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(September 1990) and
Amendment No. 2 (May 1991) to
IEC 268-3 : 1988)*

Sound system equipment

Part 3. Methods for specifying and measuring the characteristics of sound system amplifiers

(Implementation of CENELEC HD 483.3 S2)

Equipements pour systèmes
électroacoustiques
Partie 3. Amplificateurs

Elektroakustische Geräte
Teil 3. Verstärker

UDC 534.86:621.375

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British Telecommunications plc
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Federation of British Audio
Independent Television Association
Institution of Electrical Engineers
National Council for Educational Technology (NCET)
Professional Lighting and Sound Association
Radio Electrical and Television Retailers' Association
Royal Institute of British Architects
Royal National Institute for Deaf People
Society of Cable Television Engineers
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National foreword

This new edition of this Part of BS 6840 has been prepared under the direction of the Electronic Equipment Standards Policy Committee and is identical with IEC 268-3 : 1988 *Sound system equipment Part 3 Amplifiers*, as amended by Amendment No. 1 (September 1990) and Amendment No. 2 (May 1991). This standard implements Harmonization Document HD 483.3 S2 published by the European Committee for Electrotechnical Standardization (CENELEC). For ease of production, some of the figures also include the French text. This British Standard supersedes BS 6840 : Part 3 : 1989 which is withdrawn.

This edition introduces technical changes to bring this standard up-to-date but does not reflect a full review of the standard, which will be undertaken in due course. The changes introduced are indicated by a side line in the margin.

BS 6840 consists of the following Parts:

- Part 1 *Methods for specifying and measuring general characteristics used for equipment performance*
- Part 2 *Glossary of general terms and calculation methods*
- Part 3 *Methods for specifying and measuring the characteristics of sound system amplifiers*
- Part 4 *Methods for specifying and measuring the characteristics of microphones*
- Part 5 *Methods for specifying and measuring the characteristics of loudspeakers*
- Part 6 *Methods for specifying and measuring the characteristics of auxiliary passive elements*
- Part 7¹⁾ *Methods for specifying and measuring the characteristics of headphones and headsets*
- Part 8 *Methods for specifying and measuring the characteristics of automatic gain control devices*
- Part 9 *Methods for specifying and measuring the characteristics of artificial reverberation, time delay and frequency shift equipment*
- Part 10 *Methods for specifying and measuring the characteristics of peak programme level meters*
- Part 11 *Specification for application of connectors for the interconnection of sound system components*
- Part 12 *Specification for applications of connectors for broadcast and similar use*
- Part 13 *Guide for listening tests on loudspeakers*
- Part 14 *Guide for circular and elliptical loudspeakers; outer frame diameters and mounting dimensions*
- Part 15 *Specification for matching values for the interconnection of sound system components*
- Part 16 *Guide to the 'RASTI' method for the objective rating of speech intelligibility in auditoria*
- Part 17 *Methods for specifying and measuring the characteristics of standard volume indicators*

Compliance with a British Standard does not of itself confer immunity from legal obligations.

¹⁾ In preparation.

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English version

Sound system equipment Part 3: Amplifiers

(IEC 268-3 : 1988 + A1 : 1990 + A2 : 1991)

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Elektroakustische Geräte
Teil 3: Verstärker
(IEC 268-3 : 1988 + A1 : 1990 + A2 : 1991)

This Harmonization Document was approved by CENELEC on 1992-06-16. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

This Harmonization Document exists in three official versions (English, French, German).

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 268-3 : 1988 and its amendments 1 : 1990 and 2 : 1991 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as Harmonization Document.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as HD 483.3 S2 on 16 June 1992.

The following dates were fixed:

- latest date of
announcement of the HD
at national level (doa) 1992-12-01
- latest date of publication
of a harmonized national
standard (dop) 1993-06-01
- latest date of withdrawal
of conflicting national
standards (dow) 1993-06-01

For products which have complied with HD 483.3 S1 : 1990 before 1993-06-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1998-06-01.

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative.

SOUND SYSTEM EQUIPMENT

Part 3: Amplifiers

1. Scope

This standard applies to amplifiers which form part of a sound system for professional and household applications.

2. Object

The purpose of this standard is to give recommendations relative to the characteristics to be specified and the relevant measuring methods for amplifiers.

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 will give equivalent results.

Rated conditions and standard test 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*

This standard shall be used in conjunction with:

- IEC Publication 268-1 (1985): Sound system equipment, Part 1: General, and
- IEC Publication 268-2 (1987): Sound system equipment, Part 2: Explanation of general terms and calculation methods.

