiner to the band-pass filter. Connect a spectrum analyzer and average-reading power meter to a test point at which both carrier and noise power are combined.

Connect the Red, Green, and Blue outputs of a suitable source of picture material (*e.g.*, an HD-DVTR for motion sequences or the PIXAR for static images) or an electronically generated test signal to the respective inputs of the SUT.

19.1.3.2. Measurement Technique

The reference power level condition for Simulcast systems is established by injecting random noise power at a level of 10 dB above the receiver noise level. The noise level of an ATV receiver is determined by, first, calculating the thermal noise in 6 MHz (KTB=-106 dBm). Then, an assumed Noise Factor for the ATV tuner is added. A Noise Factor of ~10 dB is representative of current receivers. Hence, the noise level of the ATV receiver, referred to the antenna terminals, is -96 dBm. The noise power to be injected is -86 dBm, to swamp out the ATV receiver noise. Under this input noise condition, ATV signals produced by a variety of still images, test signals, and motion video sequences will be applied at levels just strong enough to produce a "just perceptible level" of impairment in the picture. The average power, peak power and RF signature of the ATV system will be recorded along with the injected noise power and video material that produced these values. If the proponent system incorporates an AGC reference pulse that has constant peak power, independent of picture content, then the peak

power of this pulse shall be measured. The combination of picture material and power measurement technique will be collected for validation or archival purposes.

Once the reference power level is established, daily setup and calibration of the system will be performed by adjusting the power to this level using a stationary test signal.

19.1.3.3. Presentation of Data

The following documentation should be provided for the output of the proponent-supplied receiver. Use viewing methods described in the Video Subjective Test Procedures Manual.

At the threshold of noise visibility, log the average power and the peak power of the ATV system along with the injected noise power and the video material used for each measurement. Photograph the spectrum analyzer display or obtain a hard-copy output from a printer or plotter, if the instrumentation provides this capability.

19.2. Power Levels for Testing Simulcast Systems

19.2.1. Introduction

There is also a need to establish specific values of ATV power, similar to the reference NTSC power levels (-15 DBm, -35 dBm, -55 dBm), to determine ATV reception in the presence of interference from NTSC or ATV. These values will be used to test the impact of co- and adjacent-channels and UHF taboos on Simulcast systems within the ATV service area.

As in the case of ATV-to-NTSC, testing of NTSC-to-ATV and ATV-to- ATV will also include three input power levels. In addition, two auxiliary levels will be also measured. The basic levels as defined have the following merits:

1. The levels cover the range of interest from those providing minimally acceptable pictures, to strong levels at which receivers may become susceptible to interference due to non-linear mechanisms.

2. An intermediate level to indicate what sort of data interpolation will be reasonable for subsequent analyses.

3. The definitions allow comparisons between systems despite the fact that the levels may not be expressible in absolute units.

The auxiliary levels will be useful and possibly crucial for development of an allotment plan. One level will relate to the "robustness" of potential new ATV services in proximity to co-channel NTSC stations -- it is an indication of whether ATV reception will be intolerably degraded by the presence of existing NTSC stations. The other level relates to the extent to which the potential new ATV services are benign to co-channel NTSC services.

19.2.2. Test and Measuring Equipment

The following special test equipment is required:

(1) An RF step attenuator, having 1 dB steps, to be applied to the output of the noise source.

(2) A spectrum analyzer.

(3) An average-reading power meter, to measure this noise power in a nominal 6 MHz bandwidth.

(4) One DVTR to capture the video outputs for any archival purposes deemed appropriate by the testing laboratory.

19.2.3. Procedure

The levels shall be determined as follows:

(1) "Weak" signal level. Inject a random noise power of 10 dB above the receiver noise as described in section 19.1.3.2. Increase the ATV power level until a "just perceptible level" of impairment in the picture is observed. Attenuate the signal until at least four of the five expert observers agree that a minimally watchable picture is achieved. The midpoint in dB between the just perceptible point and the minimally watchable point is the "Weak" signal level.

