



Methods for

Specifying and measuring the characteristics
of sound system equipment

Part 2. Amplifiers

Méthodes de spécification et de mesure des caractéristiques des équipements pour
systèmes électroacoustiques
Partie 2. Amplificateurs

Verfahren zur Bestimmung und Messung der Eigenschaften von Schall-Aufnahme
und Wiedergabegeräten
Teil 2. Verstärker

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Foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee. It is closely based on Publication 268-3 : 1969 'Sound System Equipment' Part 3 'Amplifiers' published by the International Electrotechnical Commission (IEC). This standard incorporates the supplements to IEC 268-3 (i.e. IEC 268-3A: 1970, IEC 268-3B: 1972 and IEC 268-3C: 1978) and Amendment No. 1: 1978 to IEC 268-3. It also incorporates other modifications and additions to IEC 268-3 which are expected to be published in the near future by the IEC.

This standard supersedes BS 3860 : 1965 which will be withdrawn.

BS 5428 is being published in a series of separate Parts. Each Part corresponds to a respective Part of IEC Publication 268 as follows.

Part 1 General	IEC 268-1,1A,1B and 2 (Related)
Part 2 Amplifiers	IEC 268-3,3A,3B and 3C (Technically equivalent)

Part 3 Microphones	IEC 268-4 (Identical)
Part 4 Auxiliary passive elements	IEC 268-6 (Identical)
*Part 5 Mechanical design features	IEC 268-14
*Part 6 Headphones	IEC 268-7
Part 7 Automatic gain control devices	IEC 268-8 (Identical)
Part 8 Artificial reverberation, time delay and frequency shift equipment	IEC 268-9 (Identical)
*Part 9 Programme level meters	IEC 268-10,10A
*Part 10 Preferred interface values	IEC 268-15
Part 11 Loudspeakers	IEC 268-5 (Identical)
*Part 12 Listening tests	IEC 268-13

*In course of preparation.

British Standard Methods for

Specifying and measuring the characteristics of sound system equipment

Part 2. Amplifiers

1. Scope

1.1 This standard applies to amplifiers forming part of a sound system, i.e. a system for the amplification and distribution of sound via input elements such as microphones and pick-ups and via output elements which are, in general, loudspeakers.

1.2 The titles of the standards publications referred to in this standard are listed on the inside back cover.

2. Object

This standard gives recommendations relative to the characteristics to be specified and the relevant measuring methods.

In general, the methods of measurement recommended are those which are seen to be the most directly related to the definitions. This does not exclude the use of other methods which give equivalent results.

Rated conditions and normal working conditions as specified hereafter have been adopted as conditions for specifications and measurements.

3. Conditions

3.1 Conditions for specifications and measurements

3.1.1 *General conditions.* Reference is made to BS 5428 : Part 1 concerning the following:

- (a) units and system of measurement;
- (b) frequencies of measurement;
- (c) quantities to be specified and their accuracy;
- (d) marking (see clause 13);
- (e) filters, networks, and measuring instruments for noise specification and measurement;
- (f) ambient conditions;
- (g) individual specification and type specification;
- (h) graphical presentation;
- (i) scales for graphical presentation.

3.2 Rated conditions and normal working conditions

3.2.1 *Introduction.* For convenience in specifying how amplifiers are to be set up for measurement or verification, certain sets of conditions have been defined in this standard under the titles of rated conditions and normal working conditions respectively.

Five ratings are basic to the formulation of these concepts:

- (a) rated power supply;
- (b) rated source impedance;
- (c) rated source e.m.f.;

(d) rated load impedance;

(e) rated output voltage or rated output power.

To obtain the correct conditions for measurements, the above-mentioned ratings shall be taken from the manufacturer's specification. These ratings themselves are not subject to measurement but they constitute the basis for measuring the other characteristics.

The prefix 'rated' applied to other characteristics relates to the specification or measurement of the particular characteristic under rated conditions or under conditions unambiguously connected with them. This applies to the following characteristics:

- (a) rated voltage gain;
- (b) rated matched insertion gain;
- (c) rated signal-to-noise ratio;
- (d) rated equivalent noise source e.m.f.;
- (e) rated equivalent input noise level;
- (f) rated noise index;
- (g) rated signal-to-hum ratio;
- (h) rated equivalent hum source e.m.f.;
- (i) rated equivalent input hum level;
- (j) rated equivalent source e.m.f. for external magnetic field.

3.2.2 *Rated conditions.* An amplifier, considered as a four-terminal network, with regard to a specified pair of input terminals and a specified pair of output terminals, shall be understood to be working under rated conditions when the following conditions have been fulfilled.