3.2 *Rated conditions and standard test conditions*

3.2.1 *Introduction*

For convenience in specifying how amplifiers shall be set up for measurement, certain sets of conditions are defined in this standard under the titles of rated conditions and standard test conditions, respectively.

A full explanation of the term “rated” is given in IEC Publication 268-2.

The rated conditions used in this part are:

- rated power supply voltage;
- rated source impedance;
- rated source e. m. f.;
- rated load impedance;
- rated total harmonic distortion, or rated (distortion-limited) output voltage or power;
- rated mechanical and climatic conditions.

Notes 1. – Total harmonic distortion and (distortion-limited) output voltage or power are inter-dependent. Both cannot be taken as rated conditions simultaneously because normally a given sample amplifier produces less than rated total harmonic distortion at rated output voltage or power.

2. – If the power supply frequency is critical, it also represents a rated condition.

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

Methods of measurement for these other characteristics are given in this standard and the manufacturer is either required or permitted (see Clause 31) to state "rated values" for these characteristics in the specification of the equipment. These include:

- rated voltage gain;
- rated distortion limited output voltage or power (when not adopted as a rated condition);
- rated signal-to-noise ratio;
- rated equivalent noise source e. m. f.

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 are fulfilled:

- a) the amplifier is connected to 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 an appropriate frequency. Unless there is a special reason to the contrary, this frequency shall be the standard reference frequency of 1 000 Hz according to IEC Publication 268-1, Clause 3: "Frequencies of measurement".
Such a reason could be that the standard reference frequency is outside or near the limit of the effective frequency range of the amplifier;
- f) the volume control, if any, is set to such a position that the rated distortion-limited 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;
- h) the balance control(s), if any, is (are) set to the central position;
- i) the rated mechanical and climatic conditions according to IEC Publication 268-1 are complied with.

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

3.2.3 *Standard test conditions*

These are obtained by bringing the amplifier under rated conditions (see Sub-clause 3.2.2) and then reducing the source e. m. f. to a level of -10 dB referred to the rated source e. m. f.

Note. – The signal frequency is 1 000 Hz, unless there is a special reason to the contrary (see Sub-clause 3.2.2, Item *e*)).

3.2.4 *Influence of the power supply*

When specifying the characteristics of an amplifier, rated power supply voltage 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 harmonics or ripple.

3.3 *Other conditions*

If supplementary data of the amplifier are presented, applying to other than the rated or standard test conditions, for example at different frequencies or at different settings of controls, then the conditions shall be fully defined in the presentation. These conditions shall, if possible, be chosen according to the recommendations made in the relevant clauses of this standard.

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

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 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 the 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.

Note. – Other classes of operation have been commercialized but no formal definitions of such classes have been submitted for standardization.

SECTION ONE — GENERAL

5. **Rated source impedance**

If the rated source impedance according to Sub-clause 17.1 is not stated by the manufacturer, the appropriate impedance specified in IEC Publication 268-15 shall be adopted as the rated source impedance.

6. **Interchangeable parts**

For type measurements, interchangeable parts shall have the mean characteristics specified for these parts.

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

7. **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 either on a signal passing through the amplifier itself or on an external control signal.

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

8. **Special instructions for operation**

The manufacturer may have 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 other information with respect to normal or abnormal operating 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.

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.

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 Sub-clause 3.2.4).

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

10. Position of the volume controls

If a characteristic is measured at only one position of the volume control, the control shall be at the position corresponding to rated conditions (see Sub-clause 3.2.2), unless a maximum or minimum position of the control is inherent in the characteristic to be measured.

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, and -3 dB, -6 dB, -10 dB, -20 dB and -40 dB with respect to the setting for rated conditions.

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

11. Series of measurements

If a series of measurements is made, the amplifier should preferably be maintained under standard test 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 after pre-conditioning according to Clause 12.

12. Pre-conditioning for measurements

Before beginning measurements on an amplifier, it shall be operated under approximately standard test conditions for a period of 1 h, or as specified by the manufacturer.

Before operating the amplifier the manufacturer's instructions concerning initial operation should be studied.

The amplifier is then brought under standard test conditions as given in Sub-clause 3.2.3. Due to internal heating the output voltage may subsequently vary with time. Unless excessive, this effect is ignored during the pre-conditioning period. When the pre-conditioning period is over, the amplifier shall be brought under rated conditions or standard test conditions, as required.