(2) "Moderate" and "Strong" signal levels are, respectively, one-third and two-thirds of the way between the "Weak" level and the highest signal remaining free of receiver overload effects. The latter is determined by decreasing the input level from overload until expert observers agree that none of the available moving or still pictures shows the type of degradation seen in the overload condition.

(3) Auxiliary Level A. While observing a full range of motion and still material on the ATV monitor as in determination of Weak, Moderate, and Strong levels superimpose an NTSC signal at -55 dBm. Now decrease the ATV signal, from the nearly overloaded value used in determination of Moderate and Strong levels until clearly perceptible interference (from the -55 dBm NTSC signal) occurs in at least one of the motion and still samples. The picture content of the NTSC signal shall, to the extent found to have significant effects, range over a set of moving and still material similar to that being viewed on the ATV monitor but in an uncorrelated order. Level A of ATV input power shall be recorded as the level at which there is a clearly perceptible effect on the most sensitive sample.

(4) Auxiliary Level B. Turn to the bank of NTSC receivers to make this measurement. Set the NTSC input power to -45 dBm, and set the ATV power into the NTSC receivers at a low value. Now increase the ATV power until interference is just perceptible on about 10% of the NTSC receivers. This procedure is similar to that used in initial ranging of the tests of NTSC impairment of ATV reception, except that a special value of NTSC input

power is used midway between the values -55 dBm and -35 dBm. The picture material supplied to the NTSC set shall be a 50-IRE flat gray field; the ATV video source material shall include a full range of still and motion samples.

19.3. Susceptibility to Noise

The behavior of NTSC transmission systems in noisy environments has been studied and documented well over the past four decades. Standards have been developed for the weighting of noise measurements, based upon the perceived impairment of luminance and audio performance. The effect of noise upon each of these signal components is a function of the bandwidth, modulation method, and location within the frequency spectrum of that component. These parameters and others, such as time expansion, all may be variables among the various proponent ATV systems. Fundamental studies of the noise susceptibility of each system have not been undertaken, and the temporal weighting factor for noise, and the weighting factor for chroma noise, are unknown.

It is well known that noise in the transmission environment exists in two general forms -- random and impulsive. The effects of both of these forms are evaluated in this section. Results necessarily must be given as unweighted SNR.

19.3.1. Random Noise

19.3.1.1. Introduction

Random noise is characterized by a uniform spectral energy distribution. It follows that the noise power is directly proportional to the bandwidth over which it is measured. A useful indicator of the robustness of a transmission method is the ratio of carrier power to random noise power density (C/N_0) that is required to deliver pictures of acceptable quality. Both power measurements are taken over the 6-MHz bandwidth of the transmission system.

19.3.1.2. Test and Measuring Equipment

The following special test equipment is required:

(1) A broadband noise source, covering the VHF test channel. This source must have a flat noise energy distribution per unit bandwidth.

(2) An RF step attenuator, having 1-dB steps, to be applied to the output of the noise source.

(3) A spectrum analyzer or other instrument suitable for measuring the carrier power.

(4) An average-reading power meter, to measure the noise power in a known noise bandwidth.

(5) A filter, of calibrated equivalent-noise bandwidth, to be applied to the output of the noise source. The manufacturer of the RF Test Bed shall calibrate this filter.

19.3.1.3. Procedure

19.3.1.3.1. Setup

Refer to the Functional Diagram for the test center facility, Figure 6-1. The output of the proponent-supplied ATV Modulator is connected to the RF Test Bed.

Connect the output of the noise source, through an attenuator and calibrated noise bandwidth filter (Item 5), to one input of an RF Combiner. Connect the output of the ATV Modulator, heterodyned to Channel 12, to the other input of the Combiner. Connect the output of the Combiner to the band-pass filter. Connect a spectrum analyzer and average-reading power meter to a test point at which both carrier and noise power are combined.

Connect the Red, Green, and Blue outputs of a suitable test signal generator, through attenuators, to the respective inputs of the SUT. The test patterns to be used for determination of the threshold of visibility and the point of unusability are described in the Video Subjective Test Procedures manual. Use equal lengths of identical coaxial cable into 75-ohm terminations at the encoder input.

