ATIS-0100502.2005(R2010)

System M-NTSC Television Signals – Network Interface Specifications and Performance Parameters

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American National Standard for Telecommunications

SYSTEM M-NTSC TELEVISION SIGNALS – NETWORK INTERFACE SPECIFICATIONS AND PERFORMANCE PARAMETERS

Secretariat

Alliance for Telecommunications Industry Solutions

Approved November 3, 2005

American National Standards Institute, Inc.

Abstract

This standard defines network interface specifications and performance parameters and values for television transmission service channels supporting 525-line, system M-NTSC color or monochrome video signals and the associated audio signals.

FOREWORD

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

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Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PRQC Secretariat, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time it approved this document, PRQC, which is responsible for the development of this Standard, had the following members:

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The **PRQC Quality of Service (QoS)** Task Force was responsible for the development of this document.

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1 SCOPE, PURPOSE, & APPLICATION

1.1 Scope

This standard covers interface and performance specifications of television transmission service channels. Hypothetical reference channels have been defined and utilized to apportion performance parameters. Television signals created or transmitted in accordance with other standards or make-ups may not necessarily be compatible with the specifications of this standard.

This standard specifies the performance of transmission service channels provided to convey 525-line, System M-National Television Systems Committee (NTSC) color or monochrome video signals and their associated audio signals only. This specification for television transmission service channels applies to both interface and performance parameters. The performance parameters are expressed as a function of the length between the endpoints of a channel or as a function of the facility type utilized. Performance definitions and measurement methods are provided if appropriate. Interface specifications are provided to facilitate compatibility between end users, service providers, and carriers.

The performance characteristics identified within this standard apply to the transmission quality between the defined interfaces. Those interfaces are: (1) between transmission service providers and end users; and (2) between the jurisdictions of one transmission service provider and another. This standard defines neither the interconnection nor the performance characteristics of specific apparatus or equipment.

1.2 Purpose

The purpose of this standard is to assure the uniform application of standard values of transmission parameters for television signals transported by portions of the telecommunications network. It is intended to provide a common understanding by both suppliers and their customers.

1.3 Application

The primary applications of this standard are for specifying and evaluating the performance of a transmission service provided by common carriers. These services are used to transport the audio and video portions of broadcast-quality television signals.

2 NORMATIVE REFERENCES

The following standard contains provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

ANSI/IEEE 743-1995, *IEEE Standard equipment requirements and measurement techniques for analog transmission parameters for telecommunications*.[1]

3 DEFINITIONS

3.1 Special word/phrase usage

3.1.1 exchange carrier (EC): The telecommunications common carrier franchised to provide telecommunications services within one or more exchanges. An EC may also provide exchange access service, intra-LATA long-distance service, and -- in some unusual cases -- inter-LATA service.

3.1.2 hypothetical reference transport service channel: A *hypothetical reference transport service channel* is a model used to define administration and jurisdictional responsibilities. These models, discussed in clause 6, apportion transmission parameter values by *facility lengths*. *Facility lengths* specified as short haul, medium haul, satellite, long haul, and end-to-end are defined in 6.4.

3.1.3 interexchange carrier (IC): A telecommunications common carrier authorized to provide telecommunications services between LATAs. An IC may also provide service within some LATAs.

3.1.4 local access and transport area (LATA): A geographic area established for the provision and administration of telecommunications services. A LATA encompasses one or more exchanges that have been grouped to serve common social, economic, and other purposes.

3.1.5 network interface (NI): The point of demarcation between the carrier's facilities and the customer's installation that establishes the technical interface and division of operational responsibility.

3.1.6 point of termination (POT): The point of demarcation between carriers that establishes the technical interface and division of operational responsibility.

3.1.7 transmission service channel: A one-way transmission path between two designated points (see 6.3).

3.1.7.1 end-to-end: A transmission service channel employing various circuits, such as a terrestrial or satellite inter-LATA transmission service channel, in conjunction with its associated access transmission service channels.

3.1.7.2 long haul: A transmission service channel with a route length of greater than 150 miles (241 km) but less than or equal to 3000 miles (4827 km).

3.1.7.3 medium haul: A transmission service channel with a route length of greater than 20 miles (32.2 km) but less than or equal to 150 miles (241 km).

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[1] This document is available from the Institute of Electrical and Electronics Engineers (IEEE). < http://shop.ieee.org/store/ >

3.1.7.4 satellite: A transmission service channel consisting of one transmitting earth station terminal, one satellite transponder (repeater) and one receiving earth station terminal.

3.1.7.5 short haul: A transmission service channel with a route length of 20 miles (32.2 km) or less.

3.2 Video signals

3.2.1 Video signal description

The waveform terminology used throughout the standard is in accordance with Figure 1, in which the standard video-signal waveform terminology is shown and measured in IRE units as shown in Figure 2.

3.2.2 Test signal description

Reference to time (T) in the description of the following test signals refers to the half-amplitude pulse width duration and not to the rise time nor to the fall time of a pulse transition, and has a value of 125 nanoseconds.

3.2.2.1 Composite test signal

The composite test signal shown in Figure 3 consists of a line bar (125-nanosecond rise time and fall time), a 2T pulse (250-nanosecond half-amplitude duration), a 12.5T chrominance pulse (1.5625-microsecond half amplitude duration), and a modulated 5-riser staircase signal superimposed upon standard synchronizing and blanking signals. Reference "A" and "B" are the measurement points utilized in the measurement of insertion gain and insertion-gain variation.

3.2.2.2 Combination test signal

The combination test signal shown in Figure 4 consists of a white flag, a multiburst, and a 3-level chrominance signal superimposed upon standard synchronizing and blanking signals.

3.2.2.3 Multipulse test signal

The multipulse test signal shown in Figure 5 consists of a white flag, a 2T pulse, and modulated pulses. The modulating frequencies of the pulses correspond to the frequency packets of the multiburst portion of the combination test signal (with the exception of 0.5 MHz), superimposed upon standard synchronizing and blanking signals.

3.2.2.4 Field-bar test signal

The field-bar test signal shown in Figure 6 consists of a field-rate square wave, extending to the total luminance signal level (100 IRE units), superimposed upon standard synchronizing and blanking signals.

3.2.2.5 Flat-field test signal with variable APL

The flat-field test signal with variable APL shown in Figure 7 consists of a uniform luminance signal, the average picture level (APL) of which is transitioned between 10% and 90%, and is superimposed upon standard synchronizing and blanking signals.

3.2.3 Method of measurement

When conducting in-service vertical interval test signal (VITS) measurements, the composite test signal appearing in the Vertical Interval shall be used.[2] The flat-field and field-bar test signals can be used only in out-of-service testing. The maximum range of the composite signal as shown in Figure 3, is from -40 IRE units to + 110 IRE units (peak of subcarrier on modulated steps).

It should be noted that except where full field test signals are essential to the measurement of a particular transmission parameter (for example, field-time waveform distortion), the performance limit specified for each transmission parameter applies equally to both VITS and full-field test signals. Furthermore, the performance values apply irrespective of the APL within the 10% to 90% APL range. This is an important point to remember when making VITS measurements, particularly during program transmission periods in which control cannot be exercised over the APL value of the picture signal. Many of the transmission parameters can be markedly affected by APL variations. Therefore, sufficient time should be allowed when making VITS measurements to ensure that a good portion of the APL range is explored by the picture signal before recording the test signal measurement. When performing out-of-service testing of a video transmission service channel, the associated audio transmission service channel(s) shall be exercised at peak operating level. Test equipment shall be calibrated in accordance with the manufacturer's recommendations and terminated as specified.

3.3 Acronyms & Abbreviations List

APL	Average Picture Level
CLDI	Chrominance-to-Luminance Delay Inequality
DUT	Device Under Test
EC	Exchange Carrier
FD	Field-time waveform Distortion
IC	Interexchange Carrier
IRE	Institute of Radio Engineers (unit of voltage used in measuring gray scale)
LATA	Local Access and Transport Area
LD	Line-time waveform Distortion
NC	Network Channel
NCI	Network Channel Interface
NI	Network Interface

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[2] VITS are inserted only by program originators and not by channel providers. The location of specific test signals within the Vertical Interval varies from program originator to program originator.

NTSC	National Television Systems Committee
POT	Point of Terminations
RCL	Relative Chrominance Level
RCT	Relative Chrominance Time
RMS	Root-Mean-Square
SD	Short-time waveform Distortion
SPST	Single-Pole, Single-Throw
T	Time, expressed as the half-amplitude pulse width duration
VITS	Vertical Interval Test Signal
VU	Volume Unit

4 BASEBAND TELEVISION INTERFACE AND PERFORMANCE SPECIFICATIONS FOR ANALOG TRANSMISSION

4.1 Video signal electrical interface specifications

4.1.1 Impedance

4.1.1.1 Source impedance

4.1.1.1.1 Definition. The video source impedance of a transmission service channel, Z_s in figures 8(a) and 8(b), is the impedance presented to the input terminals of a transmission service channel or other video baseband input point by the output terminals of the signal source. Proper source impedance is required for service channel evaluation.

4.1.1.1.2 Standard value. The standard value shall be 75 Ω, unbalanced to ground, or 124 Ω[3], balanced to ground, with a return loss of at least 30 dB over the frequency range of 20 Hz-4.2 MHz.

4.1.1.1.3 Method of measurement. The source impedance shall be measured by using impedance measurement equipment and the return loss calculated from the following formula:

$$\text{Return Loss (dB)} = 20\log_{10}\left|\frac{Z + Z_m}{Z - Z_m}\right|$$

where

    Z = specified standard impedance
    Z_m = measured impedance

Alternately, the return loss may be measured using a return loss bridge.

4.1.1.2 Input impedance

4.1.1.2.1 Definition. The video input impedance of a transmission service channel, Z_I in figures 8(a) and 8(b), is the impedance presented by the input terminals of a transmission service channel or other video baseband input point.

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[3] The 124-Ω interface, while still possibly in use, is quite old and difficult to obtain. This note also pertains to all other mentions of the 124-Ω interface.

4.1.1.2.2 Standard value. The standard value shall be 75 Ω, unbalanced to ground, or 124 Ω, balanced to ground, with a return loss of at least 30 dB over the frequency range of 20 Hz-4.2 MHz.

4.1.1.2.3 Method of measurement. See 4.1.1.1.3.

4.1.1.3 Output impedance

4.1.1.3.1 Definition. The video output impedance of a transmission service channel, Z_o in figures 8(a) and 8(b), is the impedance presented by the output terminals of a transmission service channel or other baseband output point.

4.1.1.3.2 Standard value. The standard value shall be 75 Ω, unbalanced to ground, or 124 Ω, balanced to ground, with a return loss of at least 30 dB over the frequency range of 20 Hz-4.2 MHz.

4.1.1.3.3 Method of measurement. See 4.1.1.1.3.

4.1.1.4 Load impedance

4.1.1.4.1 Definition. The video load impedance of a transmission service channel, Z_L in figures 8(a) and 8(b), is the impedance presented by the input terminals of the device that will terminate the video baseband output of the transmission service channel. Proper load impedance is required for service channel evaluation.

4.1.1.4.2 Standard value. The standard value shall be 75 Ω, unbalanced to ground, or 124 Ω, balanced to ground, with a return loss of at least 30 dB over the frequency range of 20 Hz-4.2 MHz.

4.1.1.4.3 Method of measurement. See 4.1.1.1.3.

4.1.2 Video signal

4.1.2.1 Input signal level

4.1.2.1.1 Definition. The input signal level of a transmission service channel is the difference in voltage between sync tip (-40 IRE units) and reference white (100 IRE units) of a composite picture signal presented to the video baseband input terminals. It is expressed in volts.

4.1.2.1.2 Standard value. The standard value shall be a nominal 1 volt peak-to-peak difference between sync tip and reference white, 140 IRE units[4] (see figures 1 and 2).

4.1.2.1.3 Method of measurement. The input signal level shall be measured by means of a properly calibrated and terminated oscilloscope or waveform monitor.

4.1.2.2 Output signal level

4.1.2.2.1 Definition. The output signal level of a transmission service channel is the difference in voltage between sync tip and reference white of a composite picture signal presented by the video baseband output terminals. It is expressed in volts peak-to-peak.

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[4] Chrominance signal information may range from -23 IRE units to +131 IRE units. See ANSI/SMPTE 170M-1994.

4.1.2.2.2 Standard value. The output signal shall be a faithful reproduction of the input signal, subject to the parametric variations permitted by the performance characteristics set forth in this standard.

4.1.2.2.3 Method of measurement. The output signal level shall be measured by means of a properly calibrated and terminated oscilloscope or waveform monitor.

4.1.2.3 Polarity of the picture signal

4.1.2.3.1 Definition. The polarity of the picture signal of a transmission service channel is the sense of the potential of a portion of the signal representing a dark area of a scene relative to the potential of a portion of the signal representing a light area. Polarity is stated as "black positive" or "black negative." It is the polarity presented to the transmission service channel input terminals and presented by the transmission service channel output terminals.

4.1.2.3.2 Standard value. The polarity of the picture signal shall be "black negative."

4.1.2.3.3 Method of measurement. The polarity of the picture signal shall be determined by use of an oscilloscope or waveform monitor of known deflection polarity.

4.1.2.4 Non-useful DC component

4.1.2.4.1 Definition. The non-useful dc component of the picture signal is any dc component that is unrelated to the signal. It will be present only as a result of the transmission equipment.

4.1.2.4.2 Standard values. The standard values shall be:

> < 0.05 volt across a standard load (75 Ω);
> < 0.10 volt across a standard load (124 Ω); and
> < 0.05 volt referenced to ground.

4.1.2.4.3 Method of measurement. The non-useful dc component of the picture signal shall be measured by means of a suitable dc instrument with the video signal removed and the transmission service channel input terminals terminated.

4.2 Audio signal electrical interface specifications

4.2.1 Impedance

4.2.1.1 Source impedance

4.2.1.1.1 Definition. The audio source impedance of a transmission service channel, Z_s in Figure 8(b), is the impedance presented to the input terminals of a transmission service channel or other input point by the output terminals of the signal source. Proper source impedance is required for transmission service channel evaluation.

4.2.1.1.2 Standard value. The standard value shall be 600 Ω, balanced to ground, with no dc voltage present and with a return loss of at least 30 dB over the frequency range of 50 Hz-15 kHz.

4.2.1.1.3 Method of measurement. The source impedance shall be measured by using impedance measurement equipment and the return loss calculated from the following formula:

$$\text{Return Loss (dB)} = 20\log_{10}\left|\frac{Z + Z_m}{Z - Z_m}\right|$$

where

Z = specified standard impedance

Z_m = measured impedance

Alternately, the return loss may be measured using a return loss bridge.

4.2.1.2 Input Impedance

4.2.1.2.1 Definition. The input impedance of a transmission service channel, Z_I in Figure 8(b), is the impedance presented by the input terminals of a transmission service channel or other audio input point.

4.2.1.2.2 Standard value. The standard value shall be 600 Ω, balanced to ground with no dc voltage present and with a return loss of at least 30 dB over the frequency range of 50 Hz-15 kHz.

4.2.1.2.3 Method of measurement. See 4.2.1.1.3.

4.2.1.3 Output impedance

4.2.1.3.1 Definition. The output impedance of a transmission service channel, Z_o in Figure 8(b), is the impedance presented by the output terminals of a transmission service channel or other audio output point.

4.2.1.3.2 Standard value. The standard value shall be 600 Ω, balanced to ground, with no dc voltage present and with a return loss of at least 30 dB over the frequency range of 50 Hz-15 kHz.

4.2.1.3.3 Method of measurement. See 4.2.1.1.3.

4.2.1.4 Load impedance

4.2.1.4.1 Definition. The load impedance of a transmission service channel, Z_L in Figure 8(b), is the impedance presented by the input terminals of the device that will terminate the audio output of the transmission service channel. Proper load impedance is required for channel evaluation.

4.2.1.4.2 Standard value. The standard value shall be 600 Ω, balanced to ground, with no dc voltage present and with a return loss of at least 30 dB over the frequency range of 50 Hz-15 kHz.

4.2.1.4.3 Method of measurement. See 4.2.1.1.3.

4.2.2 Audio signal

4.2.2.1 Input signal level

4.2.2.1.1 Definition. The input signal level of a transmission service channel is that level presented to the transmission service channel input terminals. It is expressed in dBm.

4.2.2.1.2 Standard value. The input peak operating level of the transmission service channel at the standard impedance is equal to the peaks of a sine wave the average power of which is +18 dBm.

NOTES:

(1) This level applies at a nominal 400 Hz with application time limited to less than 4 seconds. This level must be reduced at higher frequencies to take into account any pre-emphasis.

(2) The maximum continuous test tone amplitude (averaged over 1 second) that can be applied at the input terminals of a transmission service channel is as follows:

> +8 dBm for 50 Hz $\leq$ f $\leq$404 Hz
>
> 0 dBm for 404 Hz < f $\leq$ 15 kHz

(3) Some transmission service channels may be incompatible with certain single-frequency testing techniques.

(4) Test equipment shall be calibrated according to manufacturers' recommendations and terminated as specified.

4.2.2.1.3   Method of measurement. The audio input signal level shall be measured by properly terminated audio test equipment. Sinusoidal waveforms may be measured using a properly calibrated voltage or power meter.

4.2.2.2 Output signal level

4.2.2.2.1   Definition. The output signal level of a transmission service channel is that level presented by the transmission service channel output terminals. It is expressed in dBm.

4.2.2.2.2   Standard value. Except under the conditions indicated in Annex B, in which a customer uses a VU meter to measure audio level and has calibrated that VU meter to a calibration point other than 0 VU = +8 dBm, the output signal shall be a faithful reproduction of the input signal, subject to the parametric variations permitted by the performance characteristics set forth in this standard.

