
Methods of

Measuring and expressing the performance of radio receivers for sound broadcasting

Part 2. Measurements related to the audio- frequency part of the receiver

Méthodes de mesure et d'expression des performances des récepteurs radioélectriques
pour la radiodiffusion sonore

Partie 2. Mesures particulières à la partie à fréquence acoustique du récepteur

Verfahren zur Messung und Bezeichnung der Leistung von Radioempfängern für Hörfunk
Teil 2. Messungen des Tonfrequenzteils des Empfängers

Foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Committee and is technically equivalent to IEC Publication 315-2 'Methods of measurement on radio receivers for various classes of emission Part 2 : Measurements particularly related to the audio-frequency part of a receiver' published by the International Electrotechnical Commission (IEC).

It forms Part 2 of BS 4054 : 1980 and, together with Parts 1, 3, 4 and 5, is a revision of BS 4054 : 1966 which is to be withdrawn when all five Parts are complete. The other Parts are as follows :

- Part 1. General conditions
- Part 3. Radio-frequency measurements on receivers for amplitude-modulated emissions
- Part 4. Radio-frequency measurements on receivers for frequency-modulated emissions (In course of preparation)
- Part 5. Measurements on frequency-modulated receivers of the response to impulsive interference

The terminology and measuring methods described in this Part of this British Standard were developed from those traditionally used for radio receivers, and do not reflect all the changes in concepts and technology that have taken place in the development of more complex and comprehensive household electronic equipment, such as music centres and high-fidelity equipment.

In most cases the terminology and methods of BS 5428 : Part 2 are more widely used, and will be found more suitable for the assessment and specification of these more complex equipments, especially where high-fidelity performance (IEC Publication 581) is concerned.

This present publication is, however, suitable for the assessment and specification of simpler equipment, such as portable radio receivers. When Part 4 of this British Standard is published, reference should be made to it for further explanation of the relationship between the terminology of this Part and that of BS 5428 : Part 2.

Terminology and conventions. For ease of production the IEC text has been reproduced, with modifications, in this British Standard. Some terminology and certain conventions are not identical with those used in British Standards ; attention is especially drawn to the following.

Wherever the word 'Recommendation' appears, referring to this standard, it should be read as 'British Standard'.

NOTE. References to page numbers relate to the IEC page numbers given in brackets at the bottom of each page.

Scope (Clause 2). The scope clause of the International Standard is not presented in the way that is customary for the scope of a British Standard and has been rewritten without changing the technical meaning.

Cross-references

International standard	Corresponding British Standard
IEC 200 : This publication has been superseded by IEC 268-5 (See cross-reference under this number.)	
IEC 268	BS 5428 Methods for specifying and measuring the characteristics of sound system equipment Part 1 : 1977 General (Related)
Part 3 : 1969	Part 2 : 1979 Amplifiers (Technically equivalent)
Part 5 : 1972	Part 11 : 1977 Loudspeakers (Identical)
IEC 315	BS 4054. Methods for measuring and expressing the performance of radio receivers for sound broadcasting
Part 1 : 1970	Part 1 : 1980 General conditions (Identical)
ISO/R 226-1961	BS 3383 : 1961 Normal equal-loudness contours for pure tones and normal threshold of hearing under free-field listening conditions (Technically equivalent)

At present there is no corresponding British Standard for IEC Publication 581, but the reference occurs only in the foreword, and is for information only.

Textual changes. It has been found necessary to make some changes to the text of the international publication in order to correct some technical errors and to improve the clarity of the text. References to measurement of current distortion have been omitted as this technique is out-of-date.

Where it has been necessary to amend the IEC text, the revised text has been indicated by a vertical line in the margin.

Some printing errors have also been corrected.

IMPORTANT NOTE. It is essential that this Part be read, where applicable, in conjunction with Part 1 of this British Standard.