19.3.1.3.2. Measurement Technique

Perform the following procedure upon the ATV outputs of all systems, Enhanced-NTSC, and Simulcast, using the demodulator and decoder supplied by the proponent. Also perform this procedure upon Enhanced-NTSC systems using the reference NTSC demodulator and the consumer NTSC receivers. The methods for viewing and recording the outputs of the NTSC receivers are described in Section 1.8 of the Video Subjective Test Procedures manual.

With the noise generator output fully attenuated, select a carrier level that is well (10 dB or more) above the level at which noise is first detectable by the expert observers. Then, adjust the noise attenuator such that the noise level is just perceptible in the picture, as viewed by the expert observers. Use the procedure for threshold level determination that is described in Section 1.8.1 of the Video Subjective Test Procedures Manual.

Determine the Carrier-to-Noise power density ratio (C/N_0) at the threshold point. First, measure the noise by temporarily disconnecting the modulator from the RF combiner and terminating that input of the combiner. Read the noise power indicated on the average-reading power meter. Then, measure the signal by reconnecting the modulator and setting the noise attenuator for maximum attenuation. Read the signal power, at the peak of sync for NTSC, or using the method specified by the proponent as appropriate for this system.

Reconnect the equipment, and increase the noise level to determine the point of unusability. As directed by the Video Subjective Test Procedures manual, make a series of recordings for use in subsequent non-expert assessments.

19.3.1.3.3. Presentation of Data

The following documentation should be provided for both the ATV output of the proponent-supplied receiver. In addition for Enhanced-NTSC systems, the performance of the NTSC receivers, should be documented using the methods described in the Video Subjective Test Procedures manual.

Log the carrier level used for the testing. Also log the nature of the system failure.

From the measurements of signal power and noise power, at the threshold of visibility, and using the bandwidth measured in Section 6, calculate the C/N_0 ratio per unit bandwidth (BW), as follows:

C/N_0 (per Hz BW) =
10[log (Carrier) - log (Noise) + log (Filter Equiv. Noise BW)]

At the threshold of noise visibility, photograph the spectrum analyzer display or obtain a hard-copy output from a printer or plotter, if the instrumentation provides this capability.

Make 15-second recordings at each ranging level. Note the SMPTE time code at the start of each recording.

19.3.2. Impulse Noise

19.3.2.1. Introduction

One of the most annoying forms of transmission noise is impulsive, occurring over only a portion of the picture area, and perhaps only briefly, but often at such amplitude that the image is obliterated. These noise impulses may be created by automotive ignition systems or motor-driven electrical appliances. The effects of impulse noise on NTSC transmission systems are well-known. However, the bandwidth compression techniques employed by various ATV systems may worsen the temporal or spatial characteristics of the noise relative to that observed on an NTSC receiver.

The procedure described below is intended to compare the subjective impairment of the signal of an ATV system to that of an NTSC signal.

Expert observers shall determine the amplitude of the impulse noise, using an NTSC transmission path for calibration. An identical test shall be run immediately thereafter on the proponent ATV system.

19.3.2.2. Test and Measurement Equipment

The following equipment is required:

(1) A suitable NTSC test signal generator.

(2) A suitable ATV test signal generator.

(3) An NTSC modulator.

(4) An NTSC demodulator.

(5) An impulsive noise source, using a universal AC motor running at a constant load. The noise will be picked up inductively from the motor, amplified, and bandpass filtered into the frequency range of interest (Channel 12).

An ATV color display and, for Enhanced-NTSC, an assortment of NTSC receivers are required for viewing the outputs of the SUT.

19.3.2.3. Procedure

This procedure is segmented into two phases. The first phase is calibration, using an NTSC transmission path. Perform the calibration immediately prior to the ATV system test, using the same expert observers.