- (a) The amplifier is connected to the rated power supply.
- (b) The source e.m.f. is connected in series with the rated source impedance to the input terminals.
- (c) The output terminals are terminated with the rated load impedance.
- (d) The terminals not used are terminated as specified.
- (e) The source e.m.f. is adjusted to a sinusoidal voltage equal to the rated source e.m.f. at that frequency at which the output signal is the least influenced by the tone controls, if any. In the absence of a clear reason to the contrary, this frequency shall be the standard reference frequency of 1000 Hz (see BS 5428 : Part 1).
- (f) The volume control, if any, is set to such a position that the rated output voltage appears at the output terminals.
- (g) The tone controls, if any, are set to a specified position to give the specified frequency response, generally the flat frequency response.

Amplifiers for which the specified rated output power exceeds the specified temperature-limited output power will be subject to overloading when operated under rated conditions for an extended period of time. For these amplifiers, rated conditions shall be maintained no longer than can be tolerated by the amplifier.

3.2.3 Normal working conditions. An amplifier, considered as a four-terminal network, with regard to a specified pair of input terminals and a specified pair of output terminals, shall be understood to be working under normal working conditions when the following conditions have been fulfilled.

- (a) The amplifier is connected to the rated power supply.
- (b) The connections and impedances are as for rated conditions.
- (c) The source e.m.f. is adjusted to a sinusoidal voltage of 10 dB below the rated source e.m.f.
- (d) The source is adjusted at the frequency specified for rated conditions unless otherwise stated.
- (e) The setting of the controls is as for rated conditions unless otherwise stated.

When specifying the characteristics of an amplifier, rated power supply shall be assumed. If, however, the manufacturer claims power supply voltage tolerances exceeding $\pm 10\%$, then the characteristics to be specified shall also be stated for the upper and lower limits of these tolerances (see clause 9).

If variations of the frequency of the power supply within the tolerances specified by the manufacturer have any significant influence on the characteristics to be specified, then those characteristics shall also be stated for the upper and lower limits of the claimed frequency tolerances.

If harmonics in the a.c. power supply and ripple in the d.c. power supply within the limits specified by the manufacturer have any significant influence on the characteristics to be specified, then those characteristics shall also be stated for the upper limit of the claimed tolerances of harmonic or ripple.

3.3 Other conditions. If supplementary data of the amplifier are presented, applying to other than those conditions standardized, e.g. at different frequencies or at different settings of controls, then the conditions shall be fully defined in the presentation. Frequencies and settings of controls for supplementary data shall be chosen according to the requirements given in the relevant clauses of this standard.

The procedure for supplementary measurements can be derived from the measurement procedure given for the standardized conditions. If special precautions have to be taken, then these shall be indicated together with the measurement procedure involved.

3.4 Classes of operation

Class A, in which the current in each active device supplying the load current is greater than zero throughout each cycle of the signal for all values of load current up to and including the value determined by the rated output power or voltage and the rated load impedance.

Class B, in which the current in each active device supplying the load current is equal to zero for exactly one half of each cycle of load current.

NOTE. In common usage, the term Class B is extended to the case where current flows for slightly more than exactly one half cycle.

Class AB, in which the current in at least one of the active devices supplying the load current is zero for some part of each cycle of load current for some range of values of load current not exceeding that value defined by the rated output power or voltage and the rated load impedance.

NOTE. At sufficiently low signal levels, a Class AB amplifier usually operates in Class A.

Class D, in which the current in each active device supplying the load is switched from zero to a maximum value by a carrier signal, modulation of which conveys the useful signal.

Section one. General

4. Rated source impedance

If the rated source impedance is not specified, the appropriate impedance specified in BS 5428 : Part 10* shall be adopted as the rated source impedance.

5. Interchangeable parts

For type measurements, interchangeable parts, such as transistors and plug-in circuit elements or units, shall be selected to have the mean characteristics specified for these parts.

For measurements on a particular amplifier, the interchangeable parts supplied with that amplifier shall be used.

6. Automatic controls

The amplifier may contain automatic control circuits such as limiters, compressors, expanders and electronic fader circuits.

These circuits make certain characteristics of the amplifier dependent on a signal proper to the amplifier itself or on an external control signal.

When measuring characteristics of an amplifier, the automatic control circuits shall be disabled, except when measuring the characteristics of these controls.

7. Special instructions for operation

The manufacturer may have specified a special procedure for putting the amplifier into operation when starting from cold or after a short interruption of operation. He may also have specified particular precautions to be taken when performing switching manipulations under operation, or given other information with respect to normal or abnormal working conditions.

These specified procedures shall be followed and any information given with respect to operation shall be taken into account in the preliminary and testing procedures.

8. Preconditioning

The amplifier shall be under normal working conditions for the period of time specified by the manufacturer before measurements are made, to allow the components to reach the temperature for normal working conditions. If no period is specified, then a period of 1 h shall be allowed for stabilization.

9. Power supply

Measurements shall be made with the amplifier connected to rated power supply. Care shall be taken to maintain the power supply voltage at the rated value during the measurement.

