# CEA Standard

## Test Methods of Measurement for Audio Amplifiers

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(Formulated under the cognizance of the CEA's **R3 Audio Systems Committee**.)

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# FOREWORD

This standard was developed under the auspices of the Consumer Electronics Association's (CEA) R4 Video Systems Committee, and is maintained by the CEA's R3 Audio Systems Committee.

Since adoption of the IHF Amplifier Standard (IHF-A-201, 1966), many changes have occurred in amplifier design. These changes have been prompted by technological advancement in circuit topology, in component characteristics, in test equipment and methods of measurement, and in engineering psycho-acoustics. Also, changing conditions in the marketplace driven by consumer demand for new features like home theater and surround sound have prompted industry to consider and implement additional design changes resulting in a proliferation of multi-channel amplifiers in receivers. However, the purpose of an amplifier remains the same—to increase the power level of an electrical signal that represents speech or music. Ultimately, that signal will be reproduced as sound.

EIA-RS-490 (1981), Standard Methods of Measurement for Audio Amplifiers, superseded IHF-A-201 (1966). EIA-RS-490 (1981) was specifically meant to standardize methods of measurement for audio amplifiers. In formulating EIA-RS-490 (1981), greater emphasis was placed upon those characteristics that reflect the ability of an amplifier to faithfully aid in the reproduction of the original sound under conditions similar to those used by the listener. The revised standard test conditions more accurately reflected the performance of the amplifier in actual use.

This standard, CEA-490-A, is the successor to EIA-RS-490. The revisions reflected in EIA-RS-490 (1981) brought the standard in compliance with the Federal Trade Commission (FTC) Rule, Power Output Claims for Amplifiers Utilized in Home Entertainment Products, 46 CFR 432 (1974). The revisions incorporated into this latest edition, CEA-490-A, were motivated by recent changes to the FTC Amp Rule and questions the FTC posed in a subsequent Supplemental Notice of Proposed Rulemaking and include:

a) A standard method for measuring the output power of multi-channel amplifiers used in home theater and surround sound applications;
b) Standard language for primary ratings of amplifiers that allows consumers to make an “apples-to-apples” comparison between various brands and models of amplifiers;
c) Changes in the preconditioning power of amplifiers to make CEA-490-A consistent with changes made by the FTC to its Amplifier Rule as amended in the Federal Register on December 22, 2000;
d) Changes in preconditioning operating time from one-hour to 30 minutes; and
e) The inclusion of a formal Scope section in the standard that clearly defines the audio products are to be covered by CEA-490-A.

> NOTE--Self-powered loudspeakers (including powered speakers used in multimedia applications and powered subwoofers), as well as manufacturer-packaged audio and home theater systems (systems that include loudspeakers), are specifically not covered by CEA-490-A and may be considered under a separate standard-setting activity.

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# CONTENTS

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# Standard Test Methods of Measurement for Audio Amplifiers

## 1 Scope
This standard defines test conditions and test measurement procedures for determining various performance characteristics of single-channel and multi-channel power amplifiers, pre-amplifiers, integrated amplifiers, receivers, and tuner/pre-amplifiers that use AC mains power. These performance characteristics include power output, total harmonic distortion (THD), and sensitivity, among others.

This standard is intended to apply to defined devices intended for home audio and/or professional audio use. In addition, this standard is intended to apply only to those amplifiers that have power output ratings greater than five watts per channel when measured in accordance with the procedures specified herein.

## 2 References

### 2.1 Normative References
The following standards contain provisions that, through reference in this text, constitute normative provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in 2.1.1.

#### 2.1.1 Normative Reference List
Federal Trade Commission (FTC) Power Output Claims for Amplifiers Utilized in Home Entertainment Products, 16 CFR 432

IEC 60651, Sound Level Meters (January, 1979)

ITU-R BS.468-4, Measurement of audio-frequency noise voltage level in sound broadcasting (July, 1986)

#### 2.1.2 Normative Reference Acquisition
FTC:
- FTC Regulations, U.S. Government Printing Office, Washington, DC 20401; Internet http://www.gpo.gov/nara/cfr/index.html

IEC Standards:
- Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet http://global.ihs.com; Email global@ihs.com
- IEC Central Office, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland; Phone +41 22 919 02 11; Fax +41 22 919 03 00; Internet http://www.iec.ch; Email pubinfor@iec.ch

ITU Standards:
- International Telecommunications Union, Place des Nations, CH-1211 Geneva 20, Switzerland; Phone +41 22 730 5111; Fax +41 22 733 7256; Internet http://www.itu.int/publications/itu-r/index.html; Email itumail@itu.int

## 3 Definitions of Terms—General
Within the scope of CEA-490-A, the following definitions shall apply.

### 3.1 Power Amplifier
A device having separate input and output terminals, whose purpose is to provide a larger output power than its required input power over the audio range (or a portion thereof), normally construed to mean 20 Hz to 20 kHz.

For CEA-490-A purposes, the term power amplifier shall also apply to the power amplifier section of an integrated amplifier or receiver.

**3.2 Preamplifier**
A device, having separate input and output terminals, whose purpose is to provide a larger output voltage than its required input voltage over the audio range (or a portion thereof), and/or to provide equalization and/or other controls whose primary function is the adjustment of frequency response and/or output signal level.

For CEA-490-A purposes, the term preamplifier shall also apply to the preamplifier section of any combined audio amplifying product.

**3.3 Integrated Amplifier**
A device combining the function of the power amplifier and the preamplifier, the two sections of which may be, but need not be, electrically separable.

Each section of an integrated amplifier whose power amplifier section is electrically separable from its preamplifier section may be rated separately, or the amplifier may be rated in toto as if such electrical separation did not exist, provided that the ratings clearly indicate to which section (or combination of sections) they apply.

**3.4 Amplifier**
A general term referring to a power amplifier, a preamplifier, or an integrated amplifier.

**3.5 Receiver**
The combination of a tuner and an integrated amplifier. CEA-490-A shall apply only to the amplifier portion of a receiver. For the purposes of rating, said section shall be considered to be an integrated amplifier.

**3.6 Tuner/Preamplifier**
The combination of a tuner and a preamplifier. CEA-490-A shall apply only to the preamplifier portion of a tuner/preamplifier. For the purpose of rating, said section shall be considered to be a preamplifier.

**3.7 Rated Characteristic**
A single value of a characteristic, such as power output, distortion, etc. claimed as representative of the performance of the product and measured in conformance with the tests described in CEA-490-A.

**3.7.1 Rated Frequency**
The frequency at which the performance of an amplifier is tested to measure other characteristics, such as power output, distortion, etc. For CEA-490-A purposes, the rated frequency is 1 kHz.

**3.7.2 Rated Bandwidth**
The frequency range, normally designated by two frequencies (e.g., 20 Hz and 20 kHz) between which the performance of an amplifier is tested to measure other characteristics such as power output, distortion, etc.

**3.7.3 Rated Load**
The load impedance(s) into which the power amplifier is designed to operate and upon which other characteristics, such as power output, distortion, etc. are based.

**3.7.4 Nominal Load**
The load impedance at which the power amplifier is tested to measure other characteristics such as power output, distortion, etc. For CEA-490-A purposes, the nominal load is 8 ohms.

**3.8 Reference Characteristic**
A single value of a characteristic such as input-signal level, output-signal level, etc. that is used as a reference for the measurement of other characteristics, such as sensitivity, noise, etc.

**3.9 Channel of Amplification**
A channel of amplification shall contain at least one set of input terminals and at least one set of output terminals. A multi-channel amplifier shall fulfill these requirements per channel of amplification and shall be capable of amplification in any one channel substantially independent of simultaneous amplification in all other channels of amplification.

**3.10 Line Input**
Any set of input terminals of an amplifier whose primary function is to accept line-level input signals, normally construed to mean input levels in excess of 250 mV.