19.3.2.3.1. Calibration

Connect the output of the NTSC test signal generator to the NTSC modulator. Set the generator to provide the Desired NTSC test signal, as described in the Video Subjective Test Procedures manual. Connect the output of the RF impulse noise generator (Item 5) to one input of an RF Combiner. Connect the output of the NTSC modulator to the other input of the RF Combiner. Connect the output of the RF Combiner to the RF distribution system feeding the bank of consumer NTSC receivers.

With the noise generator output fully attenuated, set the carrier level to -35 dBm.

At the direction of the expert observers, adjust the amplitude of the impulse noise to the point at which the observers feel it is a just-perceptible artifact on half of the NTSC receivers.

This sets the power level of the impulse noise generator.

19.3.2.3.2. Setup for ATV System Test

Connect the outputs of the ATV test signal generator to the Red, Green, and Blue inputs of the SUT, using equal lengths of identical coaxial cable. Terminate all cables in 75 ohms.

Connect the output of the proponent-supplied modulator, through an up-converter, to an individual RF Combiner. Connect the output of the RF impulse noise generator, through a splitter and band-pass filters, to the other input port of both combiners. Connect the outputs of the combiners to the proponent-supplied demodulators.

Select the same test signal used in the Calibration step, but in the ATV format under test.

19.3.2.3.3. Measurement Technique

With the output of the impulse noise generator fully attenuated, adjust the ATV carrier level to the "Moderate" level. Then, restore the impulse noise to the calibrated power level. Adjust the level of the impulse noise, up or down, to the just-perceptible level. The difference between this just-perceptible level and the calibrated level is the desired data from this procedure.

For Enhanced-NTSC systems, also find the threshold of visibility as viewed on the NTSC receivers.

19.3.2.3.4. Presentation of Data

Log the difference (in ±dB) between the calibrated noise level and the just-perceptible level for the system under test. For Enhanced-NTSC systems, log this data for both the ATV receiver and NTSC receiver observations.

19.4. Susceptibility to Multipath and Airplane Flutter

19.4.1. Introduction

Multipath is a condition whereby two or more propagation paths exist between the transmitting and receiving antennas. Signals arrive at the receiving point from the different paths at different times, depending upon the lengths of the paths. The effect observed in the received picture is referred to as an echo or ghost.

The indirect paths result from reflections or refractions of the transmitted signal by either natural or man-made surfaces. Natural causes include the atmosphere and mountainous terrain. Man-made surfaces are typically tall buildings in an urban environment. The strength of the echo is a function of the efficiency and size of the reflective or refractive surface and the length of the indirect path.

Multipath may be static or varying. It may be caused by reflection from an airplane, in which case the indirect path length is continuously changing. As the reflected signal from the moving airplane alternates rapidly between in-phase and out-of-phase relationships with respect to the direct signal, a condition called "flutter" results. Some ATV systems may be extremely sensitive to even small but rapid variations of signal level due to flutter.

For NTSC transmission, a path length difference of about 1000 feet results in a horizontal displacement of about two percent of the picture width for the ghost image. A typical ATV transmission system employs a horizontal scanning rate of

twice the NTSC rate and has a wider aspect ratio. Hence, for such a system, the ghost image is displaced more than twice as far.

The procedure described below simulates in the laboratory the conditions that produce multipath and flutter in terrestrial transmission paths. The simulated path is interposed between the proponent-supplied modulator and demodulator. Means are provided to combine two identically modulated RF signals, one signal being delayed from the other. The delay is static for echo testing. An artificial Doppler effect, simulating the moving airplane, is achieved by offsetting one carrier frequency from the other by a few Hertz.

19.4.2. Test and Measuring Equipment

The special test equipment required for this procedure includes:

(1) A frequency synthesizer operating at approximately 251 MHz.

(2) Two up-converters, to generate outputs on Broadcast Channel 12 (204-210 MHz) from IF input at 44 MHz. Local oscillator inputs are at 251 MHz.

(3) A "trombone" variable delay line, to provide up to 180 degrees of phase shift of the Channel 12 video carrier.