4.2.2.2.3   Method of measurement. The audio output signal shall be measured by properly terminated audio test equipment. Sinusoidal waveforms may be measured using a properly calibrated voltage or power meter.

4.2.2.3 Polarity of the audio signal

4.2.2.3.1   Definition. The polarity of the audio signal of a transmission service channel is the sense of direction of the signal presented by the transmission service channel output terminals compared to the sense of direction of the signal applied to the transmission service channel input terminals.

4.2.2.3.2   Standard value. The audio signal polarity shall be identified at the transmission service channel input and output terminals and be of the same sense.

4.2.2.3.3   Method of measurement. The audio signal polarity shall be determined by applying a nonsymmetrical signal of a known polarity, as shown in Figure 9, to the transmission service channel input terminals and observed at the output terminals.

4.3   Video signal performance characteristics

Video signal performance characteristics are summarized in Tables 1 through 5.

4.3.1 Video signal linear distortions

4.3.1.1 Amplitude response versus frequency characteristic

4.3.1.1.1   Definition. The video amplitude response versus frequency characteristic of a transmission service channel is an expression of amplitude variation as a function of the baseband frequency of a sine-wave voltage when applied to the transmitting terminal baseband input and measured at the receiving terminal baseband output.

4.3.1.1.2   Standard value. The selected frequency values at 50 IRE units listed in Table 6 are representative of a half-level multiburst or multipulse signal.

The amplitude response versus frequency characteristics for short haul shall be as shown in Figure 10. The amplitude response versus frequency characteristics for medium haul and satellite shall be as shown in Figure 11. The amplitude response versus frequency characteristics for long haul and end-to-end shall be as shown in Figure 12.

4.3.1.1.3   Method of measurement. An out-of-service measurement may be performed by using a test signal consisting of a swept-frequency signal with synchronizing and blanking signals applied to the channel input terminals of the transmission service channel. The sweep rate shall be equal to the picture field rate and phased to coincide with the period of one field. The suggested sweep width shall be 5 MHz and the amplitude of the video sweep voltage shall extend from 15% to 65% of the luminance signal level (50 IRE units). Harmonic content of the sweep voltage should be the minimum possible, preferably less than 1%. The measurement arrangement shall permit viewing of the input and output sweep voltages on calibrated oscilloscopes having adequate bandwidth.

Alternately, in-service or out-of-service measurement may be performed by using a 50 IRE unit multiburst portion of the combination test signal or a 50 IRE unit multipulse test signal. The amplitude response versus frequency may be measured by comparing the amplitude of the bursts of either the multiburst or multipulse to the white flag.

4.3.1.2   Chrominance-to-luminance gain inequality

4.3.1.2.1   Definition. Chrominance-to-luminance gain inequality of a transmission service channel is the difference in gain of the chrominance signal (approximately 3-4 MHz) and the low-frequency luminance signal (approximately 2-600 kHz). It is measured as relative chrominance level (RCL) at the transmission service channel output terminals.

4.3.1.2.2   Standard values. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	± 2
Medium Haul	± 4
Satellite	± 4
Long Haul	± 7
End-to-end	± 7

4.3.1.2.3   Method of measurement. The 12.5T modulated pulse portion of the composite test signal, shown in Figure 3, is used for this measurement. The test signal shall be applied to the transmission service channel's input terminals.

A symmetrical bowing of the 12.5T pulse base indicates a chrominance-to-luminance gain inequality. If the bowing is in the upward direction, the chroma inequality is negative. If the bowing is in the downward direction, the chroma inequality is positive. The maximum shift of the base of the 12.5T pulse from the display baseline is a measure of the amount of the chroma gain inequality. This is exactly equal to the displacement of the peak of the pulse from the top of the bar when the distortion is purely linear. Adjust the amplitude of the midpoint (point A) of the line-bar portion of the composite test signal to 100 IRE units with respect to the zero base line (point B). The amplitude of the 12.5T

modulated pulse is compared with the midpoint of the previously adjusted bar (point A). The chrominance-to-luminance gain inequality value is twice the measured value of the difference in amplitude between the bar and the 12.5T modulated pulse.

4.3.1.3 Chrominance-to-luminance delay inequality (CLDI)

4.3.1.3.1   Definition. Chrominance-to-luminance delay inequality (CLDI) of a transmission service channel is the difference in transmission time between the chrominance signal (approximately 3-4 MHz) and the low-frequency luminance signal (approximately 2-600 kHz). It is measured at the transmission service channel's output terminals as relative chrominance time (RCT).

4.3.1.3.2   Standard values. The standard values shall be as shown in the following table:

	Nanoseconds
Short Haul	± 20
Medium Haul	± 33
Satellite	± 26
Long Haul	± 54
End-to-end	± 60

4.3.1.3.3   Method of measurement. The 12.5T pulse portion of the composite test signal shown in Figure 3 is used for this measurement. The test signal shall be applied to the transmission service channel and shall be viewed on a suitable waveform monitor at the transmission service channel output terminals. After normalizing the 12.5T pulse amplitude to 100 IRE units, chrominance-to-luminance delay inequality can be determined. Identify the amplitude of Y_1, and Y_2 distortion values in the 12.5T pulse base as shown in Figure 13. Apply the Y_1 and Y_2 amplitude values to the nomogram of Figure 13. The chrominance-to-luminance delay inequality value is identified at the intersection of the CLDI scale with a straight line placed between the Y_1 and Y_2 values of the nomogram.

The following equation will result in the same values as the nomogram:

$$CLDI = \pm 20\sqrt{(Y_1 \times Y_2)}ns$$

4.3.1.4 Field-time waveform distortion (FD)

4.3.1.4.1   Definition. Field-time waveform distortion (FD) of a transmission service channel is the linear waveform distortion of the time components from 64 microseconds to 16 milliseconds -- that is, time components of the field-time domain. This is also known as *field tilt*. It is measured at the transmission service channel output terminals.

4.3.1.4.2   Standard value. The standard value is < 3 IRE units.

4.3.1.4.3   Method of measurement. Field-time waveform distortion measurement is an out-of-service test. The field-bar test signal shown in Figure 6 is used when measuring field-time waveform distortion. Amplitude of the test signal shall be checked at the sending end prior to the commencement of the test.

The test signal shall be applied to the transmission service channel input terminals. The magnitude of the distortion shall be obtained by measuring, in IRE units, the test signal's peak-to-peak change in amplitude of the bar top with the amplitude of the bar center adjusted to 100 IRE units at the transmission service channel output terminals. In order to avoid leading and trailing overshoots, the first and last 250 microseconds (approximately four television lines) are ignored in this measurement.

4.3.1.5   Line-Time waveform distortion

4.3.1.5.1   Definition. Line-time waveform distortion (LD) of a transmission service channel is the linear waveform distortion of time components from 1 to 64 microseconds, that is, time components of the linetime domain. It is measured at the transmission service channel output terminals.

4.3.1.5.2   Standard Values. The standard values shall be as shown in the following table:

	IRE Units (P-P)
Short Haul	0.5
Medium Haul	1.0
Satellite	1.0
Long Haul	1.5
End-to-end	2.0

4.3.1.5.3   Method of measurement. The line-bar portion of the composite test signal shown in Figure 3 shall be used when measuring line-time waveform distortion (if line-time waveform distortion is measured on an out-of-service basis, then a full-field, 18 microsecond, line bar shall be utilized). The amplitude of the test signal shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The magnitude of the distortion shall be obtained by measuring, in IRE units, the test signal's bar top peak-to-peak change in amplitude with the amplitude of the bar center adjusted to 100 IRE units at the transmission service channel output terminals. The first and last microseconds are ignored in this measurement.

4.3.1.6   Short-time waveform distortion

4.3.1.6.1   Definition. Short-time waveform distortion (SD) of a transmission service channel is the linear waveform distortion of time components from 0.125 to 1.0 microsecond, that is, time components of the short-time domain. It is measured at the transmission service channel output terminals.

4.3.1.6.2   Standard values. The standard values shall be as shown in the following table:

	Percent
Short Haul	2.0
Medium Haul	2.0
Satellite	2.0
Long Haul	3.5

End-to-end	3.5

4.3.1.6.3 Method of measurement. The line-bar portion of the composite test signal shown in Figure 3 is used when measuring short-time waveform distortion. The amplitude of the test signal shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The bar portion of the test signal shall be viewed on a waveform monitor with the sweep rate of 2 microseconds using the graticule overlay shown in Figure 14 with limits specified in Table 7, at the transmission service channel output terminals. Short-time waveform distortion can be read directly from the graticule. This measurement method is described in IEEE 511 (see Annex A, Bibliography).

4.3.1.7 Long-time waveform distortion (bounce)

4.3.1.7.1 Definition. Long-time waveform distortion of a transmission service channel is the damped low frequency transient resulting from a change in APL that affects the dc component of the signal. It is the linear waveform distortion of time components from 16 milliseconds to tens of seconds, that is, time components of the long-time domain. The distortion is characterized by the peak overshoot and settling time. It is measured at the transmission service channel output terminals.

4.3.1.7.2 Standard value. The standard value is 8 IRE units peak with a 3-second settling time.

4.3.1.7.3 Method of measurement. Long-time waveform distortion measurement is an out-of-service test. A flat-field test signal with variable APL shown in Figure 7 shall be applied to the service channel input terminals. The signal shall be switched between 10% and 90% APL at intervals not shorter than five times the settling time. The APL transitions shall be made in less than 10 microseconds. The test signal shall be observed on a slow-sweep waveform monitor and the variation at blanking level noted at the transmission service channel output terminals. A photograph of the oscilloscope display may aid in determining overshoots and settling time. Figure 15 is an example of long-time waveform distortion.

4.3.1.8 Insertion gain and insertion gain variation

4.3.1.8.1 Definition. Insertion gain of a transmission service channel is defined as the difference of a signal's output level compared to its input level. Insertion-gain variation is the change of insertion gain over a specified time interval. It is measured at the transmission service channel output terminals.

4.3.1.8.2 Standard values. *Insertion gain* shall be established and periodically maintained at 0 +5.9 to -5.5 IRE units. *Insertion-gain variation* shall be maintained within the ranges listed in the following table:

		IRE Units
Short Haul	Hourly	+1.7 to -1.7
	Over one second	+1.2 to -1.2
Medium Haul	Hourly	+3.5 to -3.3
	Over one second	+1.7 to -1.7
Satellite	Hourly	+2.3 to -2.2
	Over one second	+1.7 to -1.7
Long Haul	Hourly	+5.3 to -5.0

	Over one second	+2.9 to -2.8
End-to-end	Hourly	+5.9 to -5.5
	Over one second	+3.5 to -3.3

4.3.1.8.3 Method of Measurement. The line-bar portion of the composite test signal shown in Figure 3 is used when measuring insertion gain. The amplitude of the test signal must be verified to be 100 IRE units at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The peak-to-peak amplitude of the midpoint of the flat portion of the line-bar test signal shall be measured at the transmission service channel output terminals. The difference between the measured amplitude of the test signal (level reference points "A" and "B", Figure 3) and its normal amplitude of 100 IRE units is the insertion gain of the transmission service channel.

Insertion-gain variation is measured as the difference in insertion gain at any instant during a specified time interval from the insertion gain at the beginning of that specified time interval.

4.3.2 Video signal nonlinear distortions

4.3.2.1 Luminance nonlinearity

4.3.2.1.1   Definition. *Luminance nonlinearity* of a transmission service channel is the deviation of the luminance signal from proportionality between the amplitude of the small unit step function, as the level of the step is shifted from blanking level to white level. It is measured at the transmission service channel output terminals.

4.3.2.1.2 Standard values. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	2
Medium Haul	4
Satellite	6
Long Haul	8
End-to-end	10

4.3.2.1.3 Method of measurement. The modulated 5-riser staircase portion of the composite test signal shown in Figure 3 shall be used when measuring luminance nonlinearity. The amplitude of the test signal at each step level must be checked for uniformity at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be passed through a differentiating and shaping network of the type shown in Figure 16 with the output of the network connected to the waveform monitor. The network transforms the signal into a train of five pulses of equal amplitude, under zero distortion conditions. Figure 17 shows an example of luminance nonlinearity distortion. The gain of the waveform monitor should be increased to the point at which the largest pulse amplitude is 100 IRE units and then the amplitude of the smallest pulse can be measured and recorded. This is the luminance nonlinearity at 50% APL. This measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL.

4.3.2.2 Differential gain

4.3.2.2.1   Definition. *Differential gain* of a transmission service channel is the change in amplitude of the subcarrier (chrominance) signal as the luminance signal is varied from blanking to white level. It is expressed as a percentage of the maximum level or in IRE units. It is measured at the transmission service channel output terminals.

4.3.2.2.2 Standard values. The standard values shall be as shown in the following table:

	IRE Units	Percent (%)
Short Haul	2	2
Medium Haul	5	5
Satellite	4	4
Long Haul	8	8
End-to-end	10	10

4.3.2.2.3 Method of measurement. The modulated 5-riser staircase portion of the composite test signal shown in Figure 3 shall be used when measuring differential gain. The test signal's amplitude at each step level shall be checked for uniformity at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be fed through a high-pass filter network and the output of the network connected to the waveform monitor being used for the measurement. The chrominance filter network incorporated into most television waveform monitors is suitable for this test. The gain of the waveform monitor is then adjusted until the highest subcarrier peak-to-peak amplitude is exactly 100 IRE units. The peak-to-peak amplitude of the lowest subcarrier is then measured. The difference between the highest subcarrier amplitude and the lowest subcarrier amplitude is the differential gain distortion at 50% APL. The above measurement procedure should be repeated using the same test signal transmitted at 10% APL and then tested at 90% APL. A vectorscope may also be used to measure differential gain.

4.3.2.3 Differential phase

4.3.2.3.1   Definition. *Differential phase* of a transmission service channel is the change in phase of the subcarrier (chrominance) signal after it has passed through a transmission service channel as the luminance is varied from blanking level to white level. It is measured at the transmission service channel output terminals.

4.3.2.3.2 Standard values. The standard values shall be as shown in the following table:

	Degrees
Short Haul	0.7
Medium Haul	1.3
Satellite	1.5
Long Haul	2.5
End-to-end	3.0

4.3.2.3.3 Method of measurement. The modulated 5-riser staircase portion of the composite test signal shown in Figure 3 shall be used when measuring differential phase. The amplitude and phase of the subcarrier shall be checked at each step level for uniformity at the sending end prior to the commencement of the test. Similarly, the phase comparator (vectorscope) at the receiving end should be properly calibrated. A vectorscope display of differential phase with zero distortion is shown in Figure 18(a). The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be fed to the vectorscope. The differential phase distortion is the measured peak-to-peak change in subcarrier phase at 50% APL. The above measurement procedure should be repeated using the same test signal transmitted at 10% APL and then tested at 90% APL. An example of differential phase distortion is shown in Figure 18(b).

4.3.2.4 Chrominance-to-luminance intermodulation

4.3.2.4.1 Definition. *Chrominance-to-luminance intermodulation* of a transmission service channel is the variation in amplitude of the luminance signal at the transmission service channel output terminals resulting from the superimposition on the input signal of a chrominance signal of specified amplitude.

4.3.2.4.2 Standard value. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	1
Medium Haul	2
Satellite	2
Long Haul	4
End-to-end	4

4.3.2.4.3 Method of measurement. The 3-level chrominance portion of the combination test signal shown in Figure 4 shall be used when measuring chrominance-to-luminance distortion. The amplitude of the test signal at each chrominance level shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output shall be connected to the waveform monitor, the response setting of which is in the LOW PASS mode. The unmodulated portion of the pedestal is adjusted to 50 IRE units. Chrominance-to-luminance intermodulation is the maximum departure in IRE units of the filtered luminance portion of the pedestal relative to a portion of the luminance pedestal that did not contain the chrominance modulation. An example of chrominance-to-luminance intermodulation is shown in Figure 19(a) and 19(b). The above measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL. This standard applies for all values of APL from 10% to 90%.

4.3.2.5 Chrominance nonlinear gain

4.3.2.5.1 Definition. The *chrominance nonlinear gain* distortion of a transmission service channel is the departure from proportionality in amplitude of the chrominance subcarrier burst packets at the transmission service channel output terminals as the amplitude of the subcarrier is varied from a specified minimum to a specified maximum value at a given luminance level and APL at the transmission service channel input terminals.

4.3.3.5.2 Standard values. The standard values shall be as shown in the following table:

	Chrominance Signal (IRE Units)	IRE Units
Short Haul	20	± 1
	80	± 1
Medium Haul	20	± 2
	80	± 2
Satellite	20	± 2
	80	± 2
Long Haul	20	± 4
	80	± 4
End-to-end	20	± 5
	80	± 5

4.3.2.5.3 Method of Measurement. The 3-level chrominance portion of the combination test signal shown in Figure 4 shall be used when measuring chrominance nonlinear gain distortion. The amplitude of the test signal at each chrominance level shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals. The test signal at the transmission service channel output terminals shall be connected to the waveform monitor, the response setting of which is in the 3.58-MHz band-pass mode. The gain of the waveform monitor is adjusted to the point where the middle subcarrier amplitude is exactly 40 IRE units and then the amplitude of the largest and smallest subcarrier levels are measured. This measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL.

> NOTE – Chrominance nonlinear gain is an out-of-service measurement when the APL (bounce) signal is utilized in the performance of this measurement.

4.3.2.6 Chrominance nonlinear phase

4.3.2.6.1 Definition. The *chrominance nonlinear phase* distortion of a transmission service channel is the variation of the phase of the chrominance subcarrier at the transmission service channel output terminals as the amplitude of the subcarrier is varied from a specified minimum to a specified maximum value at a given luminance level and APL at the transmission service channel input terminals.