*In course of preparation

Additional measurements may be made at the upper and lower limits claimed as tolerable for the power supply voltage, the power supply frequency and the a.c. power supply harmonics or the d.c. power supply ripple (see 3.2.3).

10. Position of the volume controls

Unless a maximum or minimum position of the volume control is inherent to the characteristic to be measured, the volume control shall be at the position for rated conditions when measuring a characteristic for only one setting of the volume control. If the characteristic is to be measured for several settings of the volume control, then the position for rated conditions shall be included, other preferred settings being maximum, 3 dB, 6 dB and 10 dB with respect to the setting for rated conditions.

Volume controls belonging to channels not to be measured shall, if possible, be put in the zero position, unless otherwise stated.

11. Series of measurements

If a series of measurements is made, the amplifier should preferably be maintained under normal working conditions in the periods between measurements.

If the amplifier has to be put out of operation for a short period between measurements, then investigation shall be made with respect to any procedure stated by the manufacturer for restoring operation and such procedure, if any, shall be followed.

If the amplifier has to be put out of operation for an extended period between measurements, then the further measurements shall be initiated by the preliminary procedure according to this standard.

12. Preliminary procedure for measurements

12.1 Steady consumption conditions. The amplifier to be put under test shall be prepared for measurement according to the following procedure.

(a) The rated load impedance is connected to the output terminals. A source of sinusoidal voltage is connected to the input terminals in series with the rated source impedance; the source frequency is set to the standard reference frequency of 1000 Hz; the source e.m.f. is set to zero.

(b) The correct kind of power supply (d.c. or a.c. or both if required) is chosen; the power supply voltage and (for alternating current) the power supply frequency are adjusted, within $\pm 5\%$, to the rated values specified for the power supply to the amplifier.

(c) The relevant instructions are examined. If a special procedure is stated by the manufacturer, the power supply is switched on according to this procedure.

(d) The relevant instructions are examined for any indication stated by the manufacturer concerning a particular preconditioning period. If no period is specified, a period of 2 min shall be chosen.

(e) If there are tone controls bearing an indication of their position for the normal frequency response, generally the flat response, then they are set to this position.

(f) The volume control, if any, is set to zero. The source e.m.f. is adjusted to rated source e.m.f. The volume control is then readjusted to obtain the rated output

voltage. The source e.m.f. is then reduced to 10 dB below the rated source e.m.f.

(g) If there are tone controls not bearing an indication of their position for normal frequency response (generally the flat response), then they are adjusted to this position by trial and error, varying the source frequency over the effective frequency range during this procedure, the source e.m.f. remaining constant. If the tone controls have already been adjusted to a predetermined position as mentioned under item (e), then this procedure is followed as a check.

(h) From the result of the procedure given under item (g), a decision is made as to whether the standard reference frequency of 1000 Hz is adequate as a reference frequency, or whether a sufficiently strong reason exists to impose another frequency. The source frequency is adjusted to the chosen reference frequency.

(i) The procedure mentioned under item (f) is repeated to obtain provisional normal working conditions.

(j) The amplifier shall remain under the provisional normal working conditions for a period of time specified by the manufacturer for preconditioning. If no period is specified, then 1 h shall be allowed for stabilization.

NOTE. Rated conditions, or normal working conditions, constitute the conditions for carrying out the measurement procedures described in this standard.

Rated conditions for measurement are obtained by following the procedure given in items (k) to (m) after the above-mentioned preconditioning period.

(k) The power supply voltage is adjusted now to the rated power supply voltage to an accuracy of within 3 %.

(l) If the tone controls have been provisionally adjusted according to the procedure of item (g), then this procedure shall be repeated to obtain an accurate setting of the tone controls.

(m) The procedure of item (f) is repeated to obtain an accurate setting of the volume control to its rated position.

Normal working conditions are obtained by following the procedure given in item (n) after rated conditions have been established.

(n) The source e.m.f. is reduced to 10 dB below the rated source e.m.f.

12.2 Variable consumption apparatus

12.2.1 Introduction. Sound system equipment is to be considered as variable consumption apparatus when it contains one or more power amplifiers operating in the Class AB or Class B modes, in which the d.c. supply for the output stages is either electronically stabilized by means of series control elements or has no stabilization.

NOTE. Where the d.c. supply is stabilized by shunt control elements, the power consumption is usually, if not always, substantially constant. The apparatus, however, behaves in some respects as a variable consumption apparatus, and in particular the text of 17.3.1 still applies.

All the measurements contained in this standard may be performed on variable consumption apparatus, in most cases with no special problems. However, certain problems may occur in the measurement of hum and rated distortion-limited output power, and some additional measurements are valuable in assessing the performance of such apparatus.