19.4.3. Procedure

19.4.3.1. Setup

Refer to Figures 19-2, 19-3, and 19-4 for functional diagrams of the test setups for this procedure. These setups simulate, respectively, a single leading ghost, a single lagging ghost, and airplane flutter.

The ATV outputs of the proponent-furnished decoder are viewed on the large screen color display. A recording may be made on an HD-DVTR at the threshold of visibility of each delay or flutter condition.

For Enhanced-NTSC systems, the signal is viewed on an assortment of consumer receivers and may be recorded on an NTSC-DVTR at the threshold of visibility.

19.4.3.2. Measurement Technique

19.4.3.2.1. Static Multipath

Connect the modulator for the channel being tested to the RF splitter feeding the two Channel 12 up- converters. Set the 251-MHz frequency synthesizer so that there is no frequency offset between the two up-converted signals.

Single echo testing of ATV systems will be carried out to determine the threshold of visibility of an echo as a function of delay for both leading and lagging echos. The range over which a leading echo shall be measured is up to -1.28 uS. and the range over which a lagging

echo is measured shall be at least 2.56 uS. In general at least six different delays shall be selected experimentally within the range to characterize the threshold of visibility of a given system. If it is found that the effect of echo is significantly different for luminance signals and for chrominance signals, then at least 6 delays shall be used for testing the effect due to chrominance delay and 6 delays used to evaluate the effect upon the luminance component. The echo amplitude (E) with respect to the main signal amplitude (M) shall be expressed in dB in reporting results. At each delay time chosen, the phase of the carrier of the echo (E) relative to the phase of the main signal (M) shall be adjusted experimentally to obtain the worst case phase relationship for the effect observed. Testing is facilitated by starting with the maximum delay as this helps the observer. In conducting this test the Main signal level shall be such as to provide a noise free picture.

Evaluate the threshold sensitivity to leading ghosts by delaying the "direct" signal by one microsecond and using less than one microsecond in the delaying path. The actual delay of the leading ghost is the difference between the two delays.

For each combination of delay and phase for which the threshold of visibility was determined, increase the amplitude to find the point of unusability.

Repeat the procedures above for Enhanced-NTSC systems as viewed on the NTSC receivers.

19.4.3.2.2. Flutter

Connect the modulator for the channel being tested to the RF splitter feeding the two Channel 12 up- converters as shown in Figure 19-4. A local oscillator is provided to one up-converter by a frequency synthesizer referenced to the other local oscillator, a crystal oscillator locked to 10 MHz. Set the synthesizer to be offset by the selected flutter frequency (i.e., 1 to 5 Hz).

Set the attenuator for the echo path to be 15 dB below the direct path, and insert one microsecond of delay into the delayed path. With the guidance of the expert panel, find the threshold of visibility of the flutter. Optionally, make a DVTR recording at an echo level of 10 dB above the threshold level. If system failure occurs at a lower level, make a recording at the highest level possible, and note the level and nature of the failure. Also note the impairment level at the point of unusability.

At the direction of the expert observers, and based upon the results of further analysis of the characteristics of airplane flutter, vary the frequency offset between the two synthesizers and the amplitude of the indirect transmission path. Note any combinations of values of these parameters that result in unusability of the picture.

For Enhanced-NTSC Systems, also determine the threshold of visibility and point of unusability as viewed on the NTSC receivers.

19.4.3.3. Presentation of Data

Document the equipment settings at which any system failure is observed, and describe the nature of the failure. To the extent that recording of the signals is possible and desired, make recordings on both the HD-DVTR and the NTSC-DVTR showing the impairments documented above. Each recording should be 15 seconds in length and should be logged with the starting SMPTE time code. It is understood that in cases of system failure, such as loss of synchronization, recording may be impossible.

Figure 19-5 is an example of the presentation format for the data.