4.3.2.6.2 Standard values. The standard values shall be as shown in the following table:

	Degrees
Short Haul	1
Medium Haul	2
Satellite	2
Long Haul	4
End-to-end	5

4.3.2.6.3   Method of measurement. The 3-level chrominance portion of the combination test signal shown in Figure 4 shall be used when measuring chrominance nonlinear phase distortion. The amplitude and phase of the test signal at each chrominance level must be checked at the sending end prior to the commencement of the test. The vectorscope at the receiving end should be properly calibrated and terminated. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be connected to the vectorscope. Under zero distortion conditions the phase at each level of the 3-level chrominance test signal should be 90 degrees relative to the phase of the color burst as shown in Figure 20(a). The phase of the three levels of the test signal should be measured relative to the phase of the color burst. The peak-to-peak variation of the phase of the 3-level chrominance test signal is the difference between the largest and smallest readings obtained. An example of chrominance nonlinear phase distortion is shown in Figure 20(b). This measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL. This standard applies to all values of APL from 10% to 90%.

> NOTE – Chrominance nonlinear phase distortion is an out of-service measurement when the APL (bounce) signal is utilized in the performance of this measurement.

4.3.2.7   Dynamic gain of the picture signal

4.3.2.7.1   Definition. *Dynamic gain of the picture signal* of a transmission service channel is the change in transmission service channel insertion gain as measured by the change in the peak-to-peak luminance level resulting from variations in APL.

4.3.2.7.2   Standard values. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	2
Medium Haul	3
Satellite	4
Long Haul	5
End-to-end	6

4.3.2.7.3.   Method of measurement. Dynamic gain of the picture signal is an out-of-service test. A multisignal waveform, which uses a composite test signal combined with a flat-field signal shown in Figure 21, shall be used to measure dynamic gain of the picture signal. The composite amplitude of the test signal at each APL setting (10%, 50%, and 90%) shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals. The waveform monitor at the receiving end shall be properly calibrated.

The composite test signal shall be observed at the transmission service channel output terminals for a change in line-bar amplitude when the input signal APL is varied. The peak-to-peak variation of the line-bar level for the three APLs, expressed in IRE units, is the dynamic gain of the picture signal.

4.3.2.8 Dynamic gain of the synchronizing signal

4.3.2.8.1 Definition. *Dynamic gain of the synchronizing signal* is a change in transmission service channel gain as measured by the change in the synchronizing pulse peak-to-peak amplitude resulting from variations in APL. It is measured at the transmission service channel output terminals.

4.3.2.8.2 Standard values. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	1.2
Medium Haul	1.6
Satellite	2.0
Long Haul	2.4
End-to-end	2.8

4.3.2.8.3 Method of measurement. Dynamic gain of the synchronizing signal is an out-of-service test. A multisignal waveform, which uses a composite test signal combined with a flat-field signal shown in Figure 21, shall be used to measure dynamic gain of the synchronizing signal. The amplitude of the composite test signal at each APL setting (10%, 50%, and 90%) shall be checked at the sending end prior to the commencement of the test. The waveform monitor at the receiving end shall be properly calibrated. The test signal shall be applied to the transmission service channel input terminals.

The test signal shall be observed for a change in the synchronizing pulse level at the transmission service channel output terminals when the signal APL is varied. The peak-to-peak variation of the synchronizing pulse level for the three APLs, expressed in IRE units, is the dynamic gain of the synchronizing signal.

4.3.2.9 Transient synchronizing signal nonlinearity

4.3.2.9.1 Definition. *Transient synchronizing signal nonlinearity* of a transmission service channel is the departure from equality in the amplitude of the synchronizing pulse tip to blanking level portion of a composite picture signal when the APL is varied abruptly between high and low values. It is measured at the transmission service channel output terminals.

4.3.2.9.2 Standard values. The standard values shall be as shown in the following table:

	IRE Units
Short Haul	1.0
Medium Haul	2.0
Satellite	3.0
Long Haul	4.0
End-to-end	5.0

4.3.2.9.3 Method of measurement. Transient synchronizing signal nonlinearity is an out-of-service test. A flat-field signal superimposed upon standard synchronizing and blanking signals shall be applied to the transmission service channel input terminals. This signal shown in Figure 7 shall be

switched between 10% and 90% APL, with the APL transitions being made in less than 10 microseconds and at intervals not less than five times the settling time of any accompanying transient.

The test signal with alternating APL applied at the input terminals shall be observed at the transmission service channel output terminals on a suitable slow-sweep oscilloscope or waveform monitor. The test signal with alternating APL applied shall be connected through the differentiating network shown in Figure 16 for observation. The waveform monitor should be adjusted to present a highest synchronizing pulse amplitude of 100 IRE units (10% or 90% APL). The envelope of the pulses representing the rise of the synchronizing signal as viewed at slow-sweep speed will show the transient synchronizing signal nonlinearity. The transient distortion is recorded in IRE units relative to the largest amplitude of the synchronizing signal displayed. A photograph of the waveform monitor may aid in determining transient synchronizing signal nonlinearity.

4.3.2.10 Signal-to-weighted-random-noise ratio (10 kHz-4.2 MHz)

4.3.2.10.1 Definition. The *signal-to-weighted-random-noise ratio* is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volt = 100 IRE units), to the weighted RMS noise level. The *noise* referred to is predominantly thermal noise in the 10 kHz-4.2 MHz range. Synchronizing signals are not included in the signal measurement. It is measured at the transmission service channel output terminals.

4.3.2.10.2 Standard values. The standard values shall be as shown in the following table:

	dB
Short Haul	67
Medium Haul	60
Satellite	56
Long Haul	54
End-to-end	54

4.3.2.10.3 Method of measurement. The video signal-to-weighted-random-noise ratio measurement is an out-of-service test. The transmissions service channel shall be operated at standard input and output levels and terminated in a standard load impedance. The video signal is removed. A true RMS reading instrument shall be connected through band-limiting and weighting networks (shown in figures 22(a), 22(b), and 22(c)) to the transmission service channel output terminals prior to the noise measurement. The low-pass port of the 10-kHz combination high-pass/low-pass filter shall be terminated for this test.

The signal-to-weighted-random-noise ratio in dB is computed using the following formula with values expressed in volts:

$$S/N_W \text{ Ratio (dB)} = 20\log_{10} \frac{\text{P–P Luminance Signal Amplitude}}{\text{RMS Weighted Noise}}$$

Where:

    S = signal
    N_W = weighted random noise

4.3.2.11 Signal-to-low-frequency noise ratio (0-10 kHz)

4.3.2.11.1   Definition. The *signal-to-low-frequency-noise ratio* of a transmission service channel is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally, 0.714 volt = 100 IRE units), to the peak-to-peak low-frequency noise voltage. *Low-frequency noise*, as used here, includes all frequencies below 10 kHz and will generally have its source in power supplies. Synchronizing signals are not included in the signal measurement. It is measured at the transmission service channel output terminals.

4.3.2.11.2 Standard values. The standard values shall be as shown in the following table:

	dB
Short Haul	53
Medium Haul	48
Satellite	50
Long Haul	44
End-to-end	43

4.3.2.11.3   Method of measurement. Signal-to-low-frequency-noise ratio is an out-of-service test. The transmission service channel shall be operated at standard input and output levels and terminated in standard load impedances. The video signal is removed. The low-pass portion of the filter shown in Figure 22(b) shall be inserted between the transmission service channel output terminals and the final termination. The high-pass port of the 10-kHz combination high-pass/low-pass filter shall be terminated for this test. The peak-to-peak low-frequency noise can then be measured using an appropriate oscilloscope across the termination.

The signal-to-low-frequency-noise ratio in dB is computed using the following formula with values in IRE units:

$$\text{Signal-to-Low-Frequency-Noise-Ratio (dB)} = 20\log_{10} \frac{\text{P--P Luminance Amplitude}}{\text{P--P Low Frequency Noise Amplitude}}$$

4.3.2.12 Signal-to-periodic-noise ratio (300 Hz-4.2 MHz)

4.3.2.12.1   Definition. *Signal-to-periodic-noise interference of a transmission service channel* is the term applied to an interference that consists of a single frequency or a number of single-frequency components. The *signal-to-periodic-noise ratio* is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volts = 100 IRE units), to the peak-to-peak value of the periodic noise. *Periodic noise* as used here means any frequency between 300 Hz-4.2 MHz. It is measured at the transmission service channel output terminals.

4.3.2.12.2 Standard values. The standard values shall be as shown in the following table:

	dB
Short Haul	67
Medium Haul	62
Satellite	64

Long Haul	58
End-to-end	57

4.3.2.12.3 Method of measurement. Signal-to-periodic-noise ratio is an out-of-service measurement. The flat-field test signal shown in Figure 7(a) shall be used when measuring periodic noise. The amplitude of the test signal is adjusted to 100 IRE units at the sending end prior to commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The amplitude of the bar portion of the test signal shall be adjusted to 100 IRE units at the transmission service channel output terminals. The peak-to-peak amplitude, in IRE units, of periodic noise (300 Hz-4.2 MHz) should be measured. Examples of periodic noise interference are shown in Figure 23.

Alternately, the video input signal is removed, the channel input is terminated, and the band is swept with a frequency-selective voltmeter or spectrum analyzer of sufficiently narrow bandwidth to measure the amplitude of any interfering tones.

The signal-to-periodic-noise ratio in decibels is computed using the following formula:

$$\text{Signal} - \text{to} - \text{Periodic Noise (dB)} = 20\log_{10}\frac{0.714 \text{ Volt}}{\text{P}-\text{P of Periodic Noise Amplitude}}$$

4.3.2.13 Availability of video service

4.3.2.13.1 Definition. The availability of a television transmission service channel is the portion of time that the channel is capable of performing its function. Availability is deemed interrupted for any of the following reasons:

  a) Continuity of the transmission service channel is interrupted;
  b) Picture quality is deemed unusable due to transmission service channel impairment; or
  c) Signal-to-noise ratio is:

    < 37 dB for terrestrial transmission service channels

    < 46 dB for satellite transmission service channel.

4.3.2.13.2 Standard value. The standard value shall be 99.99 percent of the annual operating time.

4.3.2.13.3 Method of measurement. Generally accepted measuring devices shall be used to determine the availability of the video transmission service channel.

4.4 Audio signal performance characteristics

Audio signal performance characteristics are summarized in Tables 8 through 12.

4.4.1 Amplitude response versus frequency

4.4.1.1 Definition. The audio *amplitude response versus frequency* characteristic of a transmission service channel is the amplitude variation as a function of audio frequency of a sine-wave voltage applied to the transmission service channel audio input terminals and measured at the transmission service channel audio output terminals. The amplitude variation is expressed in dB.

4.4.1.2   Standard value. The standard value of the amplitude response versus frequency characteristic is represented in Figure 24.

4.4.1.3   Method of measurement. The measuring equipment shall terminate the input and the output of the audio transmission service channel under test in standard load impedances. The balanced-to-ground connection normally used shall be maintained. The required sequence of bandpass frequencies shall be applied. While the input level for the transmission service channel for each frequency at 0 dBm is maintained, the output level for the transmission service channel shall be measured and recorded. The output level at each frequency shall be compared with the output level at 400 Hz.

4.4.2   Total harmonic distortion plus noise

4.4.2.1   Definition. *Total harmonic distortion plus noise* (4 second/400 Hz/+18 dBm) of a transmission service channel is the distortion of a sinusoidal signal after it has passed through a transmission service channel that causes the generation of components harmonically related to the input sinusoid plus noise produced by the channel.

4.4.2.2   Standard value. The standard value shall be 0.5% at a nominal 400 Hz.

> NOTE – Restrictions of 4.2.2.1.2 apply.

4.4.2.3   Method of measurement. The measuring equipment shall terminate the transmission service channel input and output terminals in standard load impedances. The maximum test tone power, averaged over 1 second, that can be applied to the transmission service channel input terminals at a nominal 400 Hz is +18 dBm with a maximum 4-second duration limit. The tone applied to the transmission service channel input terminals shall have a harmonic distortion of less than 0.05% RMS at its maximum level.

The total harmonic distortion plus noise is measured at the transmission service channel output terminals.

Tone levels shall comply with 4.2.2.

4.4.3   Signal-to-noise ratio

4.4.3.1   Definition. The audio *signal-to-noise ratio* of a transmission service channel is the ratio of peak operating level to the RMS noise level at the transmission service channel output terminals. Noise is any extraneous output signal in the frequency band from 50 Hz-15 kHz.

4.4.3.2   Standard values. The standard values shall be as shown in the following table:

	dB
Short Haul	66
Medium Haul	65
Satellite	58
Long Haul	57
End-to-end	56

> NOTE – Signal-to-noise ratio referenced to +18 dBm.

4.4.3.3   Method of measurement. A composite test signal as shown in Figure 3 shall be applied to the video transmission service channel when performing signal-to-noise measurements. The measuring equipment shall terminate the transmission service channel input and output terminals in standard load impedances. A nominal 400-Hz test tone at 0 dBm or +8 dBm shall be applied to the transmission service channel input terminals and the transmission service channel output signal amplitude measured. Remove the 400-Hz tone from the input to the transmission service channel and terminate the input in a standard load impedance. Measure the noise on the transmission service channel by connecting the output of the transmission service channel through a 15-kHz flat-weighting network (as described in ANSI/IEEE 743) and terminating it in an RMS indicator. Compute the weighted signal-to-noise ratio using the following formula:

Weighted Signal-to-Noise Ratio (dB) = 18 + Received Signal - Noise Signal Level

Where:

   a)   The signals are measured in dBm; and
   b)   Weighted signal-to-noise ratio is referenced to +18 dBm.

4.4.4   Insertion gain

4.4.4.1   Definition. The audio signal *insertion gain* of a transmission service channel is the ratio in dB of the output level of a transmission service channel with respect to its input signal level.

4.4.4.2   Standard value. The standard value shall be 0 dB ± 0.5 dB.

4.4.4.3 Method of measurement. The measuring equipment shall terminate the input and the output of the transmission service channel under test in standard load impedances. The balanced-to-ground connection normally used shall be maintained. A nominal 400-Hz test tone at 0 dBm or at +8 dBm shall be applied to the input of the transmission service channel and the level measured at the transmission service channel output.

4.4.5   Stereo gain difference - A to B channel

4.4.5.1   Definition. The *stereo gain difference (A to B channel)* of a stereophonic audio transmission service channel is defined as the difference in dB between the insertion gains of channels A and B at the same frequency.

4.4.5.2   Standard value. The standard value shall be 1 dB from 50 Hz-15 kHz.

4.4.5.3   Method of measurement. The measuring equipment shall terminate the input and the output of the audio transmission service channel under test in a standard load impedance. The balanced-to-ground connections normally used shall be maintained. The required sequence of bandpass frequencies shall be applied. While the input level for both channels for each frequency at 0 dBm is maintained, the variations in the output level between transmission service channels A and B shall be measured, recorded, and compared.

4.4.6   Stereo phase difference - A to B channel

4.4.6.1   Definition. The *stereo phase difference (A to B channel)* of stereophonic audio transmission service channels is defined as the difference in phase, expressed in degrees, between the output signals of the two transmission service channels when a signal of some specified frequency is applied simultaneously to the transmitting terminals.

4.4.6.2   Standard value. The standard value for the stereo phase difference (A to B channel) is represented in Figure 25.

4.4.6.3   Method of Measurement. The measuring equipment shall terminate the inputs and outputs of the audio transmission service channels under test in standard load impedances. Using an appropriate signal generator and observing signal polarity, a 0-dBm test-tone shall be applied simultaneously to both transmission service channels A and B inputs at the required sequence of bandpass frequencies. While an appropriate phase measuring device is used and signal polarity is observed at the transmission service channel outputs, the phase difference between transmission service channels A and B shall be measured.

4.4.7   Crosstalk plus noise

4.4.7.1   Definition. *Crosstalk plus noise* of an audio transmission service channel is a term used to describe the unwanted coupling of the signal from one transmission service channel into the noise of the other.

4.4.7.2   Standard value. The crosstalk plus noise reading shall not degrade the 15- kHz flat-weighted signal-to-noise reading by more than 0.5 dB. (See ANSI/IEEE 743 for more information on the flat-weighted reading.)

4.4.7.3   Method of measurement. A noise measurement as described in 4.4.3 is taken on the desired transmission service channel and recorded. A test tone complying with 4.2.2 shall then be applied to the other transmission service channel. A second noise measurement shall be taken on the desired transmission service channel and recorded. The two noise readings shall then be compared.

4.4.8   Availability of audio service

4.4.8.1   Definition. The *availability of audio service* of a television transmission service channel is the portion of time that the channel is capable of performing its function. Availability is deemed interrupted for any of the following reasons:

a) Continuity of the transmission service channel is interrupted;
b) Audio quality is deemed unusable due to channel impairment;
c) Signal-to-noise ratio is:
    < 25 dB for terrestrial transmission service channel.
    < 34 dB for satellite transmission service channel.

4.4.8.2   Standard value. The standard value shall be 99.99% of the annual operating time.

4.4.8.3   Method of measurement. Generally accepted measuring devices shall be used to determine the availability of the audio transmission service channel.

4.4.9   Audio to video time differential

4.4.9.1   Definition. *Audio to video time differential* of a transmission service channel is the departure from equality in the transmission time of associated audio and video signals.

4.4.9.2   Standard value. The time differential between the audio signal with respect to its associated video signal shall be in the range of 25 milliseconds lead to 40 milliseconds lag.

4.4.9.3 Method of measurement. The transmission service channel shall be operated at standard input and output levels for both audio and video signals and terminated in standard load impedances. The measurement shall be made using a storage oscilloscope with a dual trace amplifier. Provisions shall be made at the input to simultaneously initiate or interrupt the audio and video signals. The difference is read on the oscilloscope display at the transmission service channel output terminals.