**3.11 MM-Phono Input**
Any set of input terminals of an amplifier whose primary function is to accept input signals from a moving-magnet, induced-magnet, or other level and impedance-equivalent phono cartridge and to provide appropriate equalization to such signals.

As a point of clarification, such inputs are normally designed to operate from a phono cartridge whose sensitivity is of the order of 0.5 to 2.0 mV/cm/s and is meant to be terminated with an impedance of greater than 10 k ohms.

**3.12 MC-Phono Input**
Any set of input terminals of an amplifier whose primary function is to accept input signals from a low impedance moving-coil or other level- and impedance-equivalent phono cartridge and to provide appropriate equalization to such signals.

As a point of clarification, such inputs are normally designed to operate from a phono cartridge whose sensitivity is of the order of 200 µV/cm/s or less, and that is meant to be terminated with an impedance of less than 10 k ohms.

**3.13 Percentage of Xth Harmonic Distortion**
The percentage of Xth harmonic distortion of a sine wave of frequency f is numerically equal to 100 times the ratio of the RMS voltage of the signal component at frequency Xf, to the RMS voltage of the signal component at frequency f.

**3.14 Percentage of Total Harmonic Distortion (THD)**
The percentage of total harmonic distortion (THD) of a sine wave of frequency f is numerically equal to 100 times the ratio of the square root of the sum of the squares of the RMS voltages of each of the individual harmonic components, to the RMS voltage of the fundamental.

> NOTE—For rating purposes, all harmonics whose amplitude exceeds 10% of the amplitude of the strongest harmonic component shall be included in the summation.

**3.15 Percentage of Weighted Total Harmonic Distortion (WTHD)**
The percentage of weighted total harmonic distortion (WTHD) of a sine wave of frequency f is numerically equal to 100 times the ratio of the square root of the sum of the squares of the amplitudes of each of the individual harmonics, each weighted in accordance with a particular algorithm, to the RMS voltage of the fundamental.

> NOTE—For rating purposes, all harmonics used shall be stated and all harmonics whose weighted amplitude exceeds 10% of the strongest weighted amplitude shall be included in the summation.

**3.16 Percentage of Total Harmonic Distortion Plus Noise (THD+N)**
The percentage of total harmonic distortion plus noise (THD+N) is defined as the reading of a device that measures in accordance with 4.9.3.

> NOTE—For rating purposes, a measurement of THD+N may be substituted for a measurement of THD, wherever the latter is called for, however, such measurement shall be designated as (THD+N).

**3.17 Percentage of SMPTE Intermodulation Distortion (SMPTE-IM)**
The percentage of SMPTE intermodulation distortion (SMPTE-IM) of a composite signal composed primarily of two sinusoidal signals, one having a relatively low frequency ($f_1$) and the other having a relatively high frequency ($f_2$); the low frequency sine wave having an amplitude 4 times greater than that of the high frequency sine wave, shall be the reading of a device that measures in accordance with 4.9.4.

NOTE—For CEA-490-A purposes, $f_1$ shall equal 60 Hz, and $f_2$ shall equal 7 kHz.

The percentage of SMPTE-IM is equivalent to 100 times the ratio of the average variation in amplitude of the higher frequency to the amplitude of the higher frequency (see 4.9.4).

**3.18 Percentage of Dual Tone Intermodulation Distortion**

The percentage of dual tone intermodulation distortion of a composite signal composed primarily of two relatively high frequency sinusoidal signals, one having a frequency $f_1$ and the other having a frequency $f_2$, of equal amplitude, is numerically equal to 100 times the square root of the sum of the squares of the second-through fifth-order distortion components divided by the square root of the sum of the squares of the amplitudes of the components at frequencies $f_1$ and $f_2$, as follows:

$$\text{IM Distortion \%} = \frac{\sqrt{\left(V_{f3}^2 + V_{f4}^2 + V_{f5}^2\right)}}{\sqrt{\left(V_{f1}^2 + V_{f2}^2\right)}}$$

where: $V_{f1}$ = RMS voltage @ 19 kHz
$V_{f2}$ = RMS voltage @ 20 kHz
$V_{f3}$ = RMS voltage @ 1 kHz
$V_{f4}$ = RMS voltage @ 18 kHz
$V_{f5}$ = RMS voltage @ 17 kHz

The second-order distortion components are defined as the two components at frequencies $f_1 \pm f_2$. The third-order distortion components are defined as the four components at frequencies $2f_1 \pm f_2$ and $2f_2 \pm f_1$. The fourth-order distortion components are defined as the two components at frequencies $2f_1 \pm 2f_2$. The fifth-order distortion components are defined as the four components at frequencies $3f_1 \pm 2f_2$ and $3f_2 \pm 2f_1$.

NOTE—For rating purposes, all distortion components whose frequency is less than or equal to 20 kHz and whose amplitude exceeds 10% of the amplitude of the strongest distortion component shall be included in the summation.

**3.19 Transient Intermodulation Distortion (TIM)**

Transient Intermodulation Distortion (TIM) is a form of dynamic intermodulation distortion that may be associated with feedback amplifiers that use internal lag-compensation, and is caused by the non-linear operation (slew-limiting) of one or more of the gain stages within the feedback loop, under conditions that include a rapid change input voltage.

NOTE—Several methods for the measurement of TIM have been proposed in the literature. CEA-490-A does not p
provided that the method is stated with the results of the measurement.

**3.20 Power Output**

Power output in watts of a sinusoidal signal is numerically equal to the square of the RMS voltage measured in volts at the amplifier output, divided by the load resistance in ohms.

NOTE—For the purposes of CEA-490-A, all power or power-out ratings shall be calculated from a voltage measurement in accordance with 5.1.

**3.20.1 dBW**

The dBW is an alternate recommended logarithmic power-rating scale. 0 dBW is defined as equivalent to 1 watt.

Power ratings in dBW are numerically equal to 10 times the common logarithm of the power in watts.

**3.21 Weighting**

Weighting is an adjustment of measurements in order to account for factors that in the normal use of the device would otherwise be different from the conditions during measurement.

**3.22 Clipping Point**
Clipping point is defined as the maximum sine wave signal level (measured at the output or input terminals, as applicable) which, when viewed on an oscilloscope (see 4.9.7) connected to the output terminals, shows no visible signs of clipping, flat-topping or other indication of distortion to the trained observer.

**3.23 Pink Noise**
Pink noise is defined as random noise that has been weighted with frequency to produce constant noise power per octave.

**3.24 Slew Factor**
Slew factor is defined as the ratio of the highest frequency that can be applied at the input terminals of an amplifier, at an input signal level that produces rated output at 1 kHz, and be reproduced at the output terminals with acceptable linearity, to 20 kHz. The procedure specified in 5.18 shall be followed.

**4 Standard Test Conditions**
Standard test conditions shall be maintained for all tests except as otherwise specified in CEA-490-A.

**4.1 AC Power Line**
Unless designed for operation exclusively from other power-line voltages and/or frequencies, the amplifier shall be tested at 120 volts, ± 1% RMS, at 60 Hz ± 2%. The power-line voltage waveform shall be sinusoidal with less than 3.5% harmonic content.

> NOTE—Direct-current-powered amplifiers shall be tested at the recommended supply voltage ±1%, and this voltage shall be stated.

**4.2 Operating Temperature**
The amplifier shall be pre-conditioned and tested in an ambient temperature of at least 25°C, in still air, and in normal operating condition. Shields, covers and bottom plates shall be in place and fastened if normally supplied. If accessory cases are available, the one resulting in the highest operating temperature shall be used.

**4.2.1 Power or Integrated Amplifier, or Receiver Preconditioning**
A power amplifier, integrated amplifier, or receiver shall be preconditioned by driving all channels simultaneously with a 1 kHz sinusoidal signal to a nominal power output into the rated load equal to one-eighth of the rated power output until 30 minutes of operating time has been accumulated. If thermal sensors or other protective devices are used, and if they should disable the amplifier periodically during the preconditioning, only those intervals during which the aforesaid percentage of rated power is being delivered into the load shall be considered as part of the preconditioning time.