12.2.2 Explanation of terms

Variable consumption apparatus. Apparatus in which the power drawn from the power supply can vary due to changes in load impedance of the output circuit or in signal parameters, or in the setting of accessible controls (excluding power supply switches).

NOTE. The changes referred to in 12.2.1 do not include any which involve the exceeding of any ratings.

Section two. Characteristics to be specified and the relevant measuring methods

13. Terminals and controls

13.1 Marking. Recommendations for marking the terminals and controls are given in clause 6 of BS 5428 : Part 1 : 1977.

Marking may concern personal safety and prevention of spread of fire in the sense of BS 415*, safety in case of faulty connections, and indications relating to normal operation.

Marking can neither prevent unwanted manipulations nor provide complete operating instructions. Marking therefore has to be considered in conjunction with adequate means of preventing dangerous or faulty operation, and with the directions for use included in the manual.

13.2 Symbols for marking. Marking should preferably be composed of letter symbols, signs, numbers and colours, which are internationally intelligible. The use of texts shall be avoided as far as possible.

Letter symbols for quantities and units shall be in accordance with BS 1991 : Part 6.

Graphical symbols shall be in accordance with BS 3939 and with BS . . . † (Graphical symbols for use on equipment).

Letter symbols or graphical symbols for items not involved in these publications and all other kinds of marking shall be clearly identified in the manual.

13.3 Conditions for test. Investigations and tests made to check compliance with the requirements of this standard shall take into consideration the physical position of the amplifier in normal operation. For amplifiers designed for mounting in racks or enclosures, terminals and controls inaccessible in the normal operating position shall be considered as internal. In this case, the requirements stated also apply to the complete enclosure.

13.4 Personal safety and prevention of spread of fire. The amplifier shall be designed and marked as indicated in BS 415*. Compliance shall be checked by inspection.

13.5 Safety in case of faulty connections. Terminals meant for accepting power or for delivering power to other units shall be so designed as to provide complete protection against misuse or faulty connection of power cords, plug-in units or any other auxiliaries proper to the normal use of the device and carrying sockets and connectors for this purpose.

Terminals meant for connection to a d.c. power supply or meant to deliver d.c. power to other apparatus shall be marked as to polarity and possible connection to 'earth' or chassis.

Selectors for power supply and output voltage, if meant to be set by the user, shall be marked with an indication of the kind of power supply and voltage concerned.

Compliance shall be checked by inspection.

For amplifiers designed to be mounted in racks or

*Or other appropriate safety standard.

† In course of preparation.

enclosures, it is recommended that a check be made as to whether the terminals meant to be internally connected to the wiring in the enclosure are unambiguously identifiable, either by marking or by virtue of their position, with respect to the instructions for connection in the installation manual; it is assumed that these instructions are to be read by skilled personnel.

13.6 Indications for normal operation. Marking cannot provide complete operating instructions. Terminals and controls shall be at least unambiguously related, either by marking or by virtue of their position, to the description of their function and to the directions for use given in the manual.

It is suggested that the terminals, controls, plug-in units and other auxiliary parts delivered for use with the amplifier be marked with respect to their function and that the terminals be marked with respect to required connections to 'earth' or chassis and with their polarity if normal operation requires the connections to be made in a particular phase relation. The scope and extent of the marking should be such as to convey to the user a broad idea of the normal specification of the amplifier.

Compliance shall be checked by inspection.

For amplifiers designed to be mounted in racks or enclosures, it is recommended that a check be made as to whether controls meant to be adjusted internally in the enclosures are unambiguously related, either by marking or by virtue of their position, to the adjustment instructions in the installation manual; it is assumed that these instructions are to be read by skilled personnel.

14. Power supply

14.1 Rated power supply

14.1.1 Characteristics to be specified. The following information shall be specified by the manufacturer for each pair of terminals to be connected to the power supply and for each position of the power supply adaptor, if any:

- (a) the type of power supply, i.e. d.c. or a.c.;
- (b) power supply voltage;
- (c) power supply frequency or range of frequencies;
- (d) apparent power drawn, under rated conditions, expressed in volt amperes;
- (e) power drawn, under normal working conditions, expressed in watts;
- (f) power drawn, with zero source e.m.f., expressed in watts;
- (g) power drawn by variable consumption apparatus from the power supply: the power drawn from the power supply may be additionally expressed as a function of output power from zero to the rated value, with specified load impedances, including the rated load impedance; it may be presented as a graph.

NOTE. Some of these data are particularly of value for battery-operated equipment.

14.1.2 Measuring methods

(a) *Power drawn from the power supply.* The amplifier is brought under rated conditions.

The power drawn from the power supply is measured in watts by means of a wattmeter, firstly with the source e.m.f. decreased to 10 dB below the rated source e.m.f., i.e. under normal working conditions, and secondly with the source e.m.f. reduced to zero.

The power drawn from the power supply is stated for the two above-mentioned conditions.