5 BASEBAND TELEVISION INTERFACE AND PERFORMANCE SPECIFICATIONS FOR MIXED ANALOG AND DIGITAL TRANSMISSION

The performance specifications for mixed analog and digital baseband television transmission service channels are under study. As new specifications become available, this clause will be revised to reflect those changes. Until such revisions, baseband performance specifications for mixed analog and digital transmission service channels shall be the same as the performance specifications for analog baseband television (clause 4).

> NOTE – Caution should be exercised in utilization of measurement techniques for mixed analog and digital transmission service channels. For example: A 5-riser modulated staircase signal is not suitable for measuring differential gain and differential phase where a digital codec is used in a circuit.

6 HYPOTHETICAL REFERENCE TRANSMISSION SERVICE CHANNELS

6.1 Terrestrial hypothetical reference transmission service channel

The hypothetical reference transmission service channel shown in Figure 26 comprises the interconnection of an inter-LATA transmission service channel (BC) and two intra-LATA access transmission service channels (AB and CD).

Terrestrial hypothetical reference transmission service channels can utilize radio, copper cable, or fiber as their transmission media. In addition, the modulation techniques adopted on any one of the circuit sections can be analog or digital in nature.

Point A is the sending end of the terrestrial hypothetical reference transmission service channel and is the point at which the program originates (studio or outside location), a switching center, or the location of an international connection.

Point D is the receiving end of the terrestrial hypothetical reference transmission service channel and is a program-mixing or recording center, a broadcasting station, a switching center, or the location of an international connection.

6.2 Satellite hypothetical reference transmission service channel

The terrestrial inter-LATA transmission service channel used in the terrestrial hypothetical reference transmission service channel (Figure 26) can be replaced by a satellite inter-LATA transmission service channel to supply an end-to-end service channel. This combination of channels will then be known as a *satellite hypothetical reference transmission service channel*, as shown in Figure 27.

6.3 Transmission service channels - intra-LATA and inter-LATA

6.3.1 Intra-LATA access transmission service channel

A transmission service channel that provides a transmission path within a LATA to directly connect POTs or NIs. For example:

1. Access transmission service channel AB of Figure 26 comprises a channel that interconnects the POT/NI, point A, the sending terminal station of the terrestrial hypothetical reference transmission service channel and the POT/NI, point B, completely within LATA 1.

2. Access transmission service channel CD of Figure 26 comprises a channel that interconnects the POT/NI, point C, at the interexchange carrier's premise and the POT/Nl, point D, at the receiving terminal station of the terrestrial hypothetical reference transmission service channel, completely within LATA 2.

6.3.2 Intra-LATA local transmission service channel

An intra-LATA local transmission service channel as shown in Figure 28, is a circuit that provides a transmission path between two POTs/NIs within the same LATA. For example, intra-LATA local transmission service channel EF connects the POT/NI at point E, the sending terminal station to the POT/NI at point F, the receiving terminal station within a LATA boundary. An intra-LATA local transmission service channel's length (longest LATA distance) may range up to 500 miles (804 km).

6.3.3 Inter-LATA transmission service channel

A transmission service channel that provides a transmission path between LATAs to directly interconnect two POTs/NIs. For example, inter-LATA transmission service channel BC of Figure 26 comprises a transmission service channel that interconnects the two POTs/Nls at points B and C.

An inter-LATA transmission service channel can fall into one of two categories: 1) a terrestrial inter-LATA transmission service channel; or 2) a satellite inter-LATA transmission service channel.

A terrestrial inter-LATA transmission service channel has been described in 6.1. It can contain many repeater or terminal stations -- depending on its length -- and may range up to 3000 miles (4827 km) or longer.

Satellite inter-LATA transmission service channel GH (Figure 29) connects point G at the sending earth station terminal in a LATA to point H at the receiving earth station terminal in another LATA.

6.4 Hypothetical reference transmission service channels versus transmission performance

Hypothetical transmission service channels and their associated circuits can contain different circuit make-ups and circuit lengths. Each transmission service channel's transmission performance limits can be identified by cross-referencing its make-up or length to the following range definitions.

> NOTE – Although Hypothetical Reference Transmission Service Channels, based strictly on route length, can achieve the parametric performance requirements when a single facility type (and hence a single modulation scheme between the baseband input and output) is employed; lack of similar type facilities (e.g., fiber, microwave, copper) along even a

short route -- necessitating multiple modulation schemes and demodulation at baseband cascade points -- may result in the Service Channel being unable to meet the most stringent requirements for some individual parameters.

6.4.1 Short haul

A transmission service channel the route length of which is 20 miles (32.2 km) or less.

6.4.2 Medium haul

A transmission service channel the route length of which is greater than 20 miles (32.2 km) but less than or equal to 150 miles (241 km).

6.4.3 Long haul

A transmission service channel the route length of which is greater than 150 miles (241 km) but less than or equal to 3000 miles (4827 km).

6.4.4 Satellite

A transmission service channel consisting of one transmitting earth station terminal, one satellite transponder (repeater), and one receiving earth station terminal.

6.4.5 End-to-end

A transmission service channel employing various circuits such as a terrestrial or satellite inter-LATA transmission service channel in conjunction with its associated access transmission service channels.

Table 1 - Short-haul transmission service channel performance specifications – Video

Parameter	Standard Value
Amplitude response versus frequency	Figure 10
(50-IRE-unit sine wave)	+0.7 to -0.7 IRE units
0.1 MHz	+0.7 to -0.7 IRE units
0.5 MHz	+0.9 to -0.9 IRE units
1.0 MHz	+1.0 to -1.0 IRE units
2.0 MHz	+1.2 to -1.1 IRE units
3.0 MHz	+0.6 to -0.6 IRE units
3.58 MHz	+1.2 to -1.1 IRE units
4.2 MHz	
Chrominance-to-luminance gain inequality	+2 to -2 IRE units
Chrominance-to-luminance delay inequality	+20 to -20 nanoseconds
Field-time waveform distortion	3 IRE units peak-to-peak
Line-time waveform distortion	0.5 IRE units peak-to-peak
Short-time waveform distortion	2%
Long-time waveform distortion	8 IRE units peak, 3-second settling time
Insertion gain	+5.9 to -5.5 IRE units
Insertion gain variation	
Hourly	+1.7 to -1.7 IRE
Over one second	+1.2 to -1.2 IRE units
Luminance nonlinearity	2 IRE units
Differential gain	2 IRE units or 2%
Differential phase	0.7 °
Chrominance-to-luminance intermodulation	1 IRE unit
Chrominance nonlinear gain	
20-IRE-unit chroma signal	± 1 IRE unit
80-IRE-unit chroma signal	± 1 IRE unit
Chrominance nonlinear phase	1 °
Dynamic gain of picture signal	2 IRE units
Dynamic gain of the synchronizing signal	1.2 IRE units
Transient synchronizing signal nonlinearity	1.0 IRE units
Signal-to-Weighted-Random-Noise Ratio (10 kHz-4.2 MHz)	67 dB
Signal-to-Low-Frequency-Noise Ratio (0-10 kHz)	53 dB
Signal-to-Periodic-Noise Ratio (300 Hz-4.2 MHz)	67 dB
Availability of Video Service	99.99%

Table 2 - Medium-haul transmission service channel performance specifications – Video

Parameter	Standard Value
Amplitude response versus frequency	Figure 11
(50-IRE-unit sine wave)	
0.1 MHz	+1.5 to -1.4 IRE units
0.5 MHz	+1.5 to -1.4 IRE units
1.0 MHz	+2.1 to -2.0 IRE units
2.0 MHz	+2.8 to -2.7 IRE units
3.0 MHz	+3.6 to -3.3 IRE units
3.58 MHz	+2.1 to -2.0 IRE units
4.2 MHz	+4.2 to -3.9 IRE units
Chrominance-to-luminance gain inequality	+4 to -4 IRE units
Chrominance-to-luminance delay inequality	+33 to -33 nanoseconds
Field-time waveform distortion	3 IRE units peak-to-peak
Line-time waveform distortion	1.0 IRE units peak-to-peak
Short-time waveform distortion	2%
Long-time waveform distortion	8 IRE units peak, 3-second settling time
Insertion gain	+5.9 to -5.5 IRE units
Insertion gain variation	
Hourly	+3.5 to -3.3 IRE units
Over one second	+1.7 to -1.7 IRE units
Luminance nonlinearity	4 IRE units
Differential gain	5 IRE units or 5%
Differential phase	1.3 °
Chrominance-to-luminance intermodulation	2 IRE units
Chrominance nonlinear gain	
20-IRE-unit chroma signal	± 2 IRE unit
80-IRE-unit chroma signal	± 2 IRE unit
Chrominance nonlinear phase	2 °
Dynamic gain of picture signal	3 IRE units
Dynamic gain of the synchronizing signal	1.6 IRE units
Transient synchronizing signal nonlinearity	2.0 IRE units
Signal-to-Weighted-Random-Noise Ratio (10 kHz-4.2 MHz)	60 dB
Signal-to-Low-Frequency-Noise Ratio (0-10 kHz)	48 dB
Signal-to-Periodic-Noise Ratio (300 Hz-4.2 MHz)	62 dB
Availability of Video Service	99.99%

Table 3 - Satellite transmission service channel performance specifications – Video

Parameter	Standard Value
Amplitude response versus frequency	Figure 11
(50-IRE-unit sine wave)	
0.1 MHz	+1.5 to -1.4 IRE units
0.5 MHz	+1.5 to -1.4 IRE units
1.0 MHz	+2.1 to -2.0 IRE units
2.0 MHz	+2.8 to -2.7 IRE units
3.0 MHz	+3.6 to -3.3 IRE units
3.58 MHz	+2.1 to -2.0 IRE units
4.2 MHz	+4.2 to -3.9 IRE units
Chrominance-to-luminance gain inequality	+4 to -4 IRE units
Chrominance-to-luminance delay inequality	+26 to -26 nanoseconds
Field-time waveform distortion	3 IRE units peak-to-peak
Line-time waveform distortion	1.0 IRE units peak-to-peak
Short-time waveform distortion	2%
Long-time waveform distortion	8 IRE units peak, 3-second settling time
Insertion gain	+5.9 to -5.5 IRE units
Insertion gain variation	
Hourly	+2.3 to -2.2 IRE units
Over one second	+1.7 to -1.7 IRE units
Luminance nonlinearity	6 IRE units
Differential gain	4 IRE units or 4%
Differential phase	1.5 °
Chrominance-to-luminance intermodulation	2 IRE units
Chrominance nonlinear gain	
20-IRE-unit chroma signal	± 2 IRE unit
80-IRE-unit chroma signal	± 2 IRE unit
Chrominance nonlinear phase	2 °
Dynamic gain of picture signal	4 IRE units
Dynamic gain of the synchronizing signal	2 IRE units
Transient synchronizing signal nonlinearity	3 IRE units
Signal-to-Weighted-Random-Noise Ratio (10 kHz-4.2 MHz)	56 dB
Signal-to-Low-Frequency-Noise Ratio (0-10 kHz)	50 dB
Signal-to-Periodic-Noise Ratio (300 Hz-4.2 MHz)	64 dB
Availability of Video Service	99.99%

Table 4 - Long-haul transmission service channel performance specifications – Video

Parameter	Standard Value
Amplitude response versus frequency (50-IRE-unit sine wave)	Figure 12
0.1 MHz	+2.5 to -2.4 IRE units
0.1 0.5 MHz	+2.5 to -2.4 IRE units
1.0 MHz	+3.5 to -3.2 IRE units
2.0 MHz	+4.7 to -4.3 IRE units
3.0 MHz	+6.1 to -5.4 IRE units
3.58 MHz	+3.6 to -3.3 IRE units
4.2 MHz	+7.4 to -6.4 IRE units
Chrominance-to-luminance gain inequality	+7 to -7 IRE units
Chrominance-to-luminance delay inequality	+54 to -54 nanoseconds
Field-time waveform distortion	3 IRE units peak-to-peak
Line-time waveform distortion	1.5 IRE units peak-to-peak
Short-time waveform distortion	3.5%
Long-time waveform distortion	8 IRE units peak, 3-second settling time
Insertion gain	+5.9 to -5.5 IRE units
Insertion gain variation	
Hourly	+5.3 to -5.0 IRE units
Over one second	+2.9 to - 2.8 IRE units
Luminance nonlinearity	8 IRE units
Differential gain	8 IRE units or 8%
Differential phase	2.5 °
Chrominance-to-luminance intermodulation	4 IRE units
Chrominance nonlinear gain	
20-IRE-unit chroma signal	± 4 IRE unit
80-IRE-unit chroma signal	± 4 IRE unit
Chrominance nonlinear phase	4 °
Dynamic gain of picture signal	5 IRE units
Dynamic gain of the synchronizing signal	2.4 IRE units
Transient synchronizing signal nonlinearity	4.0 IRE units
Signal-to-Weighted-Random-Noise Ratio (10 kHz-4.2 MHz)	54 dB
Signal-to-Low-Frequency-Noise Ratio (0-10 kHz)	44 dB
Signal-to-Periodic-Noise Ratio (300 Hz-4.2 MHz)	58 dB
Availability of Video Service	99.99%

Table 5 - End-to-end transmission service channel performance specifications – Video

Parameter	Standard Value
Amplitude response versus frequency	Figure 12
(50-IRE-unit sine wave)	
0.1 MHz	+2.5 to -2.4 IRE units
0.5 MHz	+2.5 to -2.4 IRE units
1.0 MHz	+3.5 to -3.2 IRE units
2.0 MHz	+4.7 to -4.3 IRE units
3.0 MHz	+6.1 to -5.4 IRE units
3.58 MHz	+3.6 to -3.3 IRE units
4.2 MHz	+7.4 to -6.4 IRE units
Chrominance-to-luminance gain inequality	+7 to -7 IRE units
Chrominance-to-luminance delay inequality	+60 to -60 nanoseconds
Field-time waveform distortion	3 IRE units peak-to-peak
Line-time waveform distortion	2 IRE units peak-to-peak
Short-time waveform distortion	3.5%
Long-time waveform distortion	8 IRE units peak, 3-second settling time
Insertion gain	+5.9 to -5.5 IRE units
Insertion gain variation	
Hourly	+5.9 to -5.5 IRE units
Over one second	+3.5 to -3.3 IRE units
Luminance nonlinearity	10 IRE units
Differential gain	10 IRE units or 10%
Differential phase	3 °
Chrominance-to-luminance intermodulation	4 IRE units
Chrominance nonlinear gain	
20-IRE-unit chroma signal	± 5 IRE unit
80-IRE-unit chroma signal	± 5 IRE unit
Chrominance nonlinear phase	5 °
Dynamic gain of picture signal	6 IRE units
Dynamic gain of the synchronizing signal	2.8 IRE units
Transient synchronizing signal nonlinearity	5 IRE units
Signal-to-Weighted-Random-Noise Ratio (10 kHz-4.2 MHz)	54 dB
Signal-to-Low-Frequency-Noise Ratio (0-10 kHz)	43 dB
Signal-to-Periodic-Noise Ratio (300 Hz-4.2 MHz)	57 dB
Availability of Video Service	99.99%

Table 6 - Selected frequency values for a 50-IRE-unit sine wave

Frequency (MHz)	IRE Units				
	Short Haul[5]	Medium Haul[6]	Satellite[6]	Long Haul[7]	End-to-End[7]
0.5	+0.7 to -0.7	+1.5 to -1.4	+1.5 to -1.4	+2.5 to -2.4	+2.5 to -2.4
1.0	+0.9 to -0.9	+2.1 to -2.0	+2.1 to -2.0	+3.5 to -3.2	+3.5 to -3.2
2.0	+1.0 to -1.0	+2.8 to -2.7	+2.8 to -2.7	+4.7 to -4.3	+4.7 to -4.3
3.0	+1.2 to -1.1	+3.6 to -3.3	+3.6 to -3.3	+6.1 to -5.4	+6.1 to -5.4
3.58	+0.6 to -0.6	+2.1 to -2.0	+2.1 to -2.0	+3.6 to -3.3	+3.6 to -3.3
4.2	+1.2 to -1.1	+4.2 to -3.9	+4.2 to -3.9	+7.4 to -6.4	+7.4 to -6.4

Table 7 - Short-time waveform distortion graticule limits

Time (μs)	Peak Lobes and/or Overshoots[8]			
	Positive (% amplitude)		Negative (% amplitude)	
	SD=2%	SD=3.5%	SD=2%	SD=3.5%
0.125	8.0	14.0	4.0	7.0
0.200	5.9	10.3	4.0	7.0
0.300	4.5	7.8	4.0	7.0
0.352	4.0	7.0	4.0	7.0
0.400	3.7	6.5	3.7	6.5
0.500	3.2	5.6	3.2	5.6
0.600	2.8	4.9	2.8	4.9
0.700	2.5	4.4	2.5	4.4
0.800	2.3	4.1	2.3	4.1
0.900	2.1	3.8	2.1	3.8
1.000	2.0	3.5	2.0	3.5

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[5] See Figure 10 for the amplitude response versus frequency characteristics.

[6] See Figure 11 for the amplitude response versus frequency characteristics.

[7] See Figure 12 for the amplitude response versus frequency characteristics.

[8] Peak-to-Peak values will be twice the listed values.

Table 8 - Short-haul transmission service channel performance specification analog, diplexed dual-channel audio

| Parameter	Standard
Amplitude response versus frequency	Figure 24
Total harmonic Distortion plus noise (4 sec/400Hz/+18dBm)[9]	0.5%
Signal-to-Noise ratio[10]	66 dB
Insertion gain @ 400 Hz (nominal)	0 dB ± 0.5 dB
Stereo gain difference - A to B channel 50 - 15000 Hz	≤ 1.0 dB
Stereo phase difference - A to B channel 50 - 100 Hz 101 - 7500 Hz 7501 - 15000 Hz	≤ 10° ≤ 3° ≤ 10°
Crosstalk plus noise 50 - 15000 Hz	Crosstalk shall not degrade the measured signal/noise ratio by more than 0.5 dB
Availability of audio service	99.99%
Audio-to-video time differential range	25 ms lead 40 ms lag

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[9] See Notes in 4.2.2.1.2 and 4.4.2.2.