13. Variable consumption apparatus

Sound system equipment shall 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. power supply for the output stages is either electronically stabilized by means of series control elements or has no stabilization.

Notes 1. – 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 Sub-clause 19.4 still applies.

2. – For safety testing purposes only, a different definition is given in IEC Publication 65.

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 (see Sub-clauses 18.3.1, notes and 24.3, Item 3)).

14. Marking

Recommendations for marking the terminals and controls are given in IEC Publication 268-1, Clause 5: "Marking and symbols for marking".

Marking may concern:

- Personal safety and prevention of spread of fire in the sense of IEC Publication 65.
- Safety in case of faulty connections.
- Indications relating to normal operation, according to IEC Publication 417.

Marking can neither prevent incorrect operation 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. Care should be taken that marking is unambiguous and as clearly understandable as possible.

Terminals for the interconnection of equipment, which are inaccessible without the use of a tool when the equipment has been installed, shall be clearly and unambiguously identified with respect to the manufacturer's instructions for installation. It is assumed that these instructions are to be read by skilled personnel.

For the definitions of "inaccessible" and "tool", IEC Publication 65 shall be referred to.

15. Operating environment

Measurements, especially those including temperature measurements, shall be carried out with the amplifier mounted in a situation similar to that in which it is to be used. Restrictions on mounting and special ventilation requirements shall be stated by the manufacturer and form part of the rated conditions (see Sub-clause 3.2). IEC Publication 65 or other appropriate safety standards shall also be referred to.

SECTION TWO — CHARACTERISTICS TO BE SPECIFIED AND THE RELEVANT MEASURING METHODS

16. Power supply

16.1 Basic power supply characteristics

16.1.1 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 voltage selection, if any:

- a) the type of power supply (d.c. or a.c.);

- b) the rated power supply voltage (this is a rated condition, see Sub-clause 3.2);
- c) the power supply frequency or range of frequencies (this may be a rated condition, see Sub-clause 3.2);
- d) the power drawn, under rated conditions, expressed in watts;
- e) the power drawn, under standard test conditions, expressed in watts;
- f) for variable consumption apparatus (see Clause 13), the power drawn from the power supply may be expressed as a function of output voltage or power from zero to the rated value, with specified load impedances, including the rated load impedance. This characteristic is particularly of value for battery-operated equipment. It may be presented as a graph.

Note. – If in d), e) or f) above the apparent power drawn is significantly greater than the true power, the apparent power should be stated in addition.

16.1.2 *Method of measurement*

- 1) The amplifier is brought under rated conditions.
- 2) The power drawn from the power supply is measured in watts by means of a wattmeter:
 - i) with rated source e. m. f., see Sub-clause 17.3;
 - ii) with the source e. m. f. according to standard test conditions;
 - iii) for variable consumption apparatus according to Clause 13 for various values of output voltage or power from zero to the rated value.

16.2 *Tolerance of power supply voltage variations*

16.2.1 *Characteristics to be specified*

The tolerance of power supply voltage variation specified by the manufacturer shall be such that, for any power supply voltage within the stated limits:

- a) the upper limit of working voltage is not exceeded for any condition of normal operation; this applies particularly to such components as semiconductor devices and electrolytic capacitors;
- b) the tolerances of the heater voltage of electronic tubes used in the amplifier are not exceeded;
- c) the maximum permissible temperature is not exceeded in any component when the amplifier works under standard test conditions – except as regards power supply voltage – for an extended period of time;
- d) neither output nor gain is subject to excessive variations;
- e) the signal-to-hum ratio is not reduced by more than 3 dB with respect to the rated value.

Amplifiers designed to take their power supply from the mains are generally not 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 due to changing load, the temperature of batteries or the gradual decrease of battery voltage during life or discharge.

If the manufacturer states that the amplifier will tolerate power supply voltage variations not exceeding $\pm 10\%$, then compliance with requirements *a)*, *b)* and *c)* is considered to be within the scope of normal amplifier design. Compliance with requirements *d)* and *e)* shall be checked.

If the manufacturer states that the amplifier will tolerate power supply voltage variations exceeding $\pm 10\%$, the manufacturer's manual shall give details of any special means for compensating such variations and the proper working of these means shall be checked if possible. Compliance with the requirements *a)* to *e)* shall be checked.