**4.2.2 Preamplifier Pre-Conditioning**
A preamplifier shall be preconditioned by operating it undriven for 30 minutes.

**4.3 Input Reference Level**

**4.3.1 Line Input Terminals**
The input reference level for line-input terminals shall be 0.5 V RMS.

**4.3.2 MM-Phono Inputs**
The input reference level for MM-phono inputs shall be 5 mV RMS at 1 kHz.

**4.3.3 MC-Phono Inputs**
The input reference level for MC-phono inputs shall be 500 μV RMS at 1 kHz.

**4.4 Output Reference Level**
For output terminals whose primary function is to deliver signal voltage to a subsequent device, such as those found on a preamplifier, the output reference level shall be 0.5 V RMS.

For output terminals whose primary function is to deliver signal power to a loudspeaker, such as those found on a power amplifier, the output reference level shall be 1 watt.

**4.5 Load Impedance**
Each output terminal whose primary function is to deliver signal voltage to a subsequent device (*e.g.* an output terminal on a pre-amplifier) shall be terminated with a load consisting of a 10 k ohm ± 5% resistor in parallel with a 1000 pF ± 5% capacitor.

Each channel of a power amplifier shall be terminated with a resistive load of 8 ohms. The resistor shall have not more than 10% reactive component at any frequency up to five times the highest test frequency and shall be capable of continuously dissipating the full output of the amplifier while maintaining its resistance within 1% of its rated value.

**4.6 Input Termination**

**4.6.1 Each Line**
The input termination for each line input shall consist of a 1 k ohm ± 10% resistor.

**4.6.2 Each MM-Phono Input**
The input termination for each MM-phono input shall consist of a 1 k ohm ± 10% resistor.

**4.6.3 Each MC-Phone Input**
The input termination for each MC-phono input shall consist of a 10 ohm ± 10% resistor.

**4.7 Connection of AC Line Cord**
The AC power cable shall be grounded at only one end.

**4.8 Control Settings**

**4.8.1 Gain Control**
Gain controls, whose primary function is the simultaneous adjustment of gain of all inputs, shall be preset so that a reference-input level produces a reference-output level except that the gain control of a power amplifier (if available) shall be preset to the position of maximum gain.

**4.8.1.1 Input-Gain**
Input-gain controls whose primary function is the adjustment of gain from a single input (as, for example, phono level controls meant to equalize the output signal level when switching between the phono input and line-level inputs), shall be preset to the position of maximum gain.

**4.8.1.2 Balance**
Balance control shall be set to the normal position as indicated by markings.

**4.8.2 Tone, Loudness-Contour and Other**
Tone, loudness-contour, and other controls, whose primary function is the adjustment of frequency response, shall be switched out (if possible) or shall be preset for flattest electrical frequency response as indicated by markings.

**4.9 Test Equipment**
The net input impedance of all test equipment connected to the output terminals shall be considered as a portion of the load impedance.

The net source impedance of all test equipment connected to the input terminals shall be considered as a portion of the input termination impedance.

**4.9.1 Test Frequency**
The test frequency shall be within 1% of specified value.

**4.9.2 Voltmeter**
The voltmeter shall have true RMS characteristics to an accuracy of at least ± 2% of full scale at any frequency to be measured.

The indicator range shall be set to the most sensitive position capable of indicating the reading.

**4.9.3 Harmonic Distortion Measurement Device**
The harmonic distortion measurement device shall be capable of measuring distortion components within a 50 kHz bandwidth to an accuracy of at least ± 3% of full scale.

**4.9.4 SMPTE Intermodulation-Distortion**
The SMPTE intermodulation-distortion-measurement device shall measure the average variation in amplitude of a 7 kHz signal in the presence of a 60 Hz signal of four times greater amplitude and shall express, as a percentage, the ratio of such variation in amplitude to the amplitude of the 7 kHz signal.

**4.9.5 Dual Tone Intermodulation Distortion**
The dual tone intermodulation distortion (formerly IHF intermodulation distortion) measurement device shall measure dual tone intermodulation distortion as defined in 3.18. A spectrum analyzer is recommended.

**4.9.6 Spectrum Analyzer**
A spectrum analyzer is recommended as the measurement device for distortion defined in 3.13, 3.14, 3.15, and 3.18. The spectrum analyzer shall have a bandwidth of at least 50 kHz and a residual internal noise, resolution, and integration time sufficient to establish the reliability of each reading within an accuracy of 20%.

**4.9.7 Oscilloscope Display**
The oscilloscope shall be capable of displaying the waveform of an input signal between dc and 100 MHz as a vertical deflection to ± 5% accuracy. The oscilloscope shall be capable of triggered sweep. A means of expanding the time base, either by means of a delayed sweep or by means of a sweep magnifier, is helpful for certain tests. The sweep time calibration shall be accurate within 10%.

**4.9.8 A-Weighted Noise Measurement Device**
The A-weighted noise measurement device shall have the characteristics of a sound-level meter, A-scale in accordance with IEC 60651, and shall have unity gain at a frequency of 1 kHz. When testing products such as switch-mode amplifiers that may have large out-of-band noise levels due to either digital noise-shaping methods or incompletely attenuated output stage PWM ripple, sharp cut-off 20 kHz filters of either analog or digital origin are needed to make proper A-weighted measurements.

**4.9.9 ITU-R/ARM Noise Measurement Device**
The ITU-R/ARM noise measurement device shall have the characteristics recommended by ITU-R BS.468-4 except that the unity-gain point shall occur at a frequency of 2 kHz and an average responding meter shall be used as the indicating device.

**5 Test and Ratings, Single-Channel Amplifiers**
Unless otherwise specified, all measurements shall be made under standard test conditions with all input and output terminations in place. When an input is to be driven from a signal source, the input termination shall be in series with the source.

**5.1 Power Output Rating**
For primary ratings (as defined in 7.1), the power output rating of a power amplifier (or such section) shall be the minimum sinewave power output in watts that can be delivered into an 8 ohm load at 1 kHz at no more than 1% THD (see 3.20).

For secondary ratings (as defined in section 7.2), when a power amplifier is rated for more than one load impedance, the power output shall be rated separately for each nominal load impedance. For other secondary ratings, the nominal load impedance, rated bandwidth, and rated total harmonic distortion (THD+N) shall be specified as part of the power output rating.

For the purpose of this section, continuous shall mean that the signal shall be applied for a period of not less than 5 minutes.

For a power amplifier, or for an integrated amplifier or receiver in which a separate input is provided to the power amplifier section and it is desired to rate the power amplifier section separately (see 3.3), the signal shall be applied at the input terminals so provided.

For an integrated amplifier or receiver that will be rated as an entity, the signal shall be applied at a line input, or, if no such input is provided, at the phono input.

For the purpose of this section, the gain control shall be preset so that the gain of the amplifier is 12 dB greater than Standard Test Conditions (see 4.8.1).

For secondary ratings (as defined in section 7.2), the rated percentage of maximum total harmonic distortion (THD) shall not be less than the maximum THD measured at any frequency within the rated bandwidth, at any power level between 250 mW (-6 dBW) and the rated power level.

### 5.2 Dynamic Headroom

The dynamic headroom of a power amplifier (or such section) shall be the ratio of the maximum power output level or a 20 ms burst of a 1 kHz sine wave at the clipping point of the amplifier (see 3.22), to the power output rating (see 5.1), said ratio to be expressed in decibels.

The signal shall be applied at the line input and shall consist of a 1 kHz sinusoidal wave, alternating in level between a nominal level and a level that is 20 dB greater than the nominal level. The signal shall maintain the nominal level for a period of 480 ms ± 10% and shall increase in level for a period of 20 ms ± 10%. The cycle shall repeat with a 0.5 second ± 10% period.

Care shall be taken that the transition in level occurs at the axis crossing of the sinusoidal input signal.