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British Standard Methods of

Measuring and expressing the performance of radio receivers for sound broadcasting

Part 2. Measurements related to the audio-frequency part of the receiver

CHAPTER 1: GENERAL

SECTION ONE — INTRODUCTION

1. Object

See IEC Publication 315-1, Methods of Measurement on Radio Receivers for Various Classes of Emission, Part 1: General Conditions for Measurements and Measuring Methods applying to Several Types of Receivers.

2. Scope

This part of BS 4054 describes methods of measuring and expressing the performance of the audio-frequency part of radio receivers for sound broadcasting. It should be used in conjunction with Part 1 and, if applicable, in conjunction with other parts covering other measurements to be carried out on the particular type of receiver under test.

The measurements described in this part do not necessarily represent the audio-frequency properties of a complete radio receiver.

SECTION TWO — GENERAL NOTES ON MEASUREMENTS

3. Introduction

As the results of various measurements described in Part 2 may be influenced by other properties of the receiver, the related measurements, given in Part 1, shall be carried out first. All measurements shall, unless otherwise specified, be carried out under the conditions specified in Part 1.

4. Various requirements

With respect to general procedures for carrying out the measurements, the description of measuring conditions, the accuracy of measuring instruments, the presentation of results and deviations from the recommended methods, reference is made to Section Two of Part 1.

5. Environmental conditions

For environmental conditions, see Section Three of Part 1.

6. Precautions during measurements

For precautions during measurements, see Section Four of Part 1.

SECTION THREE — AUDIO-FREQUENCY INPUT SIGNAL

7. Introduction

For the purpose of audio-frequency measurements, the audio-frequency input signal shall preferably be applied to the audio-frequency input terminals.

Where the audio-frequency terminals are connected to a pick-up forming part of a radio-gramophone, the audio-frequency signal may be obtained from a frequency test record of known characteristics. The result of these measurements represent the over-all characteristics of the pick-up and the audio-frequency part of the receiver. The characteristics of the test record shall be added to the results.

If such terminals are not available, the audio-frequency signal may be applied to a suitable point of the audio-frequency circuit.

If the audio-frequency circuit is not accessible, a suitable modulated radio-frequency signal can be applied to the radio-frequency input circuit (see Clause 10). For a.m. receivers, there is generally no point in carrying out those tests which are likely to be materially affected by the characteristics of the radio-frequency, intermediate frequency and detector stages.

Typical examples of response/frequency characteristics of broadcast receivers operating in Band 5 or Band 6 (long waves and medium waves, see Clause 41 of Part 1) are shown in Sections Fifteen and Sixteen. These characteristics shall be measured as over-all characteristics in accordance with the relevant tests described in the part covering the radio-frequency properties of the receiver under test.

8. Input arrangements for receivers with audio-frequency input terminals

The signal is derived from an audio-frequency generator of relatively low output impedance and additional components are used to attain the required source impedance.

If the source impedance for which the input terminals are designated is specified, these additional components shall be chosen to simulate the specified source impedance, for example by using a series resistor of suitable value.

If the required source impedance for these terminals has not been specified, the following shall be used:

- a capacitor of 1 nF connected in series with the source to simulate a piezo-electric pick-up;
- a resistor of 1 000 Ω in series with an inductance of 0.5 H to simulate a pick-up with an inductive source impedance;
- a resistor of 100 000 Ω in series to simulate a tape recorder.

Where several sets of audio-frequency input terminals are provided, for example separate sets for disk and for tape reproduction, audio-frequency measurements shall be carried out for each set of input terminals, each being fed from the appropriate source impedance.

It shall be checked whether the simultaneous application of separate signal sources or impedances to their designated input terminals influences the audio-frequency reproduction.

9. Input arrangements for receivers without audio-frequency input terminals

For a receiver without audio-frequency input terminals, the signals shall, if practicable without infringement of Clause 13 of Part 1, be applied to the most suitable point, nearest to the input of the audio-frequency amplifier and before the volume control.

To simulate the audio-frequency output impedance of the radio-frequency part, an appropriate resistor shall be inserted in series with the audio-frequency generator (its value to be stated with the results).