[10] See Note in 4.4.3.2

Table 9 - Medium-haul transmission service channel performance specification analog, diplexed dual-channel audio

Parameter	Standard
Amplitude response versus frequency	Figure 24
Total harmonic Distortion plus noise (4 sec/400Hz/+18dBm)[8]	0.5%
Signal-to-Noise ratio[9]	65 dB
Insertion gain @ 400 Hz (nominal)	0 dB ± 0.5 dB
Stereo gain difference – A to B channel 　　50 - 15000 Hz	≤ 1.0 dB
Stereo phase difference – A to B channel 　　50 - 100 Hz 　　101 - 7500 Hz 　　7501 - 15000 Hz	≤ 10° ≤ 3° ≤ 10°
Crosstalk plus noise 　　50 - 15000 Hz	Crosstalk shall not degrade the measured signal/noise ratio by more than 0.5 dB
Availability of audio service	99.99%
Audio-to-video time differential range	25 ms lead 40 ms lag

Table 10 - Satellite transmission service channel performance specification analog, diplexed dual-channel audio

Parameter	Standard
Amplitude response versus frequency	Figure 24
Total harmonic Distortion plus noise (4 sec/400Hz/+18dBm)[8]	0.5%
Signal-to-Noise ratio[9]	58 dB
Insertion gain @ 400 Hz (nominal)	0 dB ± 0.5 dB
Stereo gain difference - A to B channel 　　50 - 15000 Hz	≤ 1.0 dB
Stereo phase difference - A to B channel 　　50 - 100 Hz 　　101 - 7500 Hz 　　7501 - 15000 Hz	≤ 10° ≤ 3° ≤ 10°
Crosstalk plus noise 　　50 - 15000 Hz	Crosstalk shall not degrade the measured signal/noise ratio by more than 0.5 dB
Availability of audio service	99.99%
Audio-to-video time differential range	25 ms lead 40 ms lag

Table 11 - Long-haul transmission service channel performance specification analog, diplexed dual-channel audio

Parameter	Standard
Amplitude response versus frequency	Figure 24
Total harmonic Distortion plus noise (4 sec/400Hz/+18dBm)[8]	0.5%
Signal-to-Noise ratio[9]	57 dB
Insertion gain @ 400 Hz (nominal)	0 dB ± 0.5 dB
Stereo gain difference - A to B channel 50 - 15000 Hz	 ≤ 1.0 dB
Stereo phase difference - A to B channel 50 - 100 Hz 101 - 7500 Hz 7501 - 15000 Hz	 ≤ 10° ≤ 3° ≤ 10°
Crosstalk plus noise 50 - 15000 Hz	 Crosstalk shall not degrade the measured signal/noise ratio by more than 0.5 dB
Availability of audio service	99.99%
Audio-to-video time differential range	25 ms lead 40 ms lag

Table 12 - End-to-end transmission service channel performance specification analog, diplexed dual-channel audio

Parameter	Standard
Amplitude response versus frequency	Figure 24
Total harmonic Distortion plus noise (4 sec/400Hz/+18dBm)[8]	0.5%
Signal-to-Noise ratio[9]	56 dB
Insertion gain @ 400 Hz (nominal)	0 dB ± 0.5 dB
Stereo gain difference - A to B channel 50 – 15000 Hz	 ≤ 1.0 dB
Stereo phase difference - A to B channel 50 – 100 Hz 101 – 7500 Hz 7501 - 15000 Hz	 ≤ 10° ≤ 3° ≤ 10°
Crosstalk plus noise 50 - 15000 Hz	 Crosstalk shall not degrade the measured signal/noise ratio by more than 0.5 dB
Availability of audio service	99.99%
Audio-to-video time differential range	25 ms lead 40 ms lag

Waveform Terminology

A   The peak-to-peak amplitude of the composite video signal
B   The difference between black level and blanking level (set-up)
C   The peak-to-peak amplitude of the color burst
L   Luminance signal – nominal value
M   Monochrome video signal peak-to-peak amplitude (M = L + S)
S   Synchronizing signal – amplitude
Tb   Duration of breezeway
Tsl   Duration of line blanking period
Tsy   Duration of line synchronizing pulse
Tu   Duration of active line period

Figure 1 - Standard video signal general waveform terminology Video
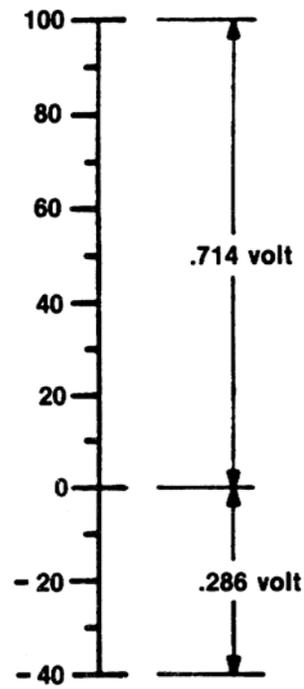
(For a 1V P-P composite signal)