The output of the amplifier shall be observed on an oscilloscope (see 4.9.7).

#### 5.2.1 Output Level

The output level shall be adjusted to the maximum value without output clipping (see 3.22).

#### 5.2.2 Maximum Peak-to-Peak Output Voltage Level

The maximum peak-to-peak output voltage level shall be recorded.

#### 5.2.3 Dynamic Headroom Rating

The dynamic headroom rating of a power amplifier (or such section) shall be the ratio of the average power of a sine wave, having the same peak-to-peak voltage as that measured in 5.2, to the power output rating (see 5.1) of the amplifier expressed in decibels.

If the amplifier is rated for more than one load impedance, then the dynamic headroom shall be measured and rated separately for each such load impedance.

### 5.3 Clipping Headroom

The clipping headroom rating of a power amplifier (or such section) shall be the ratio of the maximum power output level (see 3.20) of a sine wave at the clipping point of the amplifier (see 3.22), to the power output rating of the amplifier (see 5.1), said ratio to be expressed in decibels.

If the amplifier is rated for more than one load impedance then the clipping headroom shall be rated separately for each load impedance.

Clipping headroom, specified without a frequency descriptor, shall mean the headroom measured at 1 kHz.

The clipping headroom may be specified at other frequencies, or over a band of frequencies, by stating the headroom followed in parentheses by the frequency(ies) or bandwidth over which the headroom is available.

### 5.4 Total Harmonic Distortion

The total harmonic distortion (THD) rating of a preamplifier (or such section) shall be the greatest value of total harmonic distortion (THD) measured at the output terminals of the preamplifier, at any frequency within the rated bandwidth of the preamplifier. The rated bandwidth of the preamplifier shall be specified as part of the rating.

If more than one set of input terminals is provided, then each set shall be measured for total harmonic distortion (THD) in turn and shall be rated separately with the markings of each such set of input terminals recorded.

For the purpose of this section, standard test conditions shall apply except that the input signal level shall be 12 dB greater than the input reference level (see 4.3). That is, the total harmonic distortion (THD) of a preamplifier shall be measured at a 2.0 volt input level.

If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then the input signal shall be adjusted with frequency in conformance with the inverse of the nominal equalization.

**5.5 Maximum Voltage Output**

The Maximum Voltage Output rating of terminals whose primary function is to supply signal voltage to subsequent equipment shall be the minimum sine wave output level in RMS volts (or dBV) that can be delivered into the reference load (see 4.5), over the rated bandwidth, at a maximum total harmonic distortion (THD) of 1%. The rated bandwidth of the terminals shall be specified as part of the rating.

If more than one set of output terminals is provided, then each set shall be measured for maximum output voltage in turn and shall be rated separately, with the markings of each set of output terminals recorded.

**5.5.1 Gain Control Settings**

For the purpose of this section, the signal shall be applied at a line input, and standard test conditions shall be used except that the gain controls shall be preset so that the gain on the amplifier is 12 dB greater than standard test conditions (see 4.8.1).

Care shall be taken that a sufficient number of measurements are made at various test frequencies so that the intent of this section is fulfilled.

**5.6 Output and Total Harmonic Distortion (THD) versus Frequency**

Output and total harmonic distortion (THD) versus frequency shall be a series of curves, taken in accordance with 5.1 or 5.4, the first of which shall be a curve of THD with respect to frequency at an output level 6 dB less than the output reference level (see 4.4). Successive curves shall be printed out in graph from THD measurements taken at successively greater output levels in steps of 3 dB, the last of which shall be rated output level. The curves shall be marked to indicate the output and input to which they refer.

**5.7 Sensitivity**

The sensitivity rating of an amplifier shall be the level, in volts of a 1 kHz sinusoidal signal, which, when applied at the input terminals of an amplifier, will result in an output at reference level (see 4.4). Standard test conditions shall be used except that a gain control, whose primary function is the simultaneous adjustment of gain on all inputs (see 4.8.1) shall be preset to its position of maximum gain.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for sensitivity in turn, and the markings of each set of terminals shall be recorded.

If input gain controls are provided whose primary function is the adjustment of gain from a single input (see 4.8.1), then the sensitivity of such input shall be measured with said gain control preset for maximum amplification, and then the measurement shall be repeated with said gain control preset for minimum amplification. Both sensitivity ratings shall be reported in the form: X volts/Y volts, where X is the measured sensitivity with said gain control preset for maximum amplification, and Y is the measured sensitivity with said gain control preset for minimum amplification.

**5.8 Maximum Input Signal**

The maximum input signal rating of an amplifier shall be the maximum level, in volts, of a sinusoidal signal that, when applied at the input terminals of the amplifier, will result in an output level of less than the clipping point (see 3.22), when the main gain control of the amplifier adjusted for maximum gain.

If more than one set of input terminals is provided, the each set of input terminals shall be measured for maximum-input signal in turn, and the markings of each set of terminals shall be recorded.

The measurement shall be repeated at a number of frequencies within the rated bandwidth of the amplifier. Subject to 5.8.2, the maximum-input signal rating of a set of input terminals shall be the minimum value of the measurements so made.

### 5.8.1 Gain Adjustment from Single Input

If input-gain controls are provided whose primary function is the adjustment of gain from a single input (see 4.8.1), then the maximum-input signal of such input shall be measured with said gain control preset for maximum amplification, and then the measurement shall be repeated with said gain control preset for minimum amplification. Both maximum-input signal ratings shall be reported in the form: X volts/Y volts, where X is the measured maximum-input signal with said gain control preset for maximum amplification, and Y is the measured maximum-input signal with said gain control preset for minimum amplification.

### 5.8.2 Input Terminals & Equalized Frequency Response

If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then the input signal level shall be adjusted with frequency in conformance with the inverse of the nominal equalization. The maximum-input signal rating of such an input shall be the 1 kHz input signal level that is equivalent to the minimum of the measurements, after adjustment is made for the equalization.

## 5.9 Input Impedance versus Frequency

Input Impedance versus Frequency of an amplifier shall be a curve of the magnitude of impedance with respect to frequency, over the rated bandwidth of the amplifier, and shall be printed out in graph form.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for input impedance in turn, and the markings of each set of terminals shall be recorded.

It shall also be established whether any control affects input impedance, and if so, the measurement shall be repeated at as many settings of such control or controls as is required to determine the maximum and minimum input impedance. Each curve shall be marked to indicate the control and the settings that correspond to maximum and minimum input impedance.

If load resistances connected to other input terminals affect the input impedance of the set of input terminals under test, or if controls exclusively associated with other input terminals affect the input impedance of the set of input terminals under test, the maximum and minimum values of input impedance shall be recorded.

### 5.9.1 Input Impedance Measurement Method

Any standard method of measuring input impedance, that is accurate within 10% of the measured value, shall be acceptable.

One recommended method to measure input impedance values of less than 250 k ohms shall be to connect to the input terminals of the amplifier a current source whose resistance (R) is at least 10 times greater than the maximum input impedance of the amplifier and, alternately, a voltage source equal in level to the open circuit voltage level of the current source. The voltage level at the output terminals of the amplifier shall be measured under both conditions, and the input impedance shall be calculated from the approximate formula:

$$Zout \approx \frac{R}{\left(\frac{V_{\text{open circuit}}}{V_{\text{output terminals}}}\right) - 1}$$

where $V_{\text{open circuit}}$ is the open-circuit voltage level of the current source, and $V_{\text{output terminals}}$ is the voltage level measured at the output terminals of the amplifier.

Care shall be taken that neither the input nor the output circuitry of the amplifier is driven into overload during the test.

**5.9.2 Input Impedance & Phono-Input Terminals**
For phono-input terminals, if the input impedance can be modeled by a parallel combination of resistance and capacitance that, over the rated bandwidth of the amplifier, has the same impedance as the input impedance, within an accuracy of 10%, then the values of the equivalent resistor and capacitor shall constitute the Phono-Input Impedance rating. If the input impedance of such terminals cannot be modeled with the required accuracy by such a network, then 5.9.2.1 shall apply.