(b) *Apparent power drawn from the power supply.* The amplifier is brought under rated conditions. The apparent power drawn from the power supply is measured in volt amperes.

14.2 Tolerances of power supply voltage

14.2.1 Characteristics to be specified. The tolerance of the power supply voltage specified by the manufacturer shall be such that, for any power supply voltage within the stated limited, the following conditions apply.

- (a) The upper limit of working voltage is not exceeded for any component and for any condition of normal operation; this applies particularly to such components as semiconductor devices and electrolytic capacitors.
- (b) The tolerances of heater voltages of electronic tubes, when such tubes are used in the amplifier, are not exceeded.
- (c) The maximum permissible temperature is not exceeded in any component when the amplifier works under conditions which are identical to normal working conditions (see 3.2.3) except that the power supply voltage may have any value within the stated limits. The temperature shall be measured after the amplifier has operated under these conditions for an extended period of time until thermal equilibrium is reached.

NOTE 1. For ambient temperature, see BS 2011.

NOTE 2. For safety requirements, see BS 415*.

(d) Neither output nor gain are subject to excessive variations.

(e) The signal-to-hum ratio is not more than 3 dB below that specified by the manufacturer.

Amplifiers designed to take their power supply from the mains will generally not be subject to power supply variations exceeding $\pm 10\%$. Such variations do not generally require a special design of amplifier.

Amplifiers designed to take their power supply from batteries or small converters may be subject to larger variations of power supply voltage, which may be caused by changing load, temperature of batteries or the gradual decrease of battery voltage during life of discharge.

If the manufacturer has stated power supply voltage tolerances not exceeding $\pm 10\%$, then compliance with the requirements given in (a), (b) and (c) is considered to be within the scope of normal amplifier design. Compliance with the requirements mentioned under (d) and (e) shall be checked.

If the manufacturer has stated power supply voltage tolerances exceeding $\pm 10\%$, then the manufacturer's manual shall give any special means for compensating such variations, and the proper working of these means shall be checked if possible. If relevant information is available, compliance with the requirements given in (a) and (b) shall be checked. Compliance with the requirements given in (c), (d) and (e) shall be checked.

14.2.2 Warning. The amplifier shall not be submitted to power supply voltage variations exceeding $\pm 10\%$ unless the manufacturer has stated larger voltage tolerances.

The power supply voltage tolerances specified by the manufacturer shall not be exceeded.

*Or other appropriate safety standard.

14.2.3 Measuring methods

(a) *Temperature.* The amplifier is brought under normal working conditions.

The power supply voltage is adjusted to the upper limit.

The amplifier shall be capable of working under these conditions for at least 4 h without any component exceeding the maximum permissible temperature.

(b) *Variations of output voltage and gain.* The amplifier is brought under rated conditions.

The total harmonic distortion is measured as indicated in 20.2.

The source e.m.f. E_s and the output voltage U_2 are measured.

The power supply voltage is varied step by step over the range specified by the manufacturer. For each value of the power supply voltage chosen, the source e.m.f. E_s is readjusted to obtain the initial total harmonic distortion and the source e.m.f. E'_s and the output voltage U'_2 measured.

Over the range of permitted supply voltage, both E'_s and U'_2 remain substantially proportional to the power supply voltage, where no voltage regulation is provided.

(c) *Hum.* The rated signal-to-hum ratio is measured as indicated in 22.1.

The power supply voltage is varied step by step over the range specified by the manufacturer. For each value of the power supply voltage chosen, the hum voltage at the output is measured and the rated signal-to-hum ratio computed. It is expressed as the ratio of the measured hum to the rated output voltage.

NOTE. The worst signal-to-hum ratio will generally be measured at the upper limit of power supply voltage.

14.3 Tolerances of power supply frequency

14.3.1 Characteristics to be specified. The tolerance of power supply frequency, specified by the manufacturer shall be such that, for any power supply frequency within the stated limits, the following conditions apply.

- (a) The maximum permissible temperature is not exceeded in any component when the amplifier is under normal working conditions, except as regards power supply frequency, for at least 4 h.
- (b) The output voltage and the total harmonic distortion of the amplifier are not subject to significant variations.
- (c) The signal-to-hum ratio is not more than 3 dB below that specified by the manufacturer.

Compliance with the requirement given in (a) above is considered to be within the scope of normal amplifier design.

NOTE. Increase of working temperature of components may occur, particularly in the power supply portion, at the lower end of the power supply frequency range.

14.3.2 Measuring methods

(a) *Variations of output voltage and total harmonic distortion.* The amplifier is brought under rated conditions.

The total harmonic distortion is measured as indicated in 20.2.

The source e.m.f. E_s and the output voltage U_2 are measured.

The power supply frequency is varied step by step over the range specified by the manufacturer. For each value

of the power supply frequency chosen, the output voltage U_2' and the total harmonic distortion are measured.

