BRITISH STANDARD

BS EN 60315-4:1998
IEC 60315-4: 1997

Methods of measurement on radio receivers for various classes of emission —

Part 4: Receivers for frequency–modulated sound broadcasting emissions

The European Standard EN 60315-4:1998 has the status of a British Standard

ICS 33.160.20

National foreword

This British Standard is the English language version of EN 60315-4:1998. It is identical with IEC 60315-4:1997.

The UK participation in its preparation was entrusted by Technical Committee EPL/100, Audio, video and multimedia systems and equipment, to Subcommittee EPL/100/1, Receiving equipment, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Attention is drawn to the fact that CEN and CENELEC standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement these international or European publications may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 56 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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EUROPEAN STANDARD

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English version

Methods of measurement on radio receivers for various classes of emission Part 4: Receivers for frequency-modulated sound broadcasting emissions

(IEC 60315-4:1997)

Méthodes de mesure applicables aux récepteurs radioélectriques pour diverses classes d'émission
Partie 4: Récepteurs pour émissions de radiodiffusion en modulation de fréquence
(CEI 60315-4:1997)

Meßverfahren für Funkempfänger für verschiedene Sendearten
Teil 4: Empfänger für frequenz-modulierte Tonrundfunksendungen
(IEC 60315-4:1997)

This European Standard was approved by CENELEC on 1998-01-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

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Foreword

The text of document 100A/58/FDIS, future edition 2 of IEC 60315-4, prepared by SC 100A, Multimedia end-user equipment, of IEC TC 100, Audio, video and multimedia systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60315-4 on 1998-01-01.

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This part 4 of EN 60315 is to be used in conjunction with HD 560.1 S1.

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, Annex ZA is normative and Annex A, Annex B, Annex C and Annex D are informative. Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60315-4:1997 was approved by CENELEC as a European Standard without any modification.

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1 General

1.1 Scope

This part of IEC 60315 applies to radio receivers and tuners for the reception of frequency-modulated sound-broadcasting emissions with rated maximum system deviations of ± 75 kHz and ± 50 kHz in ITU Band 8. It deals mainly with methods of measurement using radio-frequency signals applied to the antenna terminals of the receiver. The measurements and specified conditions of test are selected to permit the comparison of results obtained by different observers and on other receivers. Performance requirements are not specified in this standard.

Radiation and immunity tests and requirements are not included since these are described in CISPR 13 and CISPR 20.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60315. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60315 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60098:1987, *Analogue audio disk records and reproducing equipment.*

IEC 60268-1:1985, *Sound system equipment — Part 1: General.*

IEC 60268-3:1988, *Sound system equipment — Part 3: Amplifiers.*

IEC 60315-1:1988, *Methods of measurement on radio receivers for various classes of emission — Part 1: General considerations and methods of measurement, including audio-frequency measurements.*

IEC 60315-3:1989, *Methods of measurement on radio receivers for various classes of emission — Part 3: Receiver for amplitude-modulated sound-broadcasting emissions.*

IEC 60315-7:1995, *Methods of measurement on radio receivers for various classes of emission — Part 7: Methods of measurement on digital satellite radio (DSR) receivers.*

IEC 60315-9:1996, *Methods of measurement on radio receivers for various class of emission — Part 9: Measurement of the characteristics relevant to Radio Data System (RDS) reception.*

IEC 60651:1979, *Sound level meters.*

IEC 61260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters.*

CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1: Radio disturbance and immunity measuring apparatus.*

CISPR 20:1996, *Limits and methods of measurement of immunity characteristics of sound and television broadcast receivers and associated equipment.*

ITU-R Recommendation 468-4:1990, *Measurement of audio-frequency.*

ITU-R Recommendation 559-2:1990, *Objective measurement of radio-frequency protection ratios in LF, MF and HF broadcasting.*

1.3 Definitions

For the purposes of this part of IEC 60315, the following definitions apply.

1.3.1
carrier frequency

the mean value of the instantaneous frequency or the frequency generated in the absence of modulation. With a perfect modulation system in which no d.c. component and no non-linear distortion are involved, the two values are the same

1.3.2
instantaneous frequency deviation

the difference between the instantaneous frequency of the modulated radio-frequency signal and the carrier frequency

1.3.3
peak frequency deviation

the peak value of the instantaneous frequency deviation

1.3.4
peak-to-peak deviation

twice the peak frequency deviation

NOTE 1 To avoid confusion between "peak frequency deviation" and "peak-to-peak frequency deviation", peak-to-peak deviation is expressed as, for example, ± 50 kHz.

NOTE 2 "Peak-to-peak frequency deviation" is generally abbreviated to "deviation" in this standard.

1.3.5
rated maximum system deviation

the maximum peak-to-peak frequency deviation (see **1.3.4**) specified for the system under consideration

1.3.6
modulation factor

the ratio of the peak-to-peak deviation of the signal to the rated maximum system deviation, usually expressed as a percentage

NOTE This definition arises by direct analogy with the case of amplitude modulation.

1.3.7
– 3 dB limiting level

the input signal level at which the audio-frequency output voltage level is 3 dB below the value at a specified high r.f. input signal level, preferably 80 dB(fW)

1.3.8
amplification reserve

the attenuation in decibels of the volume control when adjusted to produce rated (distortion-limited) output voltage or power, with a specified high r.f. input signal level, preferably 80 dB(fW)

NOTE This characteristic is undefined for a receiver or tuner without a volume control.