**5.9.2.1 Input Terminal Impedance Rating**
The input impedance rating of input terminals shall be the magnitude of input impedance measured at 1 kHz. The markings of the terminals shall be specified as part of the rating.

**5.10 Output Impedance versus Frequency**
Output impedance versus frequency of an amplifier shall be a curve of the magnitude of impedance with respect to frequency, over the rated bandwidth of the amplifier, displayed in graph form.

If more than one set of output terminals is provided, then each set of output terminals shall be measured for output impedance in turn, and the markings of each set of terminals shall be recorded.

It shall also be established whether any control affects output impedance, and, if so, the measurement shall be repeated at as many settings of such control or controls as is required to determine the maximum and minimum output impedance. Each curve shall be marked to indicate the control and the settings that correspond to maximum and minimum output impedance.

**5.10.1 Terminals Supplying Signal Voltage to Subsequent Equipment**
The output impedance of terminals, whose primary function is to supply a signal voltage to subsequent equipment, shall be measured with a current flow of 100 microamperes RMS.

**5.10.2 Terminals Supplying Power to Loudspeaker**
The output impedance of terminals, whose primary purpose is to supply power to a loudspeaker, shall be measured with a current flow equivalent to that which produces an output-reference power level into the rated load impedance (see 4.4 and 4.5). This current flow is 0.354 amperes RMS for an IHF reference-load impedance of 8 ohms.

**5.10.3 Output Impedance Measurement Method**
Any standard method of measuring output impedance that is accurate within 10% of the measured value shall be acceptable.

One recommended method to measure output impedance shall be to connect to the output terminals of the amplifier, a current source, whose resistance (R) is at least 10 times greater than the maximum output impedance of the amplifier. The voltage level at the output terminals of the amplifier shall be measured, and the output impedance shall be calculated form the approximate formula:

$$Zout \approx \frac{R}{\left(\frac{V_{\text{open circuit}}}{V_{\text{output terminals}}}\right) - 1}$$

where $V_{\text{open circuit}}$ is the open-circuit voltage level of the current source, and $V_{\text{output terminals}}$ is the voltage level measured at the output terminals of the amplifier.

Care shall be taken that the input impedance of the measuring voltmeter, including the reactive effect of the connecting cable, does not introduce an error in excess of 10% of the measured value.

**5.10.4 Output Impedance & Equivalent Two-Network Values**
If the output impedance can be modeled by a two-terminal combination of resistance, capacitance, and inductance that, over the rated bandwidth of the amplifier, has the same impedance as the output impedance of the amplifier, within an accuracy of 10%, then the output impedance of the amplifier may be specified in terms of the values of the equivalent two-terminal network.

**5.10.5 Output Impedance Rating**
The output impedance rating of an amplifier shall be the maximum magnitude of output impedance, measured in accordance with 5.10.3.

**5.11 Damping Factor versus Frequency**
Damping Factor versus Frequency of a power amplifier (or such section) shall be a curve of the ratio of the rated load impedance of the amplifier, to the measured output impedance of the amplifier (see 5.10), with respect to frequency, over the rated bandwidth of the amplifier, and shall be printed out in graph form.

If more than one load-impedance rating is given, then the damping factor shall be computed separately, from output-impedance measurements taken with reference to the several load impedance ratings (see 5.10.2), and the curve shall be marked to indicate said rating.

**5.11.1 Wideband Damping Factor Rating**
The wideband damping factor rating shall be the minimum magnitude of damping factor, measured in accordance with this section, referenced to an 8 ohm impedance.

**5.11.2 Low Frequency Damping Factor Rating**
The low frequency damping factor rating of an amplifier shall be the damping factor measured at 50 Hz referenced to an 8 ohm impedance.

**5.12 Weighted Signal-To-Noise Ratio (S/N)**
The weighted signal-to-noise ratio (S/N) rating of an amplifier shall be the ratio of the output reference level (see 4.4) to the measured, weighted, output noise level, said ratio to be expressed in decibels.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for signal-to-noise ratio in turn, and the markings of each set of terminals shall be recorded.

Care shall be taken to adjust the gain control when different input terminals are employed to assure standard test conditions (see 4.8.1).

The set of input terminals under test shall be terminated as specified in 4.6 except that the input termination for each MM-phono input (see 4.6.2) shall consist of a 500 mH ± 10% inductor in series with a 1 k ohm ± 10% resistor, the combination of which shall be in parallel with a 125 pF ± 10% capacitor. Care shall be taken that the termination networks do not act as pickup links for electrostatic or electromagnetic fields.

**5.12.1 Output Noise Power**
Output noise power shall be computed from a measurement of the voltage at the output terminals of a power amplifier (see 3.20).

**5.12.2 A-Weighted Signal-To-Noise Ratio Rating**
The A-weighted signal-to-noise ratio rating of a set of input terminals shall be computed in accordance with 5.12 from a measurement of the output noise level made with a measurement device fulfilling the requirements of 4.9.8. The markings of the terminals shall be specified as part of the rating.

**5.12.3 ITU-R/ARM Signal-To-Noise Ratio**
The ITU-R/ARM signal-to-noise ratio rating of a set of input terminals shall be computed in accordance with 5.12 from a measurement of the output noise level made with a measurement device fulfilling the requirements of 4.9.9. The markings of the terminals shall be specified as part of the rating.

### 5.13 Response versus Frequency

Response versus frequency (commonly called “frequency response,” but more properly, amplitude response with respect to frequency) of an amplifier shall be a curve of the variation in the output level of the amplifier, expressed in decibels, over the rated bandwidth of the amplifier, and shall be printed out in graph formwith a one-decade change in frequency equal in length to a 30 dB variation in output.

A sufficient number of points shall be measured so that smooth curves result rather than curves containing discontinuous slopes.

Care shall be taken that the network used to simulate the standard source impedance does not act as a pickup link for electrostatic or electromagnetic fields.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for Response versus Frequency in turn, and the markings of each set of terminals shall be recorded.

#### 5.13.1 Frequency Response Rating

The Frequency Response rating of a set of input terminals shall be the plus and minus decibel error from flat response, referenced at 1 kHz.

##### 5.13.1.1 Standard Equalized Frequency Response

If a set of input terminals is to result in a standard equalized frequency response as defined by other standards organizations, the results of the response versus frequency measurements shall be compared with the standard curve, and the resulting plus and minus decibel error, referenced at 1 kHz shall be the frequency response rating of such input.

A curve of the resulting error versus frequency shall be the response versus frequency of such input. This can most easily be accomplished by inserting an accurate network having the inverse frequency response characteristic to that desired in the amplifier, and measuring the error by a direct meter indication.

#### 5.13.2 Varied Frequency Response

If controls are provided, whose primary purpose is to vary the frequency response of the amplifier, a curve of response versus frequency shall be drawn under the following conditions for each control, with all other controls maintained in the setting prescribed by the standard test conditions.

The signal source shall be connected at a line input.

Care shall be exercised that the maximum output capability of the amplifier is not exceeded, and that the signal level does not fall to within 20 dB of the noise. An adjustment of input signal level sufficient to assure the accuracy of measurement is permissible.

##### 5.13.2.1 Amplifier Frequency Response Variance

If controls are provided that vary the frequency response of the amplifier either continuously or in steps as the control is adjusted, a curve of Response versus Frequency shall be drawn with the control adjusted to its normal setting (as indicated by markings), in its extreme positions, and at sufficient other settings to indicate the effect on frequency response at intermediate settings.

##### 5.13.2.2 Low- or High- Pass Filter Controls

If there are controls, whose primary purpose is to provide low-pass or high-pass filter characteristics, a curve of response versus frequency shall be drawn for each setting of each such control. The response versus frequency curve shall extend at least to that frequency at which the gain of the amplifier has been reduced by 20 dB.