Figure 2 - IRE unit scale
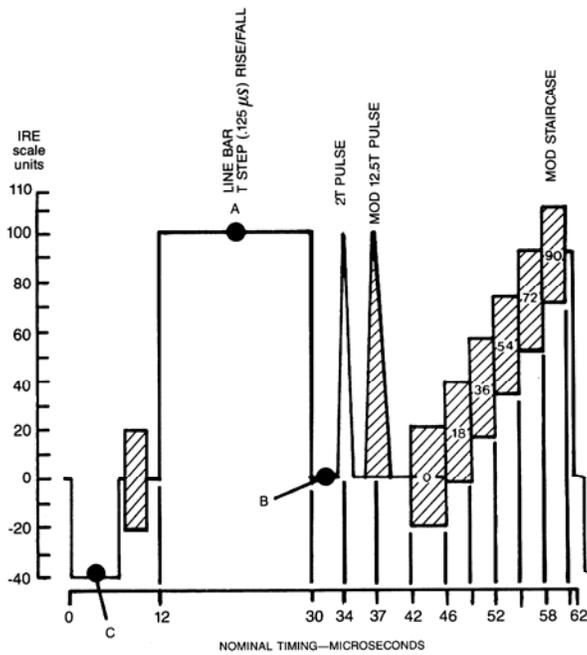
Figure 3 - Composite test signal -- Video
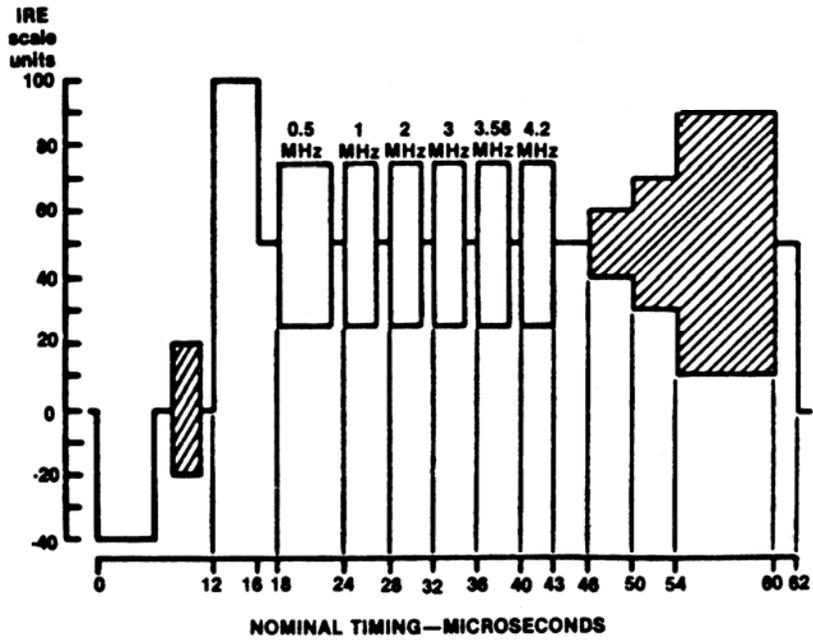
Figure 4 - Combination test signal -- Video
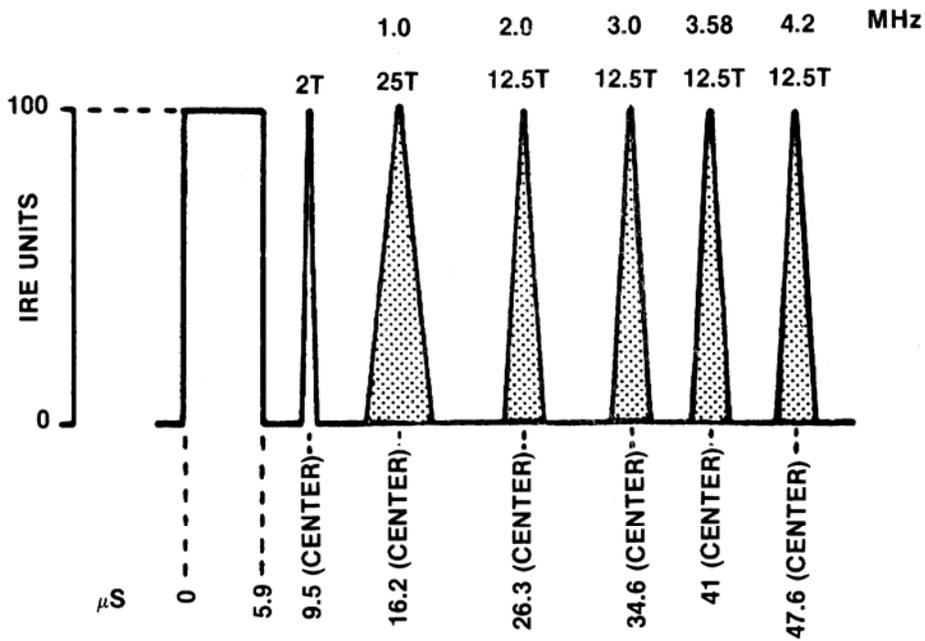
Figure 5 - Multipulse test signal -- Video
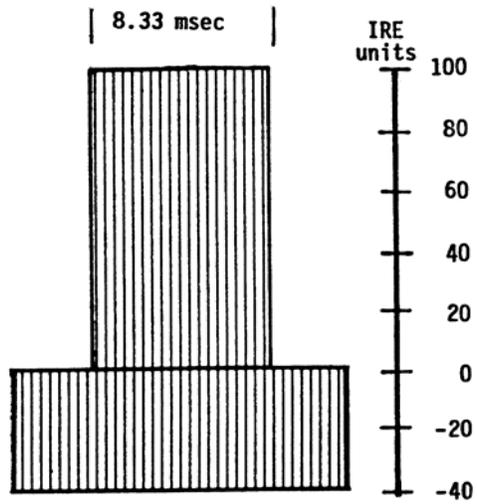
Figure 6 - Field-bar test signal -- Video
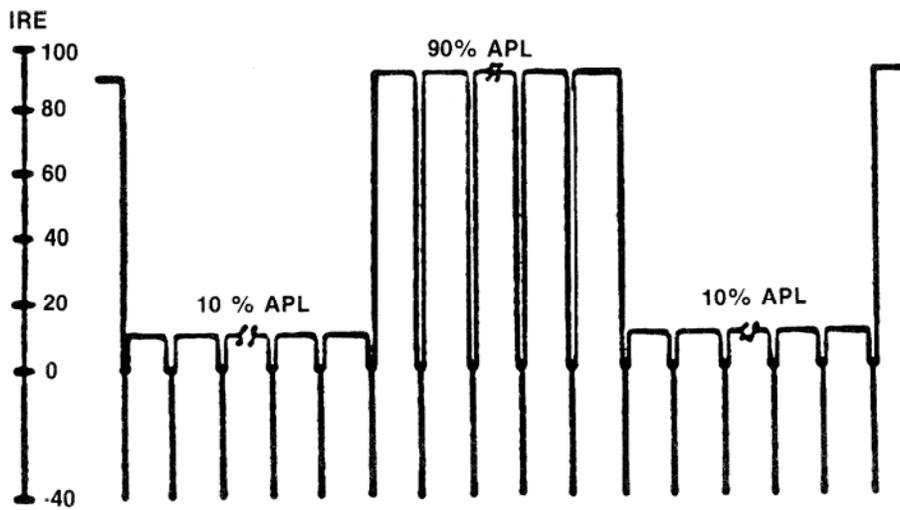
Figure 7 - Flat-field test signal with variable APL -- Video
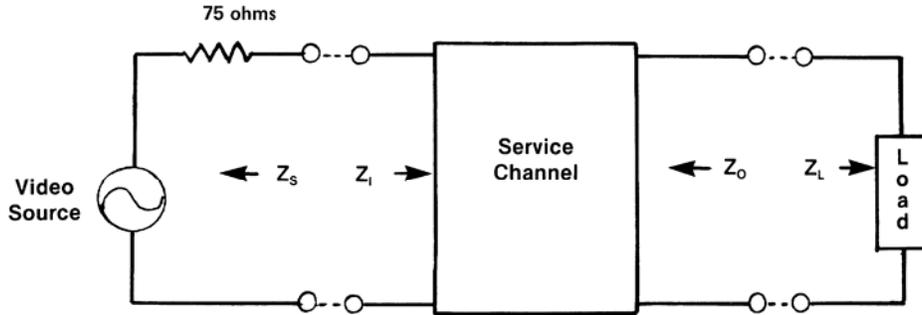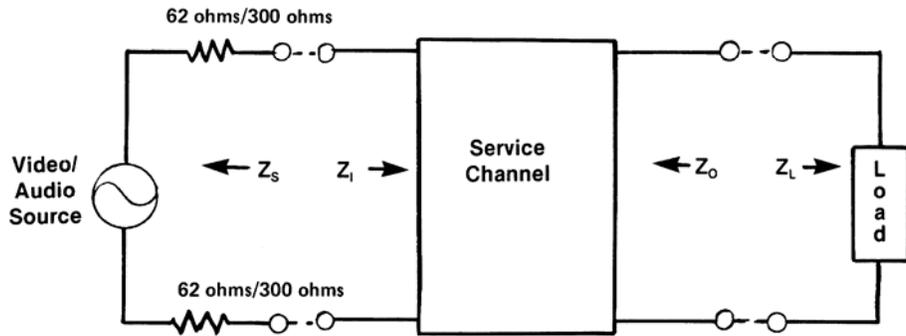
Figure 8 - Impedance reference
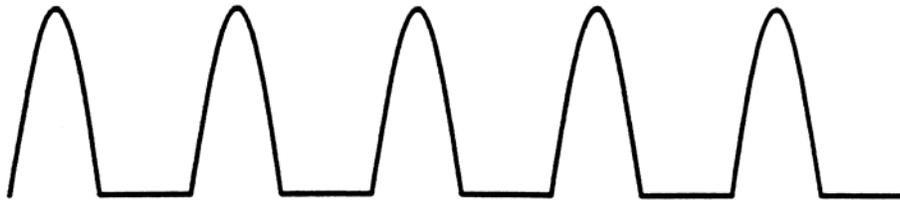
Figure 9 - Polarity test signal -- Audio
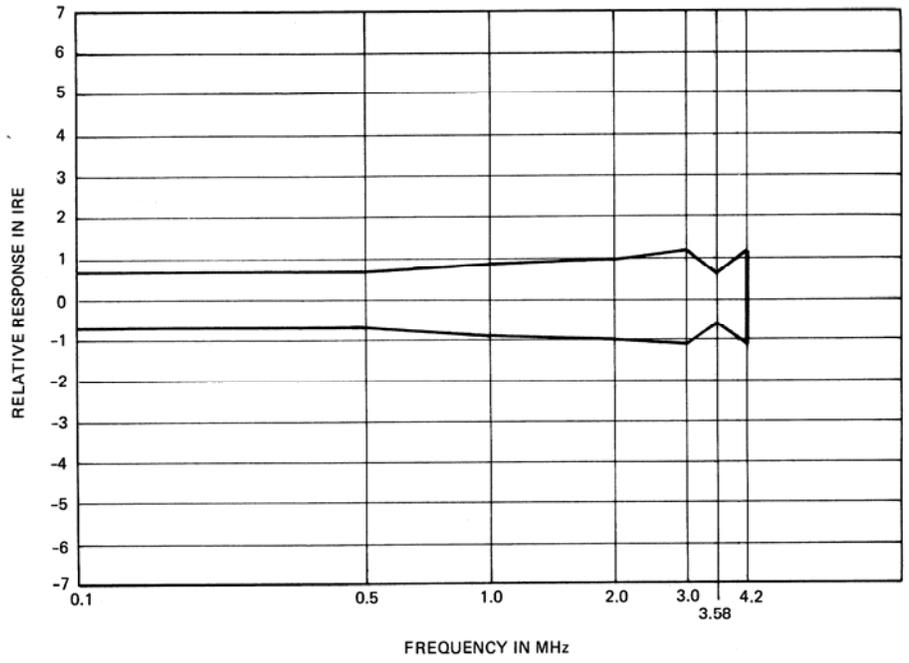
Figure 10 - Short-haul amplitude response versus frequency characteristic -- Video
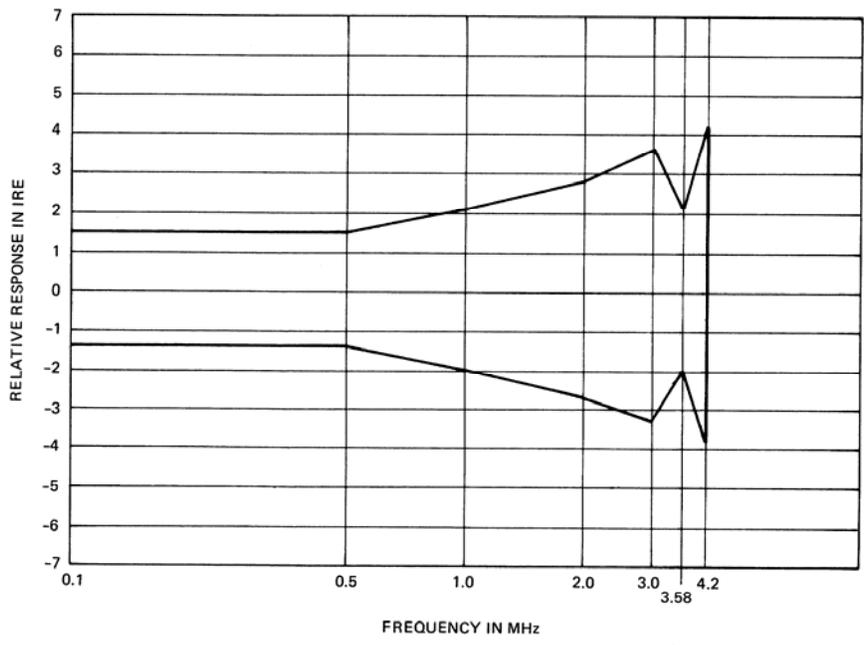
Figure 11 - Medium-haul and satellite amplitude response versus frequency characteristic -- Video
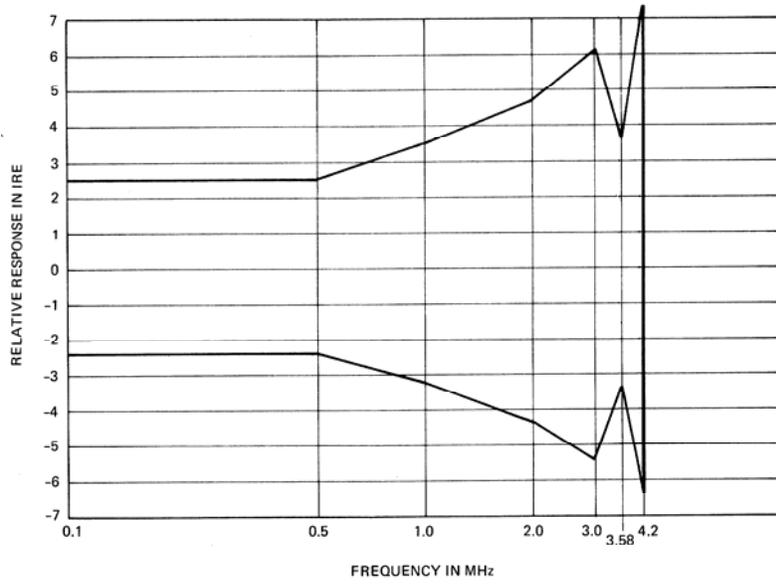
Figure 12 - Long-haul and end-to-end amplitude response versus frequency characteristic -- Video
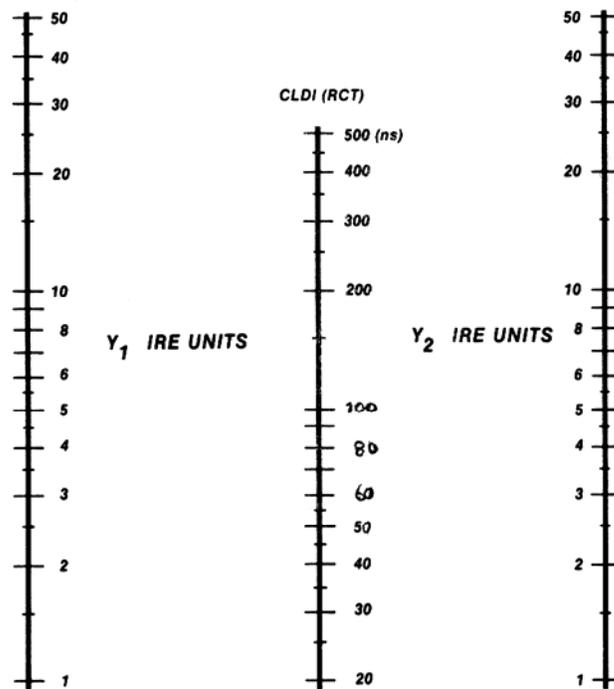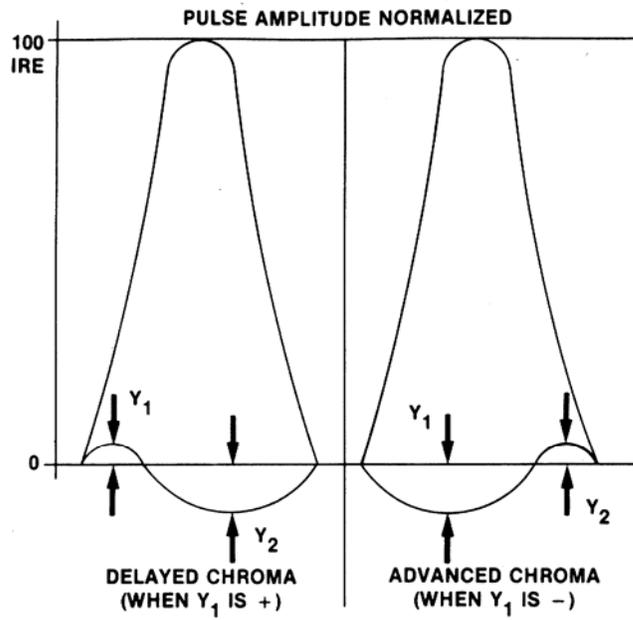
Figure 13 - Chrominance-to-luminance delay inequality nomogram -- Video
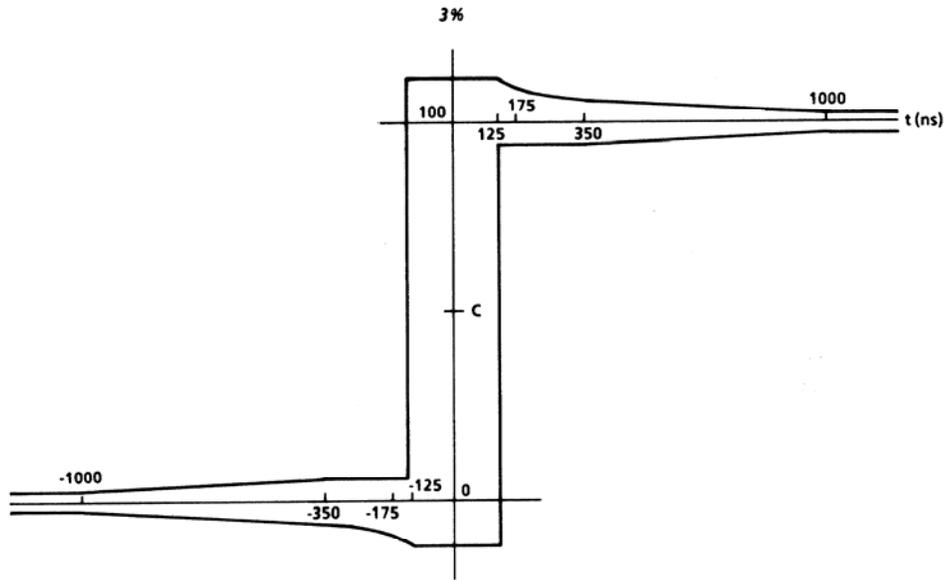
Figure 14 - Short-time waveform distortion measurement (SD) graticule -- Video
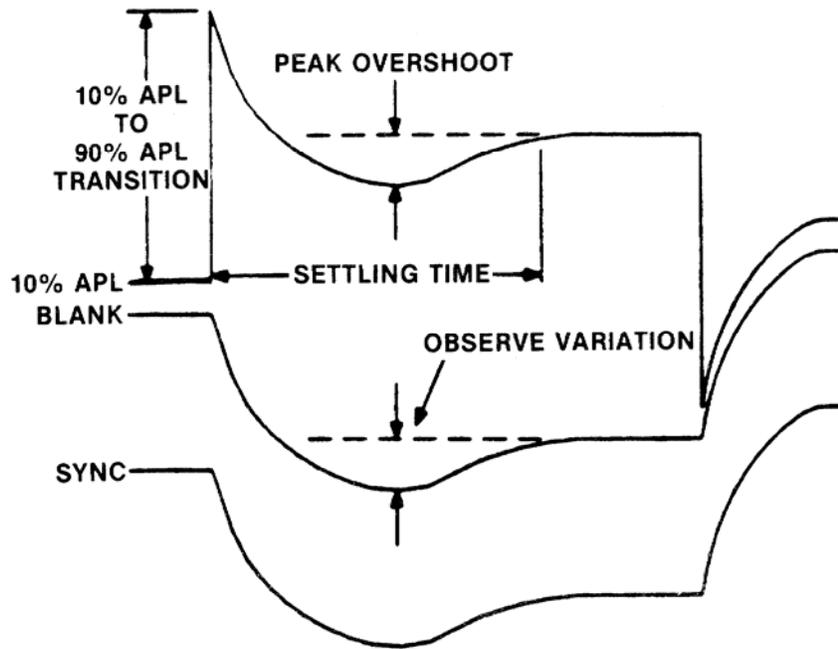
Figure 15 - Long-time waveform distortion example -- Video
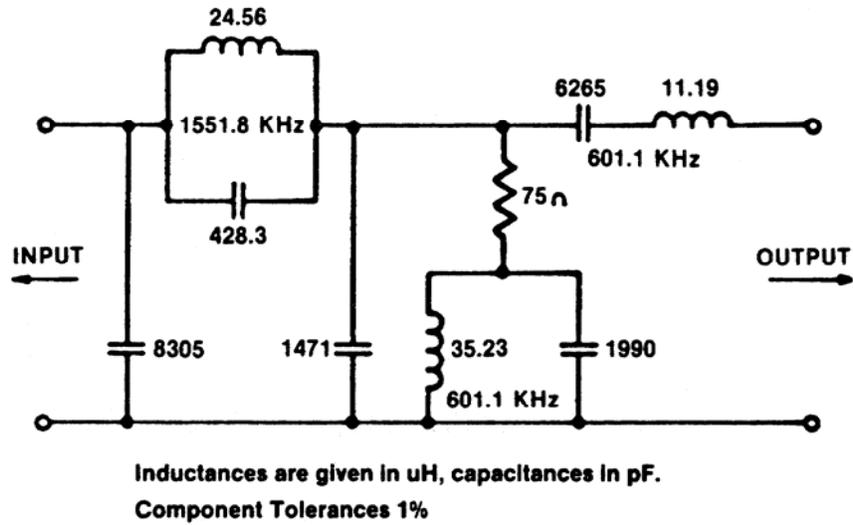
Figure 16 - Differentiating network circuit diagram -- Video
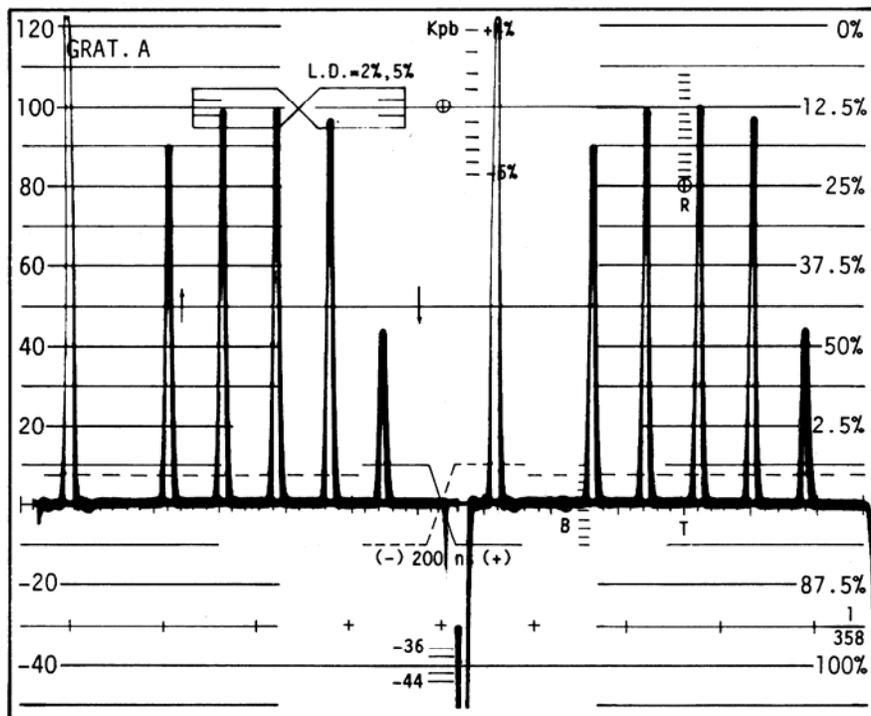
Figure 17 - Luminance nonlinearity distortion example -- Video
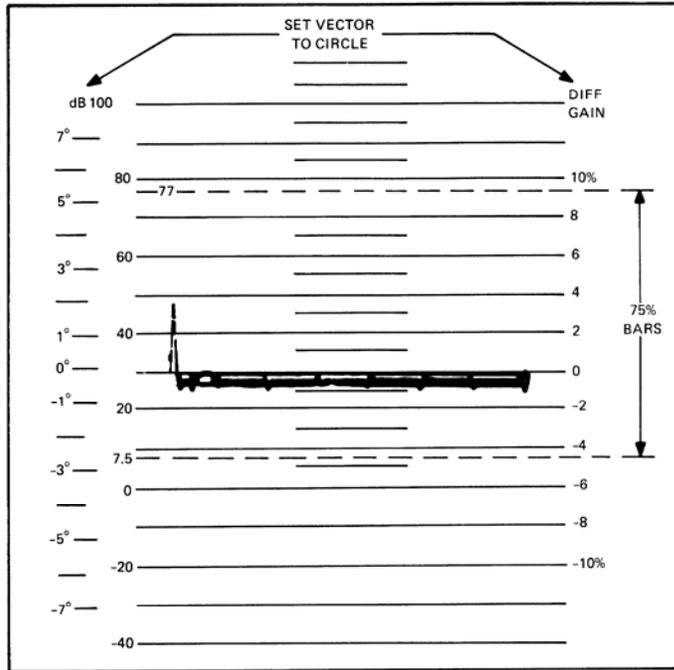
(a) Zero Distortion
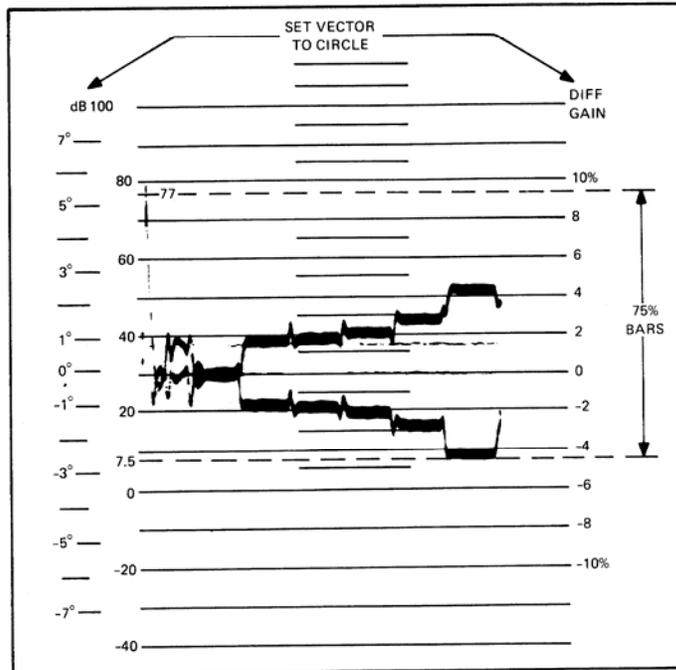
(b) 50% APL

Figure 18 - Vectorscope displays of differential phase -- Video
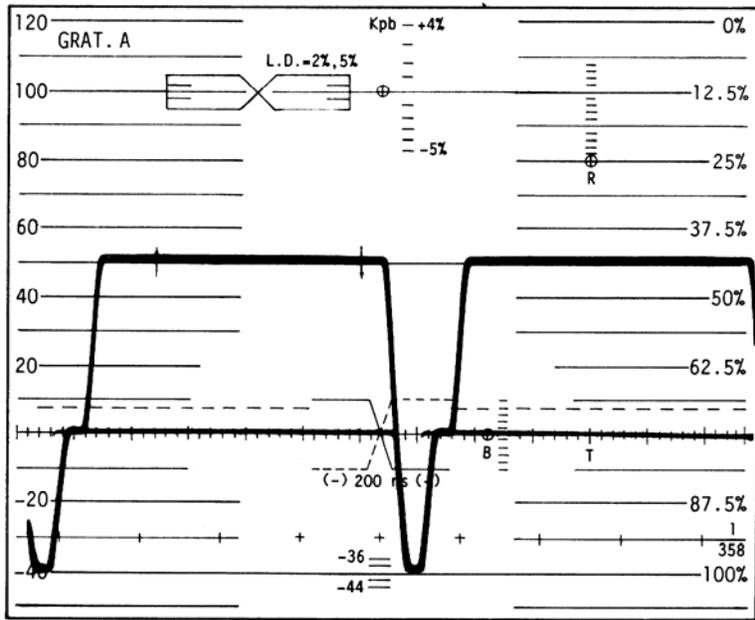
(a) Zero Distortion
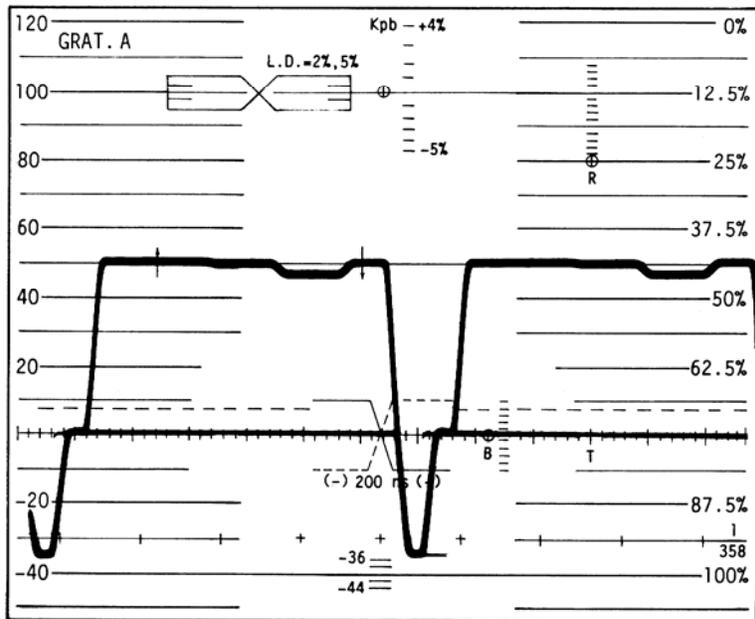
(b) Distortion