If applicable, a series resistor of value R , sufficiently high to avoid disturbing the measurement, e.g. through influence on a possible feedback circuit in the receiver, shall be applied.

Where d.c. isolation is wanted, a series capacitor having a value of at least $\frac{1}{25R}$ F shall also be inserted.

If necessary, in a.m. receivers, the signal-diode circuit shall be so biased that no additional distortion, resulting from rectification of the audio-frequency signal, takes place in the circuit, for all measurements other than the measurement of audio-frequency distortion as a function of the audio-frequency input signal level (see Section Seven).

In the case of transistor receivers, it is necessary to make sure that this operation includes precautions, in order to prevent damage to certain high-frequency transistors via the automatic gain control circuit.

10. Indirect audio-frequency input signal

If the arrangements of Clause 8 or 9 are not applicable, it is possible to carry out audio-frequency measurements by injecting an audio-frequency modulated radio-frequency signal in accordance with Chapter III of Part 1. In this case, however, the measurement becomes a measurement of the over-all characteristics of the receiver. It can be used to represent the characteristics of audio-frequency circuits only if, in the first place, one has made sure by means of suitable over-all measurements that, under the test conditions, the radio-frequency circuits and the detector do not introduce any appreciable distortion, nor affect the results of the measurements in any other way.

In particular, care shall be taken to keep the receiver tuned correctly to the frequency of the radio-frequency signal. In this respect, reference is made to Chapter IV, of Part 1, and the relevant Publication dealing with the radio-frequency part of the particular type of receiver under test.

11. Requirements for measurements using a frequency test record (if applicable)

The frequency test record shall be clean, flat and the recording not worn from excessive use. It shall be placed on the turntable and operated at its nominal speed. The frequencies shall be measured, e.g. by means of a counter, or calculated by measuring the actual speed of the record.

The results of the measurements shall be corrected for the departure of the frequency characteristics of the test record from the standard recording characteristics as shown in Table I of IEC Publication 98, Processed Disk Records and Reproducing Equipment.

Care shall be taken to ensure that:

- a) low-frequency noise arising from the gramophone motor turntable and its mechanism, and
- b) hiss from the record

do not affect the accuracy of the results of the measurement.

12. Combining networks

For the purpose of the application of two audio-frequency signals simultaneously, suitable combining networks or circuits shall be applied, in order to avoid intermodulation in the two signal generators as a result of interaction.

Two examples of networks of the passive type in which coupling between the two generators has been reduced as far as practicable are given in Figures 1 and 2. In both cases, the network is followed by a 6 dB attenuator for the purpose of reducing the influence of mismatching, when connecting the circuit to be tested. The output impedance is R_i .

Note. — If serious mismatching is present, the decoupling between the two signal generators is unfavourably affected.

Figure 1 gives an example of a passive network using resistors only, which has the disadvantage that at least one signal generator cannot be earthed if the combined output is applied to an earthed audio-frequency input circuit. If the type of signal generator used requires earthing of one output terminal, a suitable isolating transformer with a ratio 1:1 shall be used.

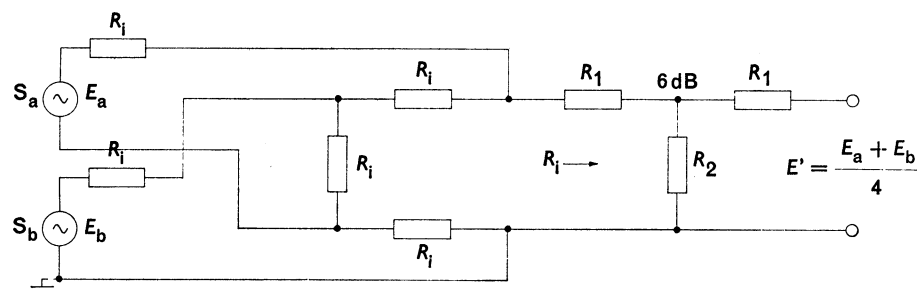


FIG. 1. — Passive combining network with resistors only.