##### 5.13.2.3 Cutoff Frequency Rating

The cutoff frequency rating of the filter shall be that frequency at which the gain of the amplifier has diminished by 3 decibels.

**5.13.2.4 Slope Rating**
The slope rating of the filter shall be the asymptotic limit of the response versus frequency curve, in dB/octave, at frequencies well beyond the cutoff frequency of the filter.

**5.13.2.5 Power Amplifier—Amplifier Gain Adjustment**
For a power amplifier, if controls are provided whose primary function is the adjustment of amplifier gain, frequency response measurements shall be made at the setting of maximum gain and at a setting at which the gain of the amplifier is 6 dB less than the maximum gain.

**5.13.2.6 Multiple Control—Frequency Interaction**
It is desirable to measure the amount of interaction in frequency response of two or more controls. In particular, groups of controls designed for interaction (such as “loudness” control and a “loudness-volume” switch) shall be measured for frequency response in the combination of settings shown for the individual controls (see 5.13.2.1).

**5.13.3 Amplifier Output/Input Connection**
The output of the amplifier and the input of the amplifier may be connected to the vertical and horizontal inputs of the oscilloscope respectively so that the phase shift with respect to frequency can be measured. Alternatively, a phase meter can be used. The results shall be printed out in graph form where one-decade change in frequency is equal in length to 300° of phase shift.

**5.14 Crosstalk versus Frequency**
Crosstalk versus frequency of an amplifier shall be a series of curves of the ratio of wanted-to-unwanted output signals, between various inputs of the same channel, when an input signal is supplied at one set of input terminals that are then made nominally non-operating. The ratio shall be expressed in decibels, and the curves shall be printed out in graph form, where one-decade change in frequency is equal in length to a 30 dB variation in output.

The amplifier shall be adjusted for standard test conditions from the set of input terminals under test. The input level shall then be increased until the output level is 3 dB less than the power output rating (see 5.1), for a power amplifier, or 3 dB less than the voltage output rating (see 5.5) for a preamplifier. The output level shall be recorded and shall be defined as the wanted output.

The amplifier source-selector control shall then be adjusted in turn for operation from all other sets of input terminals, and the output of the amplifier shall be recorded and shall be defined as the unwanted output.

The ratio of the wanted-output level to the unwanted-output level shall be expressed in decibels and shall be drawn as a series of curves versus frequency. Each curve shall indicate the crosstalk ratio from a particular set of input terminals to the set of input terminals under test.

The test shall be repeated with the signal source connected to each set of input terminals in turn.

Care shall be taken to re-establish standard test conditions for each set of input terminals.

It is recommended that a spectrum analyzer be used to measure the unwanted-output level in order to assure the accuracy of measurement in the presence of noise.

**5.14.1 Crosstalk Rating**
The crosstalk rating of an amplifier, for each set of input terminals, shall be the ratio of least magnitude, expressed in decibels, at any frequency between 100 Hz and 10 kHz, as the amplifier source-selector control is adjusted for amplifier operation from the set of input terminals under test to other sets of input terminals.

**5.14.2 Weighted Crosstalk Rating**
The weighted crosstalk rating of an amplifier, for a particular set of input terminals, shall be measured in a manner similar to that of 5.14 except that a pink-noise signal (see 3.23), band-limited to the frequency range between 20 Hz and 20 kHz, shall be applied to the input terminals under test.

The amplifier controls shall have been adjusted for standard test conditions prior to the test using a 1 kHz sine wave.

The level of the pink-noise input signal shall be adjusted until the output level is 10 dB less than the Power Output rating for a power amplifier (see 5.1) or 10 dB less than the voltage output rating for a preamplifier (see 5.5). The output level shall be recorded and shall be defined as the wanted-output level.

The amplifier source-selector control shall then be adjusted for operation, in turn, from all other sets of input terminals, and the output level of the amplifier shall be measured with a device fulfilling the requirements of 4.9.8 (for A-weighted crosstalk rating) or 4.9.9 (for ITU-R/ARM crosstalk rating).

Each measurement shall be recorded and shall be defined as the unwanted-output level.

The weighted crosstalk rating of an amplifier shall employ the same weighting curve as was used in the weighted signal-to-noise ratio rating (see 5.12).

The A-weighted crosstalk rating of a set of input terminals shall be the ratio of least magnitude of the wanted-output level to the unwanted-output level (measured with a device fulfilling the requirements of 4.9.8) as the amplifier source-selector control is adjusted for amplifier operation form the one set of input terminals under test to all other sets of input terminals, said ratio to be expressed in decibels.

The ITU-R/ARM crosstalk rating of a set of input terminals shall be the ratio of least magnitude of the wanted-output level to the unwanted-output level (measured with a device fulfilling the requirements of 4.9.9) as the amplifier source-selector control is adjusted for amplifier operation from the one set of input terminals under test to all other sets of input terminals, said ratio to be expressed in decibels.

**5.15 SMPTE Intermodulation Distortion versus Output**

SMPTE intermodulation distortion versus output of an amplifier shall be one or more curves of the percentage of SMPTE intermodulation distortion (see 3.17), measured with a device fulfilling the requirements of 4.9.4 printed out in graph form with respect to output level. The output level shall be expressed as the RMS value of a sine wave having the same peak value as the composite output. The curve(s) shall extend from an output level that is 12 dB less than the output reference level (see 4.4), to the Power Output rating (see 5.1) for a power amplifier, or to the voltage output rating (see 5.5) for a preamplifier.

**5.15.1 Ratings for Multiple Load Impedances**

If a power amplifier (or such section) is rated for more than one load impedance, a curve of SMPTE intermodulation distortion versus output shall be drawn for each rated load impedance.

**5.15.2 Multiple Output Terminals**

If more than one set of output terminals is provided, then each set of output terminals shall be measured for SMPTE-IM in turn and the markings of each set shall be recorded.

**5.15.2.1 Line Input**

A line input shall be used.

**5.15.2.2 Multiple Line Inputs**

If more than one set of input terminals is provided, then each set of input terminals shall be measured for SMPTE-IM in turn and the markings of the set shall be recorded.

If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then an accurate network, having the inverse frequency response characteristic to that desired in the amplifier, shall be interposed between the signal source and such input terminals.

**5.15.2.3 Output**

The main output shall be used.

### 5.15.3 SMPTE Intermodulation Distortion Rating

The SMPTE intermodulation distortion rating of an amplifier shall be the greatest percentage of SMPTE-IM measured from a specified input to a specified output.

The input and output terminal marking shall be specified as part of the rating.

The load impedance shall be specified as part of the rating.

### 5.16 Dual Tone Intermodulation Distortion versus Frequency

Dual tone (formerly IHF) intermodulation distortion versus frequency of an amplifier shall be a series of curves of the percentage of dual tone intermodulation distortion (see 3.18), printed out in graph form with respect to frequency, with output level as a parameter. The output level shall be expressed as the RMS value of a sine wave having the same peak value as the composite output.

The first curve shall be a curve of the percentage of dual tone intermodulation distortion, with respect to frequency, at an output level that is 12 dB less than the output reference level (see 4.4). Successive curves shall be drawn from dual tone intermodulation distortion measurements at output levels in 3 dB steps above the first curve, the last of which shall be at rated output level.

The frequency shall be expressed as the arithmetic average of the two test frequencies, which shall have a frequency separation of 1 kHz. The measurement shall be made from a frequency of 2.5 kHz to the upper rated band edge of the amplifier.

### 5.16.1 Multiple Load Impedances

If a power amplifier (or such section) is rated for more than one load impedance, a set of curves shall be drawn for each rated load impedance.

### 5.16.2 Multiple Output Terminals

If more than one set of output terminals is provided, then each set of output terminals shall be measured for dual tone intermodulation distortion in turn and the markings of each set of terminals shall be recorded.