Figure 19 - Chrominance-to-luminance intermodulation -- Video

(a) Zero Distortion   (b) Distortion
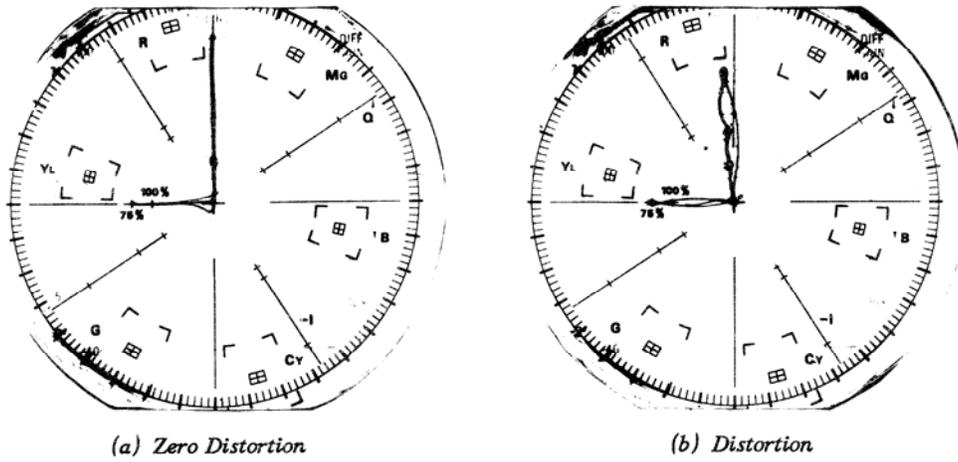
Figure 20 - Vectorscope display of chrominance nonlinear phase
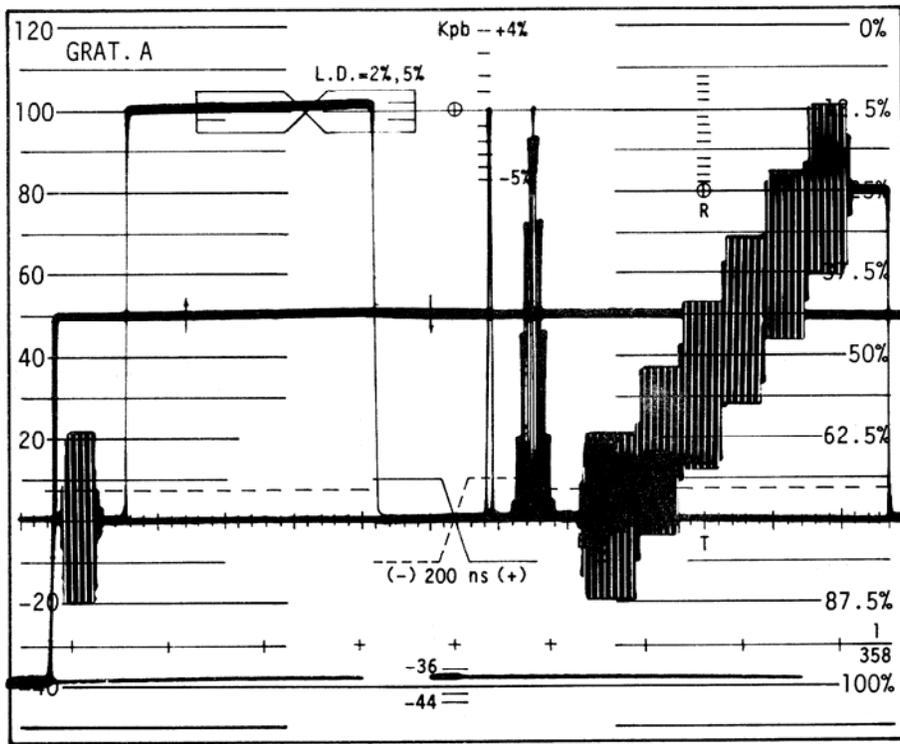
Figure 21 - Dynamic gain distortion of the picture signal composite test signal with flat-field overlay -- Video
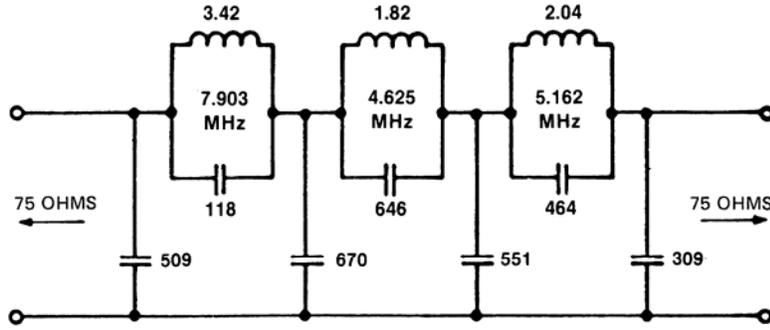
Inductances are given in uH and capacitances in pF. Q
measured at 5 MHz is between 80 and 125 for all inductors.

(a) Low-Pass 4.2 MHz

TABLE OF VALUES

COMPONENT	VALUE	TOLERANCE
C1	139,000	
C2	196,000	± 5%
C3	335,000	
C4	81,200	
L1	0.757	
L2	3.21	± 2%
L3	1.83	
L4	1.29	
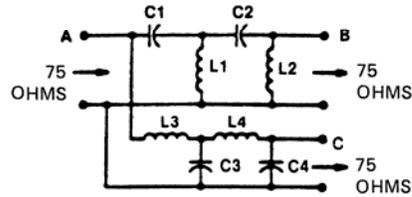
LEGEND:
A = INPUT
B = HIGH-PASS OUTPUT
C = LOW-PASS OUTPUT

(b) Combination 10-kHz High-Pass/Low-Pass — Video
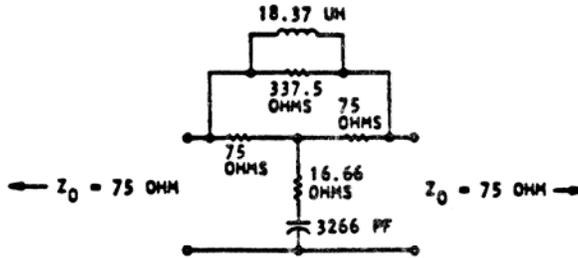
Insertion loss A

$$A = 10 \log \frac{1 + \left[\left(1 + \frac{1}{a}\right)\omega\tau\right]^2}{1 + \left[\frac{1}{a}\omega\tau\right]^2} \qquad \text{dB}$$

at high frequencies: $A_\infty \rightarrow 20 \log (1 + a)$
where:
$\tau = 245$ ns; $a = 4.5$ $\qquad (A_\infty \rightarrow 14.8$ dB$)$

(c) Weighting — Video

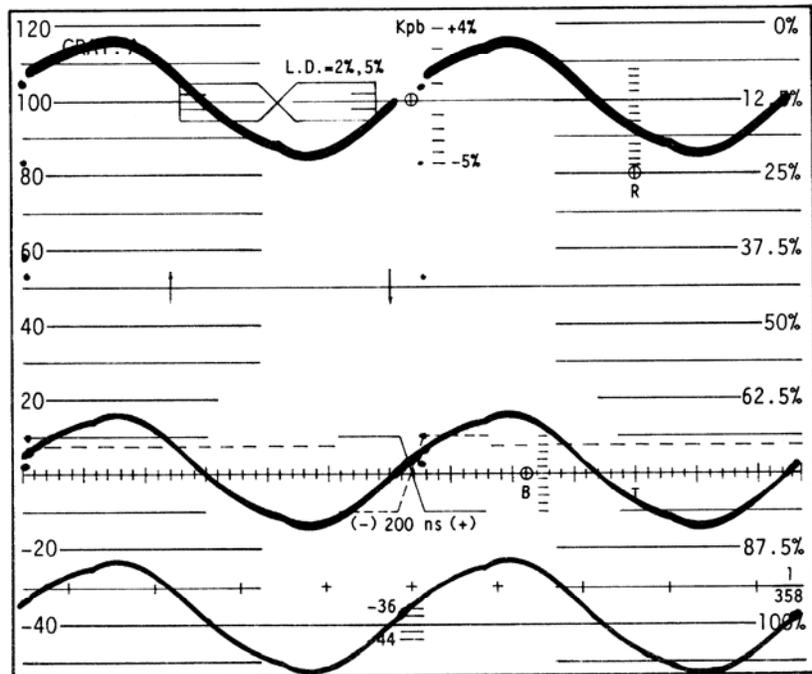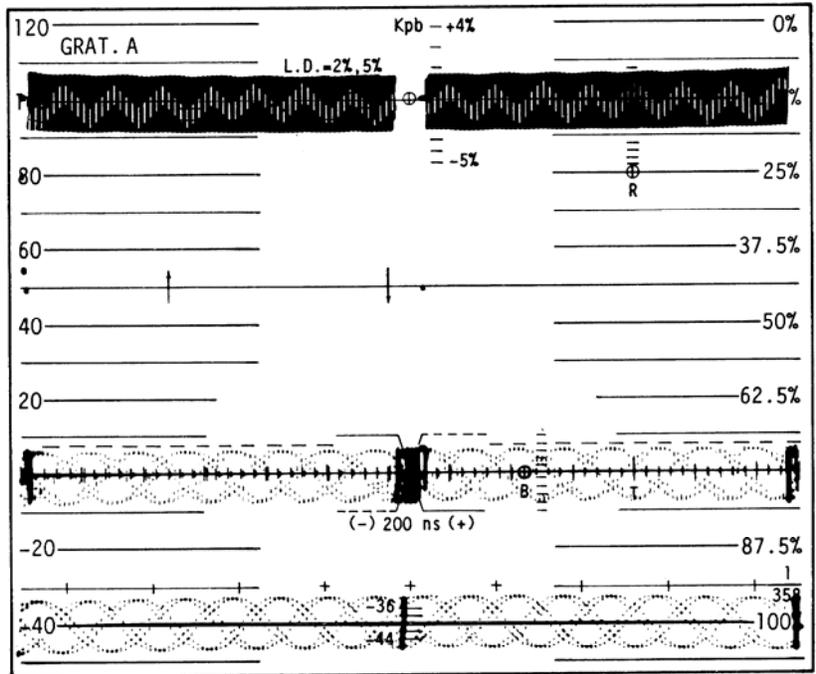**Figure 22 - Noise measurement filters**

51

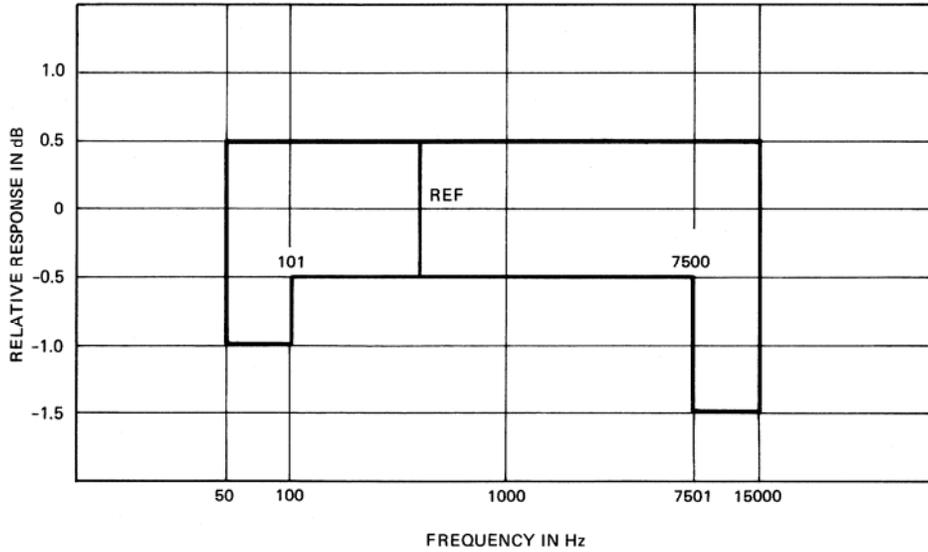**Figure 23 - Signal-to-periodic noise examples -- Video**

Figure 24 - Amplitude response versus frequency characteristic -- Audio
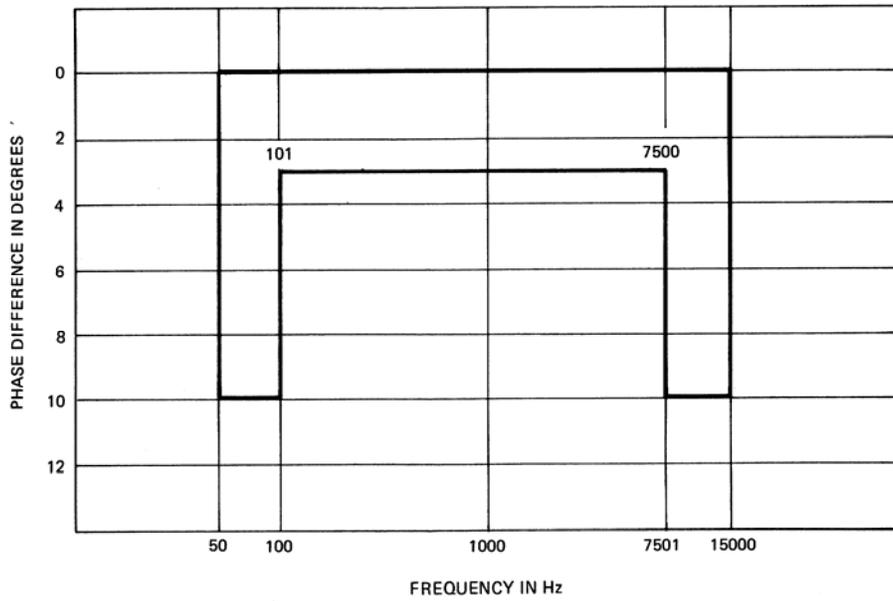

Figure 25 - Stereo phase difference -- A to B channel Audio
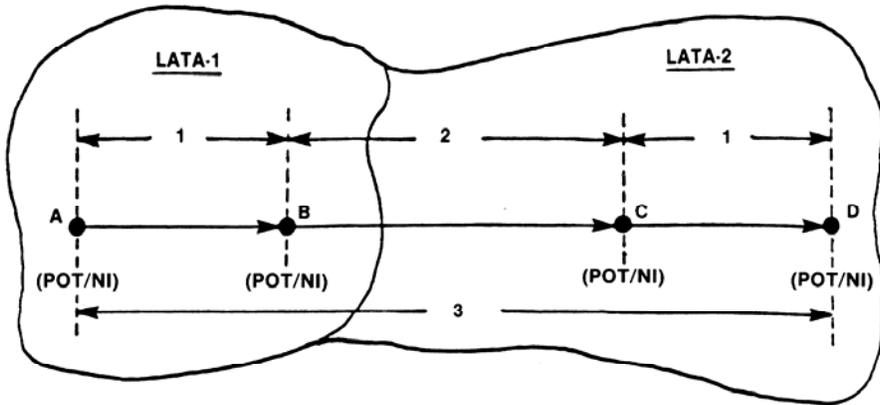
Figure 26 - Terrestrial hypothetical reference transmission service channel
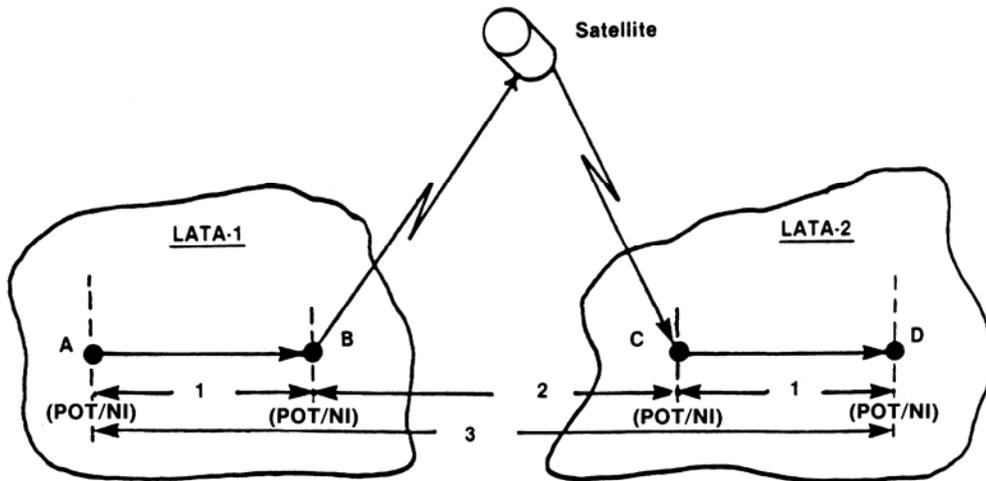