Neither the voltage U_2' nor the total harmonic distortion shall be subject to significant variations within the specified power supply frequency range.

(b) *Hum*. The rated signal-to-hum ratio is measured as indicated in 22.1.

The power supply frequency is varied step by step over the range specified by the manufacturer. For each value of the power supply frequency chosen, the hum voltage at the output is measured and the rated signal-to-hum ratio computed. It is expressed as the ratio of the measured hum to the rated output voltage.

NOTE. The worst signal-to-hum ratio will generally be measured at the lower limit of power supply frequency.

14.4 Tolerances of power supply harmonics and ripple

14.4.1 Characteristics to be specified. The tolerance of power supply harmonics, specified by the manufacturer, shall be such that within the stated tolerance, the following conditions apply.

(a) The variations of the rectified power supply voltage due to changes in the peak-to-r.m.s. ratio of power supply voltage do not exceed the variations due to the permissible power supply voltage variations specified in 14.2.

(b) The signal-to-hum ratio is not more than 3 dB below that specified by the manufacturer.

Compliance with the requirement given in (a) above requires that the tolerance of a.c. power supply harmonics does not exceed the smallest tolerance, either positive or negative, specified for power supply voltage in 14.2.

For d.c. power supply ripple, the tolerance shall not exceed the positive tolerance specified in 14.2.

NOTE. Because of the great variety of spurious signals which may occur in the power supply, it is impossible to give a uniform method of measurement involving all kinds of spurious signals.

15. Input characteristics

15.1 Rated source impedance

15.1.1 Characteristic to be specified. The internal impedance, as specified by the manufacturer, of the source supplying the signal to the amplifier.

Unless otherwise specified, the rated source impedance shall be a constant pure resistance.

NOTE. The manufacturer may also give the range of source impedances which he considers tolerable in practice.

15.2 Input impedance

15.2.1 Characteristic to be specified. The internal impedance of the amplifier measured between the input terminals under normal working conditions.

15.2.2 Measuring methods

15.2.2.1 Balanced input

(a) *Free from earth*. If the input circuit of the amplifier is balanced and free from connections to the earth (or chassis), the following procedure is recommended.

The amplifier is brought under normal working conditions, using a source with one earthed terminal, as shown in figure 1.

The output voltage U_2 is measured.

The input voltage U_1 is measured.

A resistor of value R approximately one-tenth of the input impedance is connected in series with the input terminals as shown in figure 2.

The source e.m.f. is readjusted to obtain the initial output voltage U_2 .

The voltage U_R appearing across the resistor R is measured.

The modulus of the input impedance is given by $\frac{U_1}{U_R} \cdot R$.

(b) *Connected to earth*. If the input circuit has a centre tap connected to the earth or chassis, the following procedure is recommended.

The amplifier is brought under normal working conditions, using a source free from earth (or chassis), as shown in figure 3.

The output voltage U_2 is measured.

The output voltage U_1 is measured by means of a balanced voltmeter.

A resistor of value R is connected in series with the input terminals as shown in figure 4.

The source e.m.f. is readjusted to obtain the initial output voltage U_2 .

The voltage U_R appearing across the resistor R is measured by means of a balanced voltmeter.

The modulus of the input impedance is given by $\frac{U_1}{U_R} \cdot R$.

15.2.2.2 Unbalanced input. The amplifier is brought under normal working conditions.

A shielded transformer is inserted between the source e.m.f. and the amplifier. The shields are connected as shown in figure 5.

The voltage appearing at the secondary terminals of the transformer is adjusted to a value of 10 dB below the rated source voltage.

The output voltage U_2 is measured.

The input voltage U_1 is measured.

A resistor of value R is connected in series between one of the secondary terminals of the transformer and ground as shown in figure 6.

The voltage appearing at the secondary terminals of the transformer is adjusted to obtain the initial output U_2 .

The voltage U_R appearing across resistor R is measured.

The modulus of the input impedance is given by $\frac{U_1}{U_R} \cdot R$.

15.3 Rated source e.m.f.

15.3.1 Characteristic to be specified. That e.m.f., as specified by the manufacturer, which, when connected to the input terminals in series with the rated source impedance, gives rated output voltage across the rated load impedance at an appropriate setting of the controls.

15.4 Minimum source e.m.f. for rated output

15.4.1 Characteristic to be specified. The source e.m.f. for rated output voltage of an amplifier connected for rated conditions, the tone controls, if any, being set as specified for rated conditions and the volume control, if any, set for maximum gain.

NOTE. If there is no volume control, then this characteristic is identical to 'rated source e.m.f.' (see 15.3).

15.4.2 Method of measurement. The amplifier is brought under rated conditions.

The output voltage U_2 is measured.

The volume control is adjusted for maximum gain and the source e.m.f. is readjusted to restore the initial output voltage.