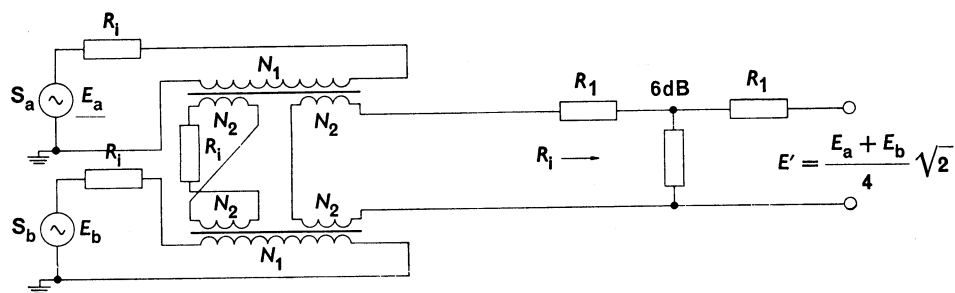
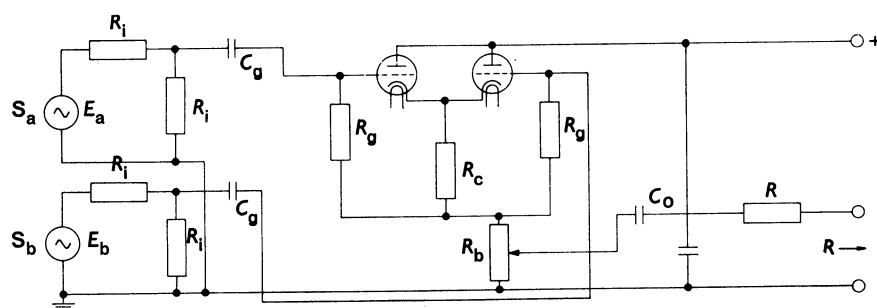


FIG. 2. — Passive combining network with differential transformers.



$$R_g \gg R_i$$

$$C_g > \frac{1}{25 R_g} \text{ F}$$

$$C_o > \frac{1}{25 R} \text{ F}$$

$$R_i \ll R$$

R_c depends on the relevant valve characteristic

Fig. 3. — Active combining circuit.

Figure 2, page 19, gives an example of a passive network using transformers and resistors, in which both signal generators may be earthed. For matching the signal generators correctly, it is required that:

$$N_2 = \frac{N_1}{2} \sqrt{2}$$

Figure 3, page 19, gives an example of an active circuit containing a twin-triode acting as two cathode followers, to combine the two signals. Care shall be taken that the values of the active and/or passive components used do not influence the results at the lower audio-frequencies. This type of circuit does not require any exact matching of the load to maintain the decoupling between the two signal generators. The output impedance is R .

13. Recommended audio frequencies for measurements

Unless otherwise specified, the recommended audio frequencies given in Section Eight of Part 1 shall be used for the measurements.

Note. — In the subsequent clauses, the term “standard reference frequency” is utilized throughout. According to Clause 32 of Part 1, this frequency is normally 1 000 Hz with a frequency of 400 Hz as a temporary alternative.

14. Audio-frequency input level

The audio-frequency input level shall be expressed in terms of apparent source e.m.f. (see Clause 52 of Part 1), input current or available power, whichever is applicable.

CHAPTER II:

AUDIO-FREQUENCY DISTORTION AND RELATED PROPERTIES

SECTION FOUR —

GENERAL NOTES ON AUDIO-FREQUENCY NON-LINEARITY DISTORTION

15. Introduction

This Chapter deals only with the audio-frequency non-linearity distortion, which is the distortion in the audio-frequency spectrum caused by non-linear elements in the audio-frequency part of the receiver.

This type of distortion depends on so many details both of design and operational conditions, that it is not possible to specify any complete set of measuring procedures. Therefore, the object of the measurements described hereafter is that of showing the influence of certain operational parameters on the non-linearity distortion which manifests itself in various forms according to the conditions of use of the receiver. The way of expressing it depends on the methods of measurement.