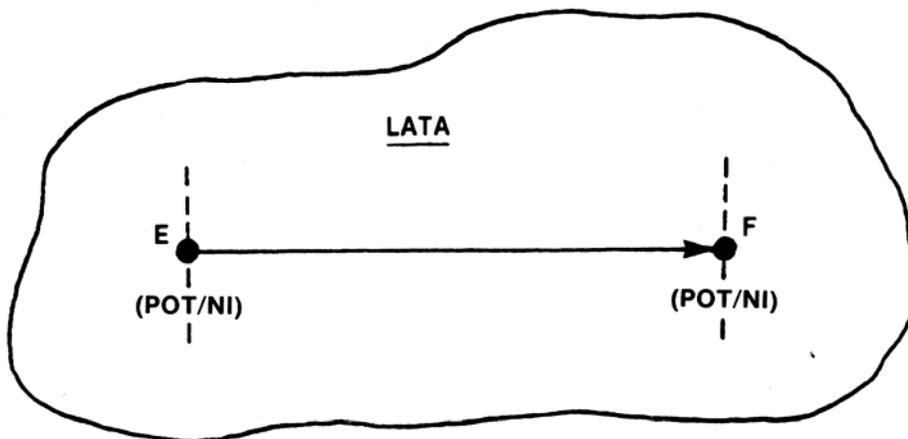**Figure 27 - Satellite hypothetical reference transmission service channel**

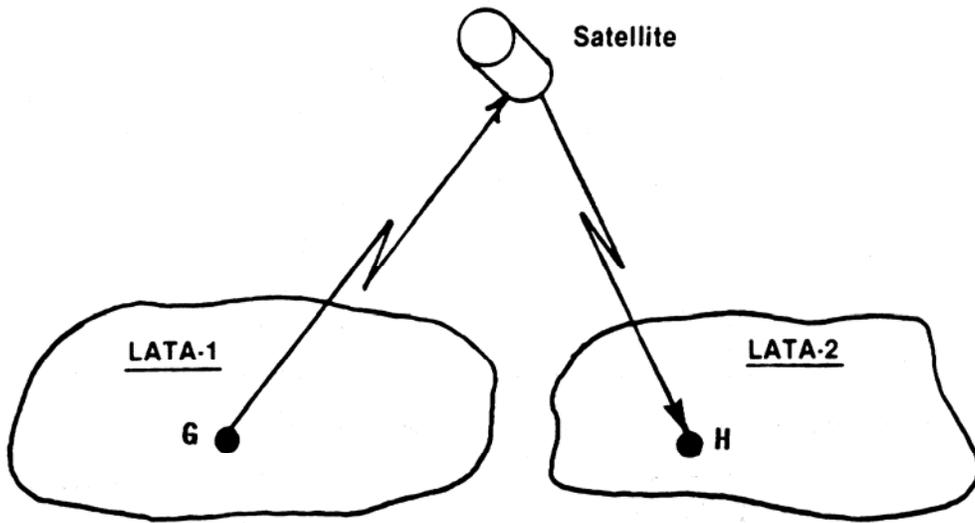**Figure 28 - Intra-LATA local transmission service channel**

Figure 29 - Satellite intra-LATA transmission channel

Annex A
(informative)

A BIBLIOGRAPHY

ANSI/EIA/TIA 250-C-1989, *Electrical Performance for Television Transmission Systems.*[11]

ANSI/SMPTE 170M-1994, Television – Composite Analog Video Signal – NTSC for Studio Applications.[12]

T1.223-2004, *Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Codes for the North American Telecommunications System.*[13]

IEEE 205-1958, *Television – Measurement of Luminance Signal Levels.*[14]

IEEE 511-1979, *Video Signal Transmission Measurement of Linear Waveform Distortion.*[14]

Recommendations and Reports of the CCIR, Geneva, Switzerland: International Radio Consultative Committee (CCIR), 1986.[15]

Volume XI: *Broadcasting Service (Television).*
Volume XII: *Transmission of Sound Broadcasting and Television Signals over Long Distances (CMTT).*

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[11] This document is available from the Telecommunications Industry Association (TIA).
< http://www.tiaonline.org/standards/overview.cfm >

[12] Available from the Society of Motion Picture and Television Engineers, White Plains, NY 10601.

[13] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < https://www.atis.org/docstore/default.aspx >

[14] While these documents are no longer standards, the measurement methods described are still considered valid. Archived versions of these document are available from Global Engineering Documents, 15 Inverness Way East, P.O. Box 1154, Englewood, CO 80150-1154; (800) 854-7179.

[15] Available from the International Telecommunications Union, ITU-R, Geneva, Switzerland.

Annex B
(informative)

B AUDIO LEVELS ON TELEVISION TRANSMISSION CHANNELS

There has been some confusion as to the audio power level expected from the customer on the audio channels associated with a television service, as with a 15kHz program audio channel. To reiterate and amplify upon clause 4.2.2.1.2 above, the interface to the exchange carrier should receive the following power levels:

♦ +8 VU normal operating level -- i.e., recurring peak readings of "0" on a standard Volume Unit indicator (VU meter), which is set up such that a 404-Hz sinusoid test tone of +8 dBm drives the meter to its "0" scale position. See below for more details on level measurement.

♦ +18 dBm, the maximum power on unusual program peaks that are too short to activate the VU meter. (This is basically the RMS power during a full electrical cycle during the program peak; it is not the instantaneous peak power of that cycle, which can be higher.)

♦ 0 dBm, the normal test tone at any frequency and the maximum test tone above 404 Hz.

♦ +8 dBm, the maximum long-term tone up to 404 Hz.

♦ +18 dBm, the maximum short-term test tone at 404 Hz for distortion tests, to be applied for four seconds or less and reapplied only with concurrence of the exchange carrier.

The objectives of these limits are threefold: 1) to prevent crosstalk in audio cabling; 2) to prevent overdriving and resulting clipping in digital coders; and 3) to avoid over-deviation and consequent distortion in FM analog diplexers. The standard pre- and de-emphasis curves used in some systems, particularly FM subcarrier systems, are shown in Figure B.1. To avoid over-driving audio channels in the higher-frequency portion of the pre-emphasis curve, the levels above 404 Hz must be limited.

B.1 Subcarrier Deviation

A maximum deviation of ±185 kHz with +18 dBm input at 404 Hz may be transmitted on subcarrier signals frequency-multiplexed with the video. (It should be noted that +18 dBm tones may not be continuously applied to the audio channels.)

Customer equipment may contain VU meters with calibrations such that a "0" reading on the meter with a sine wave occurs at values other than +8 dBm, for example 0 dBm and +4 dBm. When the lower operating levels are accommodated, sufficient gain shall be applied in the input circuit of the transmit terminal to obtain on the transport facility the telecommunications industry standard operating levels discussed immediately above.

B.2 Maximum Permitted Test-Tone Levels

The maximum continuous test-tone power that may be applied to the transmitting POT is as follows:

♦ +8 dBm0 between 50 Hz and 404 Hz

♦ 0 dBm0 between > 404 Hz and 20 kHz.

An exception to these limits is permitted for measurement of total harmonic distortion plus noise. This level may not be continuously applied to audio channels. Signal-to-noise ratio is referenced to +18 dBm.
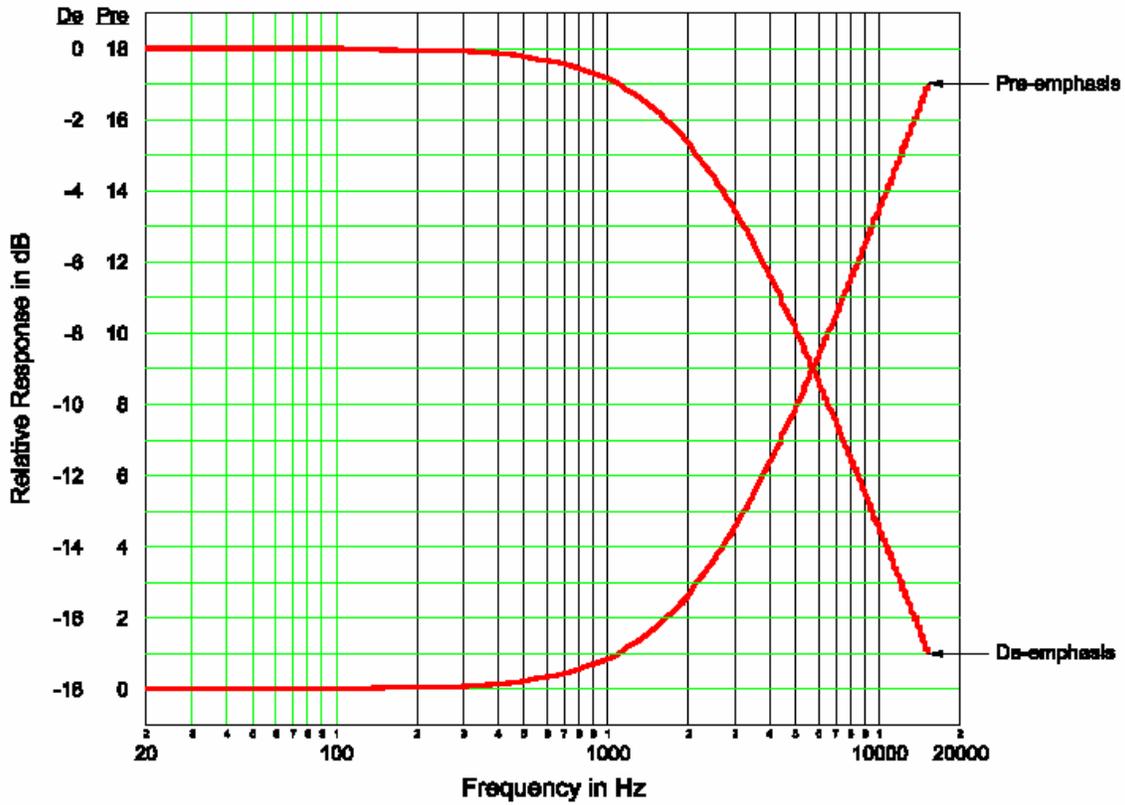

Figure B.1 - Standard Audio Pre/De-emphasis (Time Constant = 75 us)

Annex C
(informative)

C GOOD ENGINEERING PRACTICE FOR AUDIO AND VIDEO

Shielded audio cable pairs should be used. Often, the receive end shield is the only one grounded; this minimizes common mode noise.

It is recommended that the shield of the coaxial video cable not be hardwired to the chassis or green wire of the power cord. This minimizes 60Hz hum or low-frequency common-mode noise.

Annex D
(informative)

D TESTING VIDEO TRANSPORT EQUIPMENT FOR IMMUNITY TO GROUND POTENTIAL INTERFERENCE

D.1 Background

Over the years, as the baseband input to common carrier video transport equipment has shifted from balanced 124 ohms to unbalanced 75 ohms, vendor equipment has also evolved. One of the biggest problems faced by common carrier technicians installing video circuits is the amount of common-mode 60 Hz energy encountered between device grounds during installation. While there are external devices available (hum-buckers) that can reduce the effects of this noise, proper design of the transport equipment is also key. As the regulated telecommunications industry has evolved, there is no one dominant carrier or manufacturer to deal with such undefined parameters. This is an attempt to help define further one of those parameters.

D.2 Differential video input circuit characteristics

The video input to the transport equipment should minimize the amount of hum or common-mode noise that is flowing in the shield of the coaxial cable connecting the customer's signal to the input of the transport equipment. In most permanent installations, this is not a problem as there is a common ground and the cable runs are short. This is the case in most common carrier television operations centers and video production facilities. However, there are situations where equipment is located on different floors or powered from different phases of the AC line, and in those circumstances, common-mode hum can be a problem. This effect is most often encountered on temporary remote feeds where different pieces of equipment have different AC sources -- for example, portable power generators. The one common point in the whole installation is often the common carrier video equipment. It is common knowledge among the video craft that touching the connector on the coaxial cable with one hand and the common carrier equipment with the other can result in a nasty shock. Common carrier video transport equipment must function even under such extreme conditions.

D.3 Circuit description

The testing arrangement illustrated in Figure D.1 specifically tests for common-mode 60 Hz noise that is typically caused by ground loops or current flowing in the cable shield. The circuit uses test equipment that is commonly available in a video shop.

The test signal generator should be capable of generating a video test signal that is at least 10 dB better than the device under test. The generator shown in the drawing has its output BNC connector physically and electrically connected to the case or chassis. This point is also common to the third wire or "green" lead (safety ground) of the equipment. This lead is lifted from the AC mains ground using a two to three wire adapter.

A further modification to the AC power input to the test generator is to insert a 1-ohm resistor in series with the "white" or multi-grounded neutral of the 117 VAC line. The junction of the 1-ohm resistor and the white lead connected to the test generator is then connected to a single-pole, single-throw (SPST) switch. The other lead of the SPST switch is connected to the "green" wire that connects to the chassis

of the test generator. 1000 feet of Belden 8281 (or equivalent) coaxial cable is then connected between the test generator and the device under test (DUT). The DUT is connected to the same power source as the test generator. No modification is made to the power cable of the DUT.

To perform testing, first check to assure that the SPST switch is open and the 1000-foot coaxial cable is disconnected from the DUT. Connect an AC milliammeter between the shield of the coaxial cable and the chassis of the DUT. Next, close the SPST switch and measure the short-circuit current. The 1-ohm resistor should produce a current flow of about 14 ma. If not, substitute the proper resistance needed to produce 14 ma of current. Open the SPST switch, reconnect the coaxial cable to the DUT, and take a baseline video measurement. Next, close the SPST switch and perform a second video measurement. The objective is to assure no more than an additional 1.2 IRE of hum (noise) is induced in the video signal upon switch closure. The 1.2 IRE objective is based on the long-term variation of Dynamic Gain of Synchronizing Signal, which is less than 1.2 IRE. This is the parameter most affected by common-mode noise.
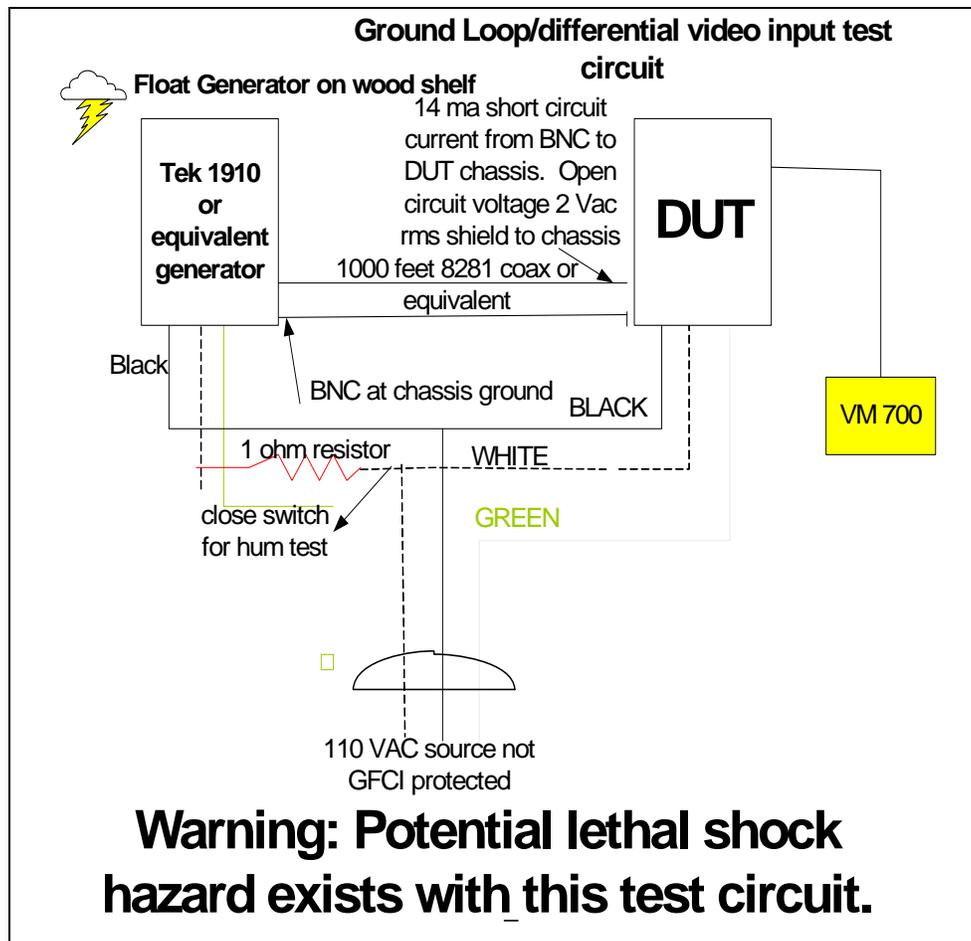

Figure D.1 - Hum Measurement Test Configuration

Annex E
(informative)

E ACCESS SERVICE CHANNEL AND INTERFACE CODES

Network Channel (NC) and Network Channel Interface (NCI) codes are used to facilitate service ordering. These codes provide shorthand notation for the interface attributes and performance characteristics described elsewhere in this document. Typically, customers use these codes in their requests for service. The structures and formats of the Network Channel (NC) and Network Channel Interface (NCI) codes are found in T1.223-2004. These codes are used to describe a service by the technical attributes of its channel and interface(s). These codes are identified in the Common Language® Network Channel and Network Channel Interface Decoder (NC/NCI Decoder) offered by Telcordia Technologies as well as in the technical service publications of individual service providers.