The source e.m.f. E_s is measured.

16. Output characteristics

16.1 Rated load impedance

16.1.1 Characteristic to be specified. That impedance, as specified by the manufacturer, by which the output terminals of the amplifier are to be terminated for measuring purposes.

Unless otherwise specified by the manufacturer, the rated load impedance shall be a constant pure resistance.

The rated load impedance for amplifiers designed for variable loading shall represent the load for which the amplifier can deliver the maximum output power without exceeding a specified amplitude non-linearity.

NOTE 1. Rated load impedance, rated output voltage and rated output power being coherent characteristics of an amplifier, it is recommended that these characteristics be set out together in a table in which the different settings of the rated output voltage switch or the different pairs of terminals for different rated output voltages, if any, are listed.

Individual definitions of these three quantities are given here but since they are interdependent, it is possible to derive any one from the manufacturer's specification for the other two.

NOTE 2. The manufacturer may also give the range of load impedance which he considers tolerable in practice.

16.2 Output impedance

16.2.1 Characteristic to be specified. The internal impedance of the amplifier measured between the output terminals under normal working conditions.

16.2.2 Method of measurement. The output impedance of an amplifier will generally be a complex quantity. Whereas the modulus of the input impedance can be measured by a simple procedure, no such procedure exists for measuring the modulus of the output impedance.

The complex output impedance can be computed from the output voltages occurring under three different conditions of load. This procedure requires very accurate measuring apparatus.

As, however, within the effective frequency range, the output impedance will generally be approximately a pure resistance, a simple procedure may be followed to obtain approximate results which are sufficiently accurate for normal practice.

The amplifier is brought under normal working conditions.

The output voltage is measured for a number of loads ranging from $0.8R_2$ to $1.2R_2$ and including the rated load impedance R_2 .

The results of the measurement are expressed in a graph presenting the inverse output voltage as a function of the inverse load impedance. The tangent of this curve for the condition of rated load is drawn and the intersection of this tangent with the ordinate is determined, thus obtaining the apparent no-load output voltage U_2' .

The output impedance is computed from the apparent no-load output voltage U_2' , the output voltage for rated

load U_2 and the rated load impedance R_2 , according to the following expression:

$$|Z| = \frac{U_2' - U_2}{U_2} \cdot R_2$$

NOTE 1. The apparent no load output voltage U_2' obtained according to the above-mentioned procedure will generally not be equal to the output voltage under no-load conditions.

NOTE 2. The error in the result obtained by this procedure is larger according to the extent of the inductive or capacitive component of the output impedance. This procedure, therefore, should not be used to measure the output impedance near or outside the limits of the effective frequency range.

NOTE 3. For amplifiers with a high degree of voltage feedback, the differences in output voltage as a result of different loading may be very small. If so, the output voltages can be measured very accurately by measuring the difference between the rectified output voltages and a compensating stabilized direct voltage.

16.3 Rated output voltage (rated distortion-limited output voltage).

16.3.1 Characteristic to be specified. The voltage at which the rated output power is delivered into the rated load impedance as specified by the manufacturer.

NOTE. See note 1 of 16.1.

16.3.2 Method of measurement of output voltage for a specified amplitude non-linearity. The amplifier is brought under rated conditions, setting the volume control, if any, to such a position that the rated output voltage, as specified by the manufacturer, appears at the output terminals.

A distortion meter is connected at the output terminals and the source e.m.f. is adjusted to obtain a specified amplitude non-linearity of the output signal.

The output voltage U_2 is measured.

16.4 Rated output power (rated distortion-limited output power)

16.4.1 Characteristic to be specified. The power that the amplifier is capable of dissipating in the rated load impedance, at a given frequency or in a given frequency band, without exceeding the rated total harmonic distortion, the amplifier being brought under rated conditions.

The rated output power shall be measured at 1000 Hz, unless there is a strong reason for taking another frequency as reference.

NOTE 1. See note 1 of 16.1.

NOTE 2. If the d.c. supply to the output stage is not electronically stabilized and has significant internal impedance, the voltage of the d.c. supply will decrease as the input source e.m.f. is increased. Some amplifiers are designed and set up in such a way that under continuous signal conditions the output waveform is unsymmetrical due to this decrease in d.c. supply voltage. When amplifying speech and music signals, the decrease in the d.c. supply voltage may be much less, with consequent reduction in even harmonic distortion.

16.4.2 Method of measurement. The amplifier is brought under rated conditions and a distortion meter is connected at the output terminals. The amplifier is operated under these conditions for a stated period of time, which shall exceed 1 min.

Immediately the above time period is over, the source e.m.f. is adjusted to obtain the rated total harmonic distortion of the output signal and the output voltage U_2 is measured.

The output power is given by $\frac{U_2^2}{R_2}$, where R_2 is the rated load impedance.