16.2.2 *Methods of measurement*

a) Temperature

- 1) The amplifier is brought under standard test conditions. If a rated temperature-limited output power is given, the source e. m. f. shall be adjusted so that this value of output power is obtained.
- 2) The power supply voltage is adjusted to the upper limit stated by the manufacturer and the source e. m. f. readjusted, if necessary, to restore the output power to the value specified in Item 1).
- 3) The amplifier shall be capable of working continuously under these conditions for at least 4 h without any component exceeding the maximum permissible temperature.

b) Variations of output and gain

- 1) The amplifier is brought under rated conditions, the total harmonic distortion being measured by the method given in Sub-clause 22.3.2.
- 2) The source e. m. f. E_s and the output voltage U_2 are measured.
- 3) 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 are measured.

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

c) Hum

- 1) The signal-to-hum ratio is measured as indicated under Clause 24.
- 2) 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 signal-to-hum ratio computed. It is expressed as the ratio in dB of the rated output voltage to the measured hum voltage.

Note. – The worst signal-to-hum ratio is generally found at the upper limit of power supply voltage.

16.3 *Tolerance of power supply frequency variations*

16.3.1 *Characteristics to be specified*

The tolerance of power supply frequency variation specified by the manufacturer shall be such that, for any power supply frequency within the stated limits:

- a)* the maximum permissible temperature is not exceeded in any component when the amplifier is under standard test 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 reduced by more than 3 dB with respect to the rated value.

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

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

16.3.2 *Methods of measurement*

a) *Variations of output voltage and total harmonic distortion*

- 1) The amplifier is brought under rated conditions, the total harmonic distortion being measured by the method given in Sub-clause 22.4.2.
- 2) The source e. m. f. E_s and the output voltage U_2 are measured.
- 3) 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.
- 4) 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 method of measurement is as given in Item c) of Sub-clause 16.2.2, except that the power supply frequency is varied instead of the power supply voltage.

Note. – The worst signal-to-hum ratio is generally found at the lower limit of power supply frequency.

16.4 *Tolerance of power supply harmonics and ripple*

16.4.1 *Characteristics to be specified*

The tolerance of power supply harmonics, specified by the manufacturer, shall be such that within the stated tolerance range:

- 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 according to Sub-clause 16.2;
- b) the signal-to-hum ratio is not reduced by more than 3 dB with respect to the rated value.

Requirement a) implies that the tolerance of a.c. power supply harmonics does not exceed the smallest tolerance, either positive or negative, specified for the power supply voltage according to Sub-clause 16.2.

Note. – For d.c. power supply ripple, the tolerance does not usually exceed the positive tolerance specified according to Sub-clause 16.2.

16.4.2 *Method of measurement*

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 applicable to all kinds of spurious signals.

17. Input characteristics

17.1 Rated source impedance (this is a rated condition, see Sub-clause 3.2)

17.1.1 Characteristic to be specified

The internal impedance, stated by the manufacturer, of the source supplying the signal to the amplifier.

Unless otherwise specified, the rated source impedance is assumed to be a constant pure resistance.

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

17.2 Input impedance

17.2.1 Characteristic to be specified

The internal impedance measured between the input terminals:

- a) under standard test conditions;
- b) at other signal frequencies.

17.2.2 Methods of measurement

In the methods given below the modulus of the input impedance is measured. If more information is required (such as the values of the components of an equivalent circuit representing the input impedance over a range of frequencies) then a suitable bridge or other technique should be used, care being taken that the measuring signal amplitude is controlled so as not to give rise to any unwanted non-linearity.

17.2.2.1 Balanced input

- 1) The amplifier is brought under standard test conditions, using a source free from earth (or chassis), as shown in Figure 1.
- 2) The input voltage U_1 is measured by means of a voltmeter with balanced input, whose input impedance is high compared with the input impedance of the amplifier.
- 3) The amplifier input is then substituted by a calibrated variable resistor, which is adjusted so that the voltmeter again reads U_1 . The value of the variable resistor is then equal to the modulus of the input impedance of the amplifier at the standard reference frequency.
- 4) The measurement may be repeated at other signal frequencies, preferably chosen from Table II of IEC Publication 268-1.

Notes 1. – If the input impedance of the amplifier is high compared with the rated source resistance, it is difficult to determine precisely the setting of the variable resistor which gives a voltmeter reading equal to U_1 . In other words, the sensitivity of the method of measurement is low. This effect can be overcome by increasing the source impedance, for this measurement, to a value of ten or more times the rated source impedance.

2. – The input impedance of the voltmeter also affects the sensitivity of the measurement. It should therefore be high compared with the parallel combination of the source impedance used for the measurement and the input impedance of the amplifier.