Hum voltages shall not be included in the calculation or the measurement of harmonic distortion; filters shall be used, if necessary.

Care shall be taken that no infringement is made on the requirements of Clause 13 of Part 1.

16. Acoustic measurements

As part of the audible distortion is caused by the loudspeaker itself, it would be most correct to measure the distortion acoustically.

Such acoustic measurements generally involve considerable difficulty and the measurements described below are therefore restricted to the electrical output power.

Note. — For appropriate acoustic measurements, reference may be made to IEC Publication 268-5: Sound System Equipment, Part 5: Sound System Loudspeakers (in preparation), when completed.

17. Measurements in case of more than one set of output terminals

If more than one set of output terminals is provided, the measurements shall be repeated at all output terminals. If two or more sets of output terminals are used simultaneously, each of these shall be connected to its proper load or, if permissible, to a relevant substitute load (see Clause 34 of Part 1) during these measurements.

SECTION FIVE —

DISTORTION IN THE PRESENCE OF A SINGLE SIGNAL (HARMONIC DISTORTION)

18. Introduction

When one applies a single sinusoidal signal at the input terminals, the distortion manifests itself through the appearance of additional components of the output power at frequencies which are harmonically related to the frequency of the applied audio-frequency input signal. This is generally described by the term “harmonic distortion”.

The degree of non-linearity distortion is determined by measuring the harmonic content of the voltage across the audio-frequency substitute load with a wave analyzer, or with a distortion factor meter (harmonic distortion analyzer of the fundamental-suppression type) from which the total degree of distortion can be read directly.

The individual harmonic components may be expressed in terms of a percentage of the fundamental.

The degree of harmonic distortion is expressed by:

$$\frac{\sqrt{A_2^2 + A_3^2 + A_4^2 + \dots}}{A_1} \times 100\%$$

where:

A_1, A_2, A_3 , etc. are the voltage values of the fundamental and the individual harmonics present in the output circuit.

Note.—A distortion factor meter usually does not have a true r.m.s. meter and does not measure the amplitude of the fundamental alone in the ‘set 100% mode’, but in most cases the measurement error is small if the degree of total harmonic distortion is less than 10%.

19. Method of measurement

The audio-frequency signal, with a frequency equal to the standard reference frequency, shall be applied in accordance with Section Three. This signal shall not contain any other frequencies of a level such that the accuracy of the measurements may be affected.

With the tone controls set at normal position (see Clause 28 of Part 1), the volume control set at maximum, the audio-frequency signal level is varied and the distortion of the output signal measured and expressed as a function of the electric output power. If desired, measurements may be repeated at other settings of the tone control and at other audio frequencies.

For audio-frequency amplifiers using transistors and having output stages operating in Class B, distortion measurements shall be extended to the region of very small output powers since with such amplifiers the non-linearity distortion may noticeably increase for decreasing values of the input signal level.

20. Presentation of the results

Curves showing audio-frequency distortion at a single audio frequency as a function of the output power are plotted with the output power as abscissa and the distortion as ordinate. The output power is expressed in watts on a logarithmic scale. For the ordinate, a linear scale is chosen.

Curves showing audio-frequency distortion as a function of the audio frequency with a constant output power are plotted with the frequency as abscissa on a logarithmic scale, and the distortion as ordinate on a linear scale. It shall be stated with the results whether voltage or current measurements have been made.

Examples of curves showing harmonic distortion as functions of output power and audio frequency are given in Figures 4 and 5, respectively.