#### 5.16.2.1 Line Inputs

A line input shall be used.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for dual tone intermodulation distortion in turn and the markings of the set shall be recorded.

If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then an accurate network, having the inverse frequency response characteristic to that desired in the amplifier, shall be interposed between the signal source and such input terminals.

#### 5.16.2.2 Outputs

The main output shall be used.

### 5.16.3 Dual Tone Intermodulation Distortion Rating

The dual tone intermodulation distortion rating of an amplifier shall be the greatest percentage of dual tone intermodulation distortion measured from a specified input to a specified output.

The input and output-terminal markings shall be specified as part of the rating.

The load impedance shall be specified as part of the rating.

As additional information, measurements made of individual harmonic distortion (see 3.13) or weighted harmonic distortion (see 3.15) may be displayed graphically or used as the basis for rating (following the format of 5.6), provided that the order of the harmonic, or the weighing algorithm used, is indicated in the rating or curve.

### 5.17 Transient-Overload Recovery Time
The Transient-Overload Recovery Time of an amplifier shall be the time required for the amplifier to recover from a 10 dB overload, of 20 ms duration, occurring at a repetition rate of once every 0.5 seconds.

The amplifier controls shall be preset for Standard Test Conditions except that the gain control shall be preset so that an Input-Reference Level (see 4.3) produces an output level that is 10 dB less than the power output rating (see 5.1) for a power amplifier, or 10 dB less than the Voltage Output rating (see 5.5) for a preamplifier.

The signal applied at the input terminals under test shall consist of a 1 kHz sinusoidal wave, alternating in level between the reference level and a level that is 20 dB greater than the reference level. The signal shall maintain reference level for a period of 480 ms ± 10% and shall increase in level for a period of 20 ms ± 10%. The cycle shall repeat with a 0.5 second ± 10% period.

Care shall be taken that the transition in level of the input signal occurs at the axis crossing of the sinusoidal signal.

The output of the amplifier shall be observed on an oscilloscope (see 5.16.2.2). The sweep shall be adjusted to observe that portion of the cycle that occurs immediately following the return of the input signal to reference level. The time required for the amplifier to recover so that there are no visible signs of distortion shall be recorded.

If more than one set of input terminals is provided, then each set of input terminals shall be measured for Transient-Overload Recovery Time, in turn, and the markings of the set of terminals shall be recorded.

#### 5.17.1 Standard Equalized Frequency Response
If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then an accurate network, having the inverse frequency response characteristic of that desired in the amplifier, shall be interposed between the signal source and such input terminals for the measurement of Transient Overload Recovery Time.

#### 5.17.2 Transient Overload Recovery Time Rating
The transient overload recovery time rating of an amplifier shall be the maximum recovery time in milliseconds measured in accordance with this section.

### 5.18 Slew Factor
Slew Factor is a measure of the highest frequency test that can be applied at the input terminals of an amplifier, at an input signal level that produces rated output of 1 kHz, and be reproduced at the output terminals with acceptable linearity.

The amplifier controls shall be preset for Standard Test Conditions except that the gain control shall be preset so that the gain of the amplifier is 12 dB greater than Standard Test Conditions. A 1 kHz sinusoidal signal shall be applied at the input terminals and shall be increased in level until the output level is equal to the power output rating (see 5.1) for a power amplifier, or to the voltage output rating (see 5.5) for a preamplifier.

The frequency of the input signal shall be increased until the total harmonic distortion (see 3.14) of the output signal is equal to 1%. This frequency shall be divided by 20 kHz to compute the slew factor.

If more than one set of input or output terminals is provided, then each such set of terminals shall be measured for slew factor in turn, and the markings of the sets of terminals shall be recorded. If a power amplifier (or such section) is rated for more than one load impedance, then the slew factor shall be measured separately for each load impedance.

### 5.18.1 Standard Equalized Frequency Response

If a set of input terminals is to result in a standard equalized frequency response, as defined by other standards organizations, then an accurate network, having the inverse frequency response characteristic of that desired in the amplifier, shall be interposed between the signal source and such input terminals.

### 5.18.2 Slew Factor Rating

The slew factor rating of an amplifier shall be the slew factor measured from a specified input to a specified output in accordance with this section.

The input and output terminal markings shall be specified as part of the rating.

The load impedance shall be specified as part of the rating.

## 5.19 Reactive-Load

The reactive-load rating of a power amplifier (or such section) indicates the ability of the amplifier to supply voltage and current to a dynamic woofer in the frequency region about the loudspeaker resonance.

For the purposes of this section, standard test conditions shall apply except that the gain control shall be preset so that the gain of the amplifier is 12 dB greater than Standard Test Conditions (4.8.1), and the resistive load impedance (see 4.5) shall be replaced with a reactive load network that simulates the impedance of a dynamic loudspeaker.

The reactive load network shall consist of the parallel combination of an 18.3 ohm ± 1% resistor, a 12.5 mH ± 2% inductor, and an 800 microFarad ± 2% capacitor; the combination shall be in series with a 5.4 ohm ± 1% resistor.

Care shall be taken that the components used to construct the network are capable of conducting the maximum current flow within the network in a linear manner.

As reference information, it is noted that the resonant frequency of the network occurs at 50.3 Hz, that the impedance at resonance is 23.7 ohms, and that the maximum phase angle between the voltage across the network and the current through the network is + 39 degrees at 40 Hz and -30 degrees at 63 Hz.

### 5.19.1 Input Signal

The input signal shall be applied at the line input terminals.

a) The input signal frequency shall be adjusted for maximum leading-phase angle in the reactive load network (40 Hz).

   The input signal level shall be adjusted until the total harmonic distortion of the output voltage is 1%.

   The output voltage level shall be measured and recorded.

b) The input signal frequency shall be adjusted for maximum lagging phase angle in the reactive load network (63 Hz).

   The input signal level shall be adjusted until the total harmonic distortion of the output voltage is 1%.

### 5.19.2 Output Voltage Level

The output voltage level shall be measured and recorded.

The lesser of the two output voltage levels, measured in accordance with 5.19.1, shall be squared and divided by 8.

The number so calculated shall be divided by the 8 ohm power output rating in watts to give the reactive load factor.

**5.19.3 Reactive Load Rating**
The Reactive Load rating of a power amplifier shall be 10 times the common logarithm of the reactive load factor (see 5.19.2) followed by the symbol dB.

**5.20 Capacitive Load**
The capacitive load rating of a power amplifier (or such section) shall be the range of values of capacitance that can be connected directly at the output terminals of the amplifier and in parallel with the rated output load resistance, without evidence of instability, or any variation in ratings, measured in accordance with 5.1 through 5.17, of greater than 10%.

**6 Test and Ratings, Multi-Channel Amplifiers**

**6.1 Performance of a Multi-Channel Amplifier**
The performance of a multi-channel amplifier shall be the performance of each channel of amplification, as measured per 5. During the testing, each channel shall be measured in turn with all other channels driven simultaneously by a signal reduced to 0.354 of the level used to drive the channel under test. If the 0.354 level signal exceeds the output capability of any of the non-measured channels, then the drive level of this non-measured channel shall be reduced to 0.354 of the signal necessary to drive that channel to clipping. The performance characteristics of each channel shall be recorded and identified with the marking of the channel.

**6.2 Separation versus Frequency**
Separation versus frequency between channels of amplification shall be a series of curves of the ratio of wanted-to-unwanted output signals, between corresponding inputs of the various channels of amplification when an input signal is supplied to one set of input terminals, which is then made nominally non-operating. The ratio shall be expressed in decibels and the curves shall be printed out in graph form, where one-decade change in frequency is equal in length to a 30 dB variation in output.

The amplifier controls shall be adjusted for standard test conditions from the set of input terminals under test. The input level shall then be increased until the output level is 3 dB less than the power output rating (see 5.1) for a power amplifier, or 3 dB less than the Voltage Output rating (see 5.5) for a preamplifier. The output level shall be recorded and shall be defined as the wanted output. The output level of each of the other channels shall be recorded and shall be defined as the unwanted output.