19.5. Susceptibility to Interference

19.5.1. Introduction

Interference may be caused by other television transmissions or by other radio services. The most important type is co-channel interference, since it is a linear interference for which receiver selectivity offers no relief. In the case of co-channel interference, the undesired (U) signal is always smaller than the desired (D) signal. Signal levels, or field strengths, are expressed as D,U. Other television interferences include adjacent channel (upper and lower), and UHF taboos. In these cases, when the interference is visible, the undesired signal is larger than the desired signal. Usually, adjacent-channel and UHF taboo interference results from a nonlinear effect that occurs in the tuner of the television receiver. Hence, receivers will vary in their immunity to these types of interference. Nonlinear distortions must be tested over a range of desired signal levels. The UHF taboos for image response are linear, but the effects will vary greatly among receivers. It is necessary to test image taboos at more than one level of D, in order to avoid noise masking at a particular level. For all testing of adjacent-channel and taboo-channel interference, three levels will be used. For testing of co-channel interference, the weakest two of the three levels will be used. For Enhanced NTSC systems, the three levels shall be: -15 dBm, -35 dBm, and -55 dBm. The first of these is above the level at which the AGC of the receiver has an effect. The -35 dBm level is within the range of AGC action. The lowest level is below that at which AGC is effective. Use of these three levels also will permit comparison of the results of this testing with those of previous testing by the FCC. For Simulcast systems, the three levels--denoted Weak, Moderate, and Strong--are established by the procedure in Section 19.2.

Interference testing has two primary objectives. The first is to measure the robustness of a system, the ability of the system to reject interfering signals. The second is to determine the degree to which the proponent system is benign, compared to NTSC.

The robustness of the proponent system shall be tested with respect to both an interfering NTSC signal and another identical ATV signal. Since it is expected that only one set of hardware will be available for each proponent system, the second ATV signal for this test must be obtained by delaying the original signal. This imposes certain limitations on ATV-into-ATV interference tests. In particular, the

test picture must be prepared carefully to permit this type of testing. The picture must include a flat gray area where interference thresholds may be determined readily. The undesired signal must be delayed for this test. Comprehensive interference testing requires movement in the picture.

Interference may arise not only from other television signals but also from strong discrete-frequency signals, usually from other radio services. The frequencies to which an NTSC transmission are particularly sensitive are those close to the visual or aural carrier or color subcarrier. A graph of just-perceptible carrier-to-interference ratio (C/I) versus interference frequency, for NTSC, follows a so-called "W-Curve." For reference, this curve is depicted in Figure 19-6. The test for robustness of the proponent ATV system shall include exploration for discrete-frequency sensitivities, which are expected near carrier frequencies.

First, the degree to which the ATV system is benign shall be tested using the proponent-supplied encoder and modulator, for the undesired signal, and both the proponent receiver and an assortment of NTSC receivers.

Three expert observers viewing an assortment of twenty-four NTSC receivers (as described in the Video Subjective Test Procedures) shall determine the threshold of visibility of a given interference for the case of NTSC-into-NTSC. Then, the ATV signal will be substituted for the interfering NTSC signal. The degree to which the ATV signal is benign, compared to NTSC, will be determined by finding the threshold at which the ATV signal causes interference to NTSC.

The robustness of a desired ATV signal with respect to an undesired NTSC signal, will be determined by a panel of 5 experts observing a large screen ATV display. The threshold of visibility of the interference and the point of unusability of the ATV signal will be found using methods described in Section 1.6 of the Video Subjective Test Procedures manual.

Finally, an ATV signal will be both the desired signal and the undesired signal, to find the ATV-into-ATV threshold. The test picture carried by both ATV channels will be the same. It contains a large, flat gray area where the threshold of visible interference can be detected readily. The interference will come from parts of the test picture having strong detail, high contrast, and perhaps highly saturated colors. Since ATV systems may generate more interference when there is movement in the picture than for static images, a dynamic test signal or videotaped motion sequence shall be used.

The picture material to be used in these tests is described further in the Video Subjective Test Procedures manual.

19.5.2. Test and Measuring Equipment

The synthesizers used in these procedures must cover the range of 200 to 820 MHz. The up-converters must cover the high-band VHF and the UHF broadcast channels.