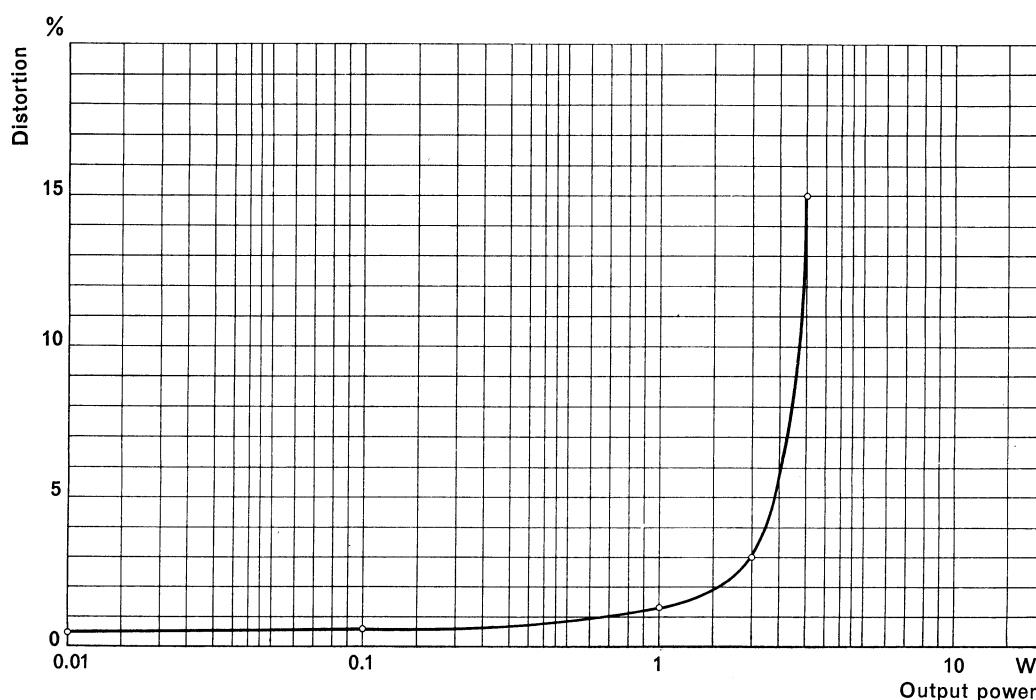


FIG. 4. — Harmonic distortion as a function of output power (at 1 000 Hz, calculated from a voltage measurement), with the volume control at maximum and the tone controls at normal position.

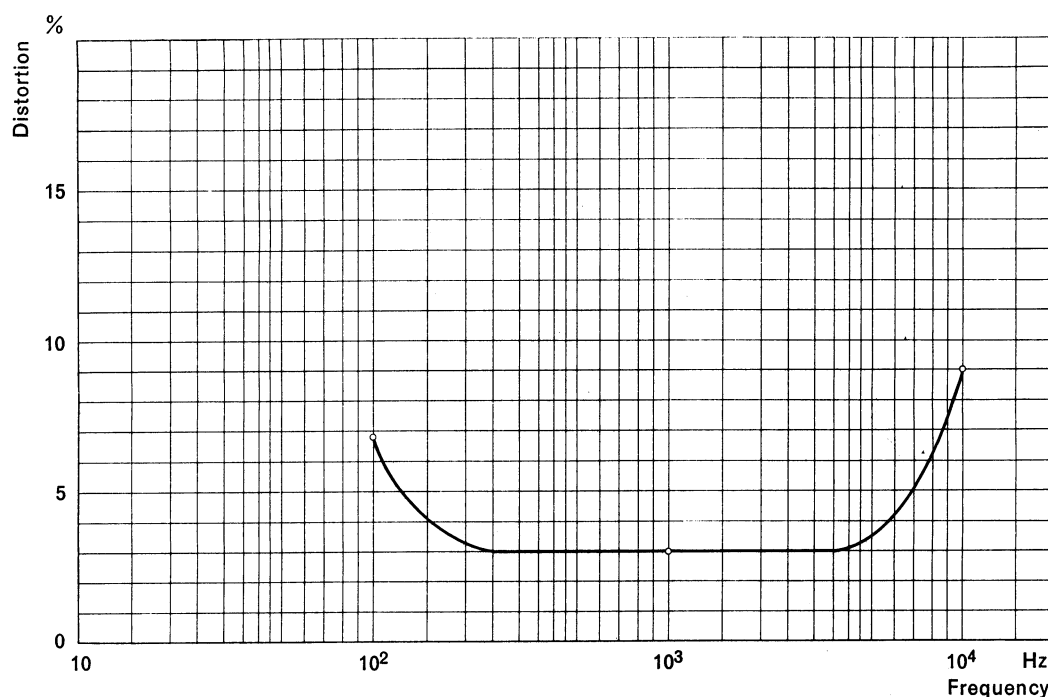


FIG. 5. — Harmonic distortion as a function of audio-frequency at an output power of 2 W (calculated from a voltage measurement), with the volume control at maximum and the tone controls at normal position.