The ratio of the wanted-output level to the unwanted-output level shall be expressed in decibels and shall be drawn as a series of curves (one for each channel) versus frequency.

The tests shall be repeated with the signal source connected to the corresponding inputs of each channel in turn.

It is recommended that a spectrum analyzer be used to measure the unwanted signal level in order to assure the accuracy of measurement in the presence of noise.

If more than one set of inputs is provided per channel, then the tests shall be repeated for each set of inputs and the markings of the terminals shall be recorded.

**6.2.1 Separation Rating**
The separation rating of an amplifier for a particular set of input terminals shall be the ratio of least magnitude, expressed in decibels, at any frequency between 100 Hz and 10 kHz, with the amplifier source selector adjusted for amplifier operation from that set of terminals.

**6.3 Difference of Response versus Frequency**
Difference of response versus frequency (or more properly, difference of amplitude response with respect to frequency) between channels of amplification, shall be a curve of the variation in the output of the second and subsequent channels of the amplifier, referred to the first channel, and expressed in decibels, over a frequency range from 20 Hz to 20 kHz, printed out in graph form, where one-decade change in frequency is equal in length to 30 dB variation in output.

A sufficient number of points shall be measured so that smooth curves result rather than curves containing discontinuous slopes.

Care shall be taken that the network used to simulate the standard source impedance does not act as a pickup link for electrostatic or electromagnetic fields.

**6.3.1 Source Signal Level**
The source signal level for each channel shall be adjusted to obtain equal output levels from each channel at 1 kHz.

The load impedance at the output terminals of each channel shall be identical.

**6.3.2 Multiple Input Terminals/Multiple Channels**
If more than one set of input terminals is provided on two or more channels of amplification, then each set of input terminals shall be measured for Difference of Response, and the markings of the set shall be recorded.

**6.3.3 Difference of Frequency Response Rating**
The difference of frequency response rating of the second and subsequent channels, for a particular set of input terminals, shall be the plus and minus decibel error with respect to the first channel.

**6.4 Gain Tracking Error**
Gain tracking error shall be the difference in amplification, between channels of amplification, expressed in decibels with respect to the first channel, as controls affecting the gain in two or more channels are adjusted.

**6.4.1 Source Signal**
The source signal shall be a 1 kHz sine wave.

The source signal level for each channel shall be identical.

The signal shall be applied at corresponding line-input sets of terminals.

**6.4.2 Gain Control**
The amplifier shall be operated under standard test conditions except that the particular gain control being tested shall be preset to its position of maximum gain, and the input signal level shall be preset to a level that results in an output level from the first channel that is 3 dB less than the power output rating (see 5.1) for a power amplifier, or 3 dB less than the voltage output rating (see 5.5) for a preamplifier.

The control being tested shall then be adjusted continuously in the direction of lower gain and the output levels of the first and subsequent channels shall be recorded. The difference in output level of the second and subsequent channels shall be referred to the first channel and expressed in decibels and shall be defined as the gain-tracking error.

The test shall be repeated with the control adjusted continuously in the direction of increased gain to show the effects of mechanical backlash between control sections.

**6.4.3 Gain-Tracking Error Rating**
The gain-tracking error rating shall be the greatest magnitude of the gain-tracking error, measured between any two channels of amplification, as the gain control is adjusted in the direction of lower gain, and in the direction of higher gain, over a gain reduction range of 60 dB.

**6.5 Tone-Control Tracking Error**
Tone-control tracking error shall be the difference in frequency response (see 6.3) between channels of amplification, expressed in decibels with respect to the first channel, as controls affecting frequency response in two or more channels are adjusted.

**6.5.1 Frequency Response**
Frequency response shall be measured over the range from 20 Hz to 20 kHz.

The signal shall be applied at corresponding line-input set of terminals.

The source signal level shall be adjusted for each channel so that there is a 0 dB error at 1 kHz for normal control settings.

Care shall be exercised that the maximum output capability of the amplifier is not exceeded, nor that the signal level falls to within 20 dB of the noise. An adjustment of input signal level sufficient to assure the accuracy of measurement is permissible.

#### 6.5.2 Frequency-Response-Affecting Control Adjustment
Each frequency-response-affecting control shall be adjusted toward maximum and minimum settings and the difference in amplification with respect to the first channel shall be recorded.

Care shall be taken that measurements are made at a sufficient number of control settings so that he intent of this section is fulfilled.

#### 6.5.3 Tone-Control Tracking Error Rating
The tone-control tracking error rating shall be the greatest difference in amplification, expressed in decibels, found at any frequency between 20 Hz and 20 kHz.

## 7 Rating
To rate amplifiers according to CEA-490-A, all primary ratings shall be listed in the following order of importance. In addition, secondary disclosures (see 7.2) may be listed provided that such ratings are based upon measurements made in accordance with CEA-490-A.

Except as otherwise noted in CEA-490-A, each specification of a multi-channel amplifier shall be based upon measurements made with all channels driven in like manner.

### 7.1 Primary Rating and Disclosure
For power amplifiers, integrated amplifiers, tuner/receivers (or such section), the primary ratings shall be:

a) Power Output (see 5.1)
b) Frequency Response (see 5.13.1)
c) Input Impedance (see 5.9.2)
d) THD (see 5.4)

The primary rating should be disclosed in the format indicated in the following examples:

a) Monaural
   Single Channel:120 Watts RMS at 8 ohms, 1 kHz, and 1% THD

b) Stereo
   Two channels: 100 Watts RMS per channel at 8 ohms, 1 kHz, and 1% THD

c) Multi--Channel
   i) Equal Power for All Channels (Example: Five channels)
      Five channels: 125 watts RMS per channel at 8 ohms, 1 kHz, and 1% THD

   ii) Unequal Power Among All Channels (Example: Five channels)
      Five channels: 80 Watts RMS per Front channel (L, C,R), 40 Watts RMS per Rear channel (L,R)— at 8 ohms, 1 kHz, and 1% THD

In each instance, the following information should be included with the primary rating disclosure: at 8 ohms, 1 kHz, and 1% THD.

### 7.2 Secondary Ratings and Disclosures
In addition to primary ratings, ratings associated with other frequency bandwidths, impedance levels, THD+N levels and other measurement characteristics may be disclosed, as applicable, such as:

a) Dynamic Headroom (see 5.2.3)
b) Clipping Headroom (see 5.3)
c) Sensitivity (see 5.7)
d) Output Impedance (see 5.10.5)
e) Wideband Damping Factor (see 5.11.1)
f) Low Frequency Damping Factor (see 5.11.2)
g) A-weighted Signal-To-Noise Ratio (see 5.12.2)
h) ITU-R/ARM Signal-To-Noise Ratio (see 5.12.3)
i) Tone-Control Response (see 5.13.2.1)
j) Filter Cutoff Frequency (see 5.13.2.3)
k) Filter Slope (see 5.13.2.4)
l) Crosstalk (see 5.14.1)
m) A-weighted Crosstalk (see 5.14.2)
n) ITU-R/ARM Crosstalk (see 4.9.9)
o) SMPTE Intermodulation Distortion (see 5.15.3)
p) Dual Tone Intermodulation Distortion (see 5.16.3)
q) Transient-Overload Recovery Time (see 5.17.2)
r) Slew Factor (see 5.18.2)
s) Reactive Load (see 5.19.3)
t) Capacitive Load (see 5.20)
u) Separation (see 6.2.1)
v) Difference of Frequency Response (see 6.3.3)
w) Gain-Tracking Error (see 6.4.3)
x) Tone-Control Tracking Error (see 6.5.3)

The format of secondary and other disclosures shall be at the manufacturer’s discretion.

**CEA Document Improvement Proposal**

If in the review or use of this document, a potential change is made evident for safety, health or technical reasons, please email your reason/rationale for the recommended change to standards@ce.org.

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