For multi-channel amplifiers the measurements shall be made on each channel separately while all other channels continue to operate under rated conditions.

The measurement may be repeated at other frequencies. The output power shall be stated for each channel separately, together with the specified percentage distortion, the frequency of the test signal and the value of the load impedance R_2 .

16.5 Regulation

16.5.1 Characteristic to be specified. The increase in output voltage, expressed in percentage terms, when, under normal working conditions, the rated load impedance is disconnected, the source e.m.f. remaining constant.

NOTE. If the amplifier contains a compressor or expander, this should be disabled.

16.5.2 Method of measurement. The amplifier is brought under normal working conditions.

The output voltage U_2 is measured.

The load is disconnected, the source e.m.f. remaining constant and the output voltage U'_2 is measured.

The regulation is given by $\frac{U'_2 - U_2}{U_2} \cdot 100$.

NOTE. The regulation can also be expressed in decibels according to the following formula:

$$20 \log_{10} \frac{U'_2}{U_2}$$

16.6 Overload restoring time

16.6.1 Characteristic to be specified. The time interval (which occurs after the amplifier working under normal working conditions is overloaded by a certain amount for a specified period) between the moment when the input voltage is restored to its original value and the moment when the output voltage has again reached its original value within specified limits.

16.6.2 Method of measurement (see figures 9(a) and 9(b)). The amplifier is brought under normal working conditions.

The input voltage is increased instantaneously by 20 dB and kept at this value for 1 s.

The input voltage is reduced to its original value instantaneously.

The time that passes before the positive as well as the negative output peak voltages have reached their ultimate value within 1 dB, unless otherwise specified, is measured by means of a suitably calibrated oscilloscope, and shall be specified as the overload restoring time.

17. Limiting characteristics

17.1 Overload source e.m.f.

17.1.1 Characteristic to be specified. The maximum source e.m.f. at which an amplifier, connected for rated conditions, and with an appropriate setting of the volume control, can deliver an output voltage 10 dB below the rated output voltage without exceeding the amplitude non-linearity specified for rated conditions.

17.1.2 Method of measurement. The amplifier is brought under rated conditions.

A distortion meter is connected at the output terminals.

The volume control is adjusted to obtain an output voltage of 10 dB below the rated output voltage.

The output voltage U_2 is measured.

The volume control is adjusted to successive positions for lower gain, increasing the source e.m.f. to restore the initial

*Or other appropriate safety standard.

output voltage U_2 , until the distortion of the output signal specified for rated conditions is obtained.

The source e.m.f. E_s is measured.

17.2 Limiting output voltage

17.2.1 Characteristic to be specified. The maximum continuous r.m.s. output voltage which the amplifier is able to deliver under any possible combination of input voltage and load impedance.

17.2.2 Method of measurement. The amplifier is brought under rated conditions.

The source e.m.f. is reduced to zero, the volume control is reset to the position for maximum gain.

The source e.m.f. is increased, starting from zero voltage to at least +20 dB with respect to rated source e.m.f., the output voltage being measured.

The measurement is repeated at a number of frequencies, at different positions of the tone controls, and for a number of loads including pure inductive and capacitive loads and no load.

The maximum output voltage occurring shall be quoted. If there is any reason to distinguish between different types of load, results may be quoted for particular loads.

17.3 Temperature-limited output power

17.3.1 Characteristic to be specified. The power which the amplifier is capable of supplying continuously, at a specified ambient temperature, without exceeding the maximum permissible temperature in any component.

The method of measurement given in 17.3.2 applies.

When the amplifier is recommended for different specified methods of mounting, e.g. in enclosures or in racks, the corresponding temperature-limited output power shall be stated.

NOTE 1. For ambient temperature, see BS 2011.

NOTE 2. For safety requirements, see BS 415*.

NOTE 3. In Class AB and Class B amplifiers, the active devices operating in these modes reach their maximum temperatures at output powers considerably less than the rated output power, and the temperature maxima of several devices may be reached at different output powers. Furthermore, where the d.c. supply to a stage is not stabilized, it is possible for temperature maxima of different values to occur at two values of output power.

17.3.2 Method of measurement. A provisional test at different output powers shall be made to determine the components which are likely to reach their limiting temperature. Appropriate thermometers are mounted on the components selected according to this provisional test.

The measurement is made according to the following procedure.

The amplifier, mounted in a specified way, is brought under normal working conditions. The ambient temperature shall be stated.

The source e.m.f. is adjusted in steps to increase the output voltage U_2 waiting after each step until the thermometer readings have become practically constant. This procedure is maintained until, at a certain output voltage U'_2 , one of the components reaches its limit temperature.

The temperature limited output power is given by $\frac{U'^2_2}{R_2}$, where R_2 is the rated load impedance.

The amplifier shall have worked continuously for at least 4 h under the conditions specified before ultimate temperature readings are made.



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