21. Distortion under dynamic conditions

The method of measurement given in Clause 19 refers to static conditions with respect to the application of the input signal. To check whether the measured distortion, at a certain value of the output power, is independent of transient application of the audio-frequency input signal, an oscilloscope may be used to display the wave form of the output signal. The chosen input signal is switched off for several seconds, but then reapplied suddenly. The original static wave form display should reappear instantly, without any gradual changes of level or waveshape.

A further check of the nuisance value of short overloads is to increase the audio-frequency input signal from a level, giving an oscilloscope picture of the output signal with barely observable distortion of known value, to a level with obviously observable distortion of the output signal on the oscilloscope screen and subsequently reduce the signal abruptly to its original value. Also in this case, the original static picture should be restored nearly simultaneously or reappear within a reasonably short restoring time.

An investigation with an audio-frequency signal which is itself modulated with a square wave may also be carried out.

If unwanted phenomena are observed when applying these check methods, they may partly be ascribed to the same properties which are the cause of non-proportional gain (see Section Nine), or to transient distortion in the negative feed-back system.

A more detailed test procedure is under consideration.

SECTION SIX — DISTORTION IN THE PRESENCE OF TWO SIMULTANEOUS SIGNALS (INTERMODULATION)

22. Introduction

When two sinusoidal signals with frequencies f_1 and f_2 are applied simultaneously at the input terminals, in accordance with Clause 12, the output contains, in addition to the harmonic distortion described in Clause 18 for each signal, intermodulation products with the frequencies:

$$m \cdot f_1 + n \cdot f_2$$

where:

m and n are integers.

For Method A (Clause 23) and Method B (Clause 24), where $f_2 \gg f_1$, the significant intermodulation frequencies are given by:

$$n = 1, m = \pm 1, \pm 2, \pm 3, \text{ etc.}$$

For Method C (Clause 25), usually only the intermodulation frequency given by $n = 1, m = -1$ is considered and measured. However, in some cases, it may be necessary to measure higher order intermodulation products as well.

Warning. — It shall be borne in mind that the methods described do not always give results that can be correlated in a simple way.

The audio-frequency input signals shall not contain any components at other unwanted frequencies with a level greater than -50 dB with respect to the relevant input level. Furthermore by applying the provisions of Clause 12, intermodulation between the input signals, which could influence the results of the measurements, shall be prevented. The signals shall be applied in accordance with Section Three.

For reference purposes, an equivalent output power related to a sinusoidal voltage or current shall be determined, either from the voltages (U_1 and U_2) or from the currents (I_1 and I_2), which corresponds to the peak value of the output power of the two combined signals. The relevant formula shall be applied:

$$\frac{(U_1 + U_2)^2}{R_p} \quad \text{or} \quad R_s (I_1 + I_2)^2$$

where:

R is the resistive part of the impedance of the output transducer, or of the relevant substitute load

the subscripts p and s refer to the parallel or series components of the impedance at the lower frequency f_1

Note. — The use of an oscilloscope facilitates the observation of intermodulation effects.

23. Method of measurement A

Method A consists of the simultaneous application of a signal with a low audio frequency f_1 of preferably 71 Hz and a signal with a high audio frequency f_2 or preferably 5 000 Hz. At the input, the amplitude of the signal at the frequency f_2 is chosen to have a definite ratio, 1 to r , to the amplitude of the signal at the frequency f_1 ; preferably, this ratio shall be 1:4.

Equipment that does not reproduce the above preferred frequencies shall be measured with a higher or lower frequency respectively, falling within its frequency range.