1.3.9
deviation sensitivity

the value of deviation required to produce rated (distortion-limited) output voltage or power with the volume control set at maximum and a specified high r.f. input signal level, preferably 80 dB(fW)

1.3.10
ultimate signal-to-noise ratio

the value of signal-to-noise ratio for r.f. input signal levels sufficiently high that no further increase in signal-to-noise ratio occurs when the input signal level is increased

1.3.11
stereo threshold

the r.f. input signal level at which the stereo decoder begins to operate

NOTE A marked decrease in signal-to-noise ratio is usual at this signal level unless signal-strength dependent cross-talk circuits are included.

1.3.12
stereo indicator threshold

the input signal level at which the visual indicator shows that the receiver is operating in the stereo mode

NOTE This level may or may not be identical to the stereo threshold.

1.3.13
muting threshold

the input signal level at which the muting circuits allow the a.f. output signal to appear at the output terminals

NOTE The threshold may be different for increasing and decreasing signal levels. This hysteresis is usually intentional as it prevents unsatisfactory operation with r.f. input signals at or near the threshold level.

1.3.14
muting attenuation

the reduction in a.f. output, selectively measured at 1 kHz, due to an input signal modulated at 1 kHz at rated maximum system deviation, when muting occurs

1.3.15
50 dB quieting sensitivity

the r.f. input signal level at which an increase in a.f. output of 50 dB occurs under defined conditions (see **2.3**) when the modulation is changed from none (except the pilot-tone if the measurement is to be made in stereo mode) to the standard value of deviation (see **1.4.2.1**)

1.4 Standard measuring conditions

1.4.1 Measurements at audio-frequency output terminals

1.4.1.1 ***Standard audio-frequency output level***

Standard audio-frequency output level is the reference output level for audio-frequency measurements and shall be 10 dB below the rated output voltage or power. Alternatively, a stated value of output voltage or power selected from 500 mV, 1 W, 500 mW, 50 mW, 5 mW or 1 mW may be used (see IEC 60315-1).

1.4.1.2 ***Audio-frequency substitute load***

The audio-frequency substitute load is a stated physical (usually resistive) impedance for terminating audio-output terminals, (see IEC 60315-1).

1.4.1.3 ***Audio-frequency filters***

When making measurements at audio-frequency output terminals, unless it is specifically intended to measure low audio-frequency and ultrasonic components in the output voltage, it is desirable to interpose a band-pass filter between the output terminals and the measuring instrument. To allow the use of practicable impedances in this filter the substitute load shall be connected directly to the audio-frequency output terminals. If the filter has significant insertion loss this shall be allowed for when determining the results.

Table 1 — Audio-frequency filters

Type of filter	Figure	Reference	Notes
200 Hz – 15 kHz band-pass	Figure 1	**1.4.1.3**	With 19 kHz notch
22,4 Hz – 15 kHz band-pass	Figure 2	**2.2.1**	With 19 kHz notch
200 Hz – 1,5 kHz band-pass	Figure 3	Figure 8	With 19 kHz notch
15 kHz low-pass	None	**1.4.2.3**	60 dB/octave attenuation slope
1 kHz band-stop	Figure 4	Figure 8	See also Annex A
1 kHz band-pass	None	Figure 6	⅓-octave: IEC 61260
A-weighting	None	Figure 8	See IEC 60651
Weighting filter for measurement of noise	Annex A of IEC 60315-1	**2.2.1**	Consistent with ITU-R Recommendation 468-4
Weighting filter for coloured noise	Figure 5	**1.4.2.3**	Consistent with ITU-R Recommendation 559-2

Table 2 — Standard values of deviation

Mode/signal	RMSD ± 50 kHz	RMSD ± 75 kHz
Mono	± 50 kHz	± 75 kHz
Stereo	± 45 kHz	± 67,5 kHz
Pilot-tone	± 4,5 kHz	± 6,75 kHz

NOTE 1 Where a single value for deviation is stated in the text, it applies to a system with RMSD = ± 75 kHz. For a system with RMSD = ± 50 kHz, the stated value is reduced in proportion. In some cases, the value for RMSD = ± 50 kHz is given in parentheses: for example, (± 50 kHz).

NOTE 2 The deviations for supplementary services (such as SCA, RDS and ARI), which may vary in different ITU regions or countries, are given in Annex B.

It is advisable to use the same filter for both monophonic and stereophonic receivers. This filter prevents errors due to the presence of pilot-tone or subcarrier components in the receiver output. The pass-band of this filter shall be 200 Hz to 15 kHz, for which frequencies the attenuation relative to that at 1 kHz shall not exceed 3 dB. Below 200 Hz the attenuation slope shall tend to at least 18 dB/octave. At 19 kHz the attenuation shall be at least 50 dB, and above 19 kHz it shall be at least 30 dB (see Figure 1). This filter usually prevents the results of measurements from being affected by hum.

Filters for octave and third-octave band measurements shall comply with the requirements of IEC 61260.

Table 1 lists the audio-frequency filters which are used in measurements in this standard.

1.4.2 Radio-frequency signal(s)

1.4.2.1 *Standard value of deviation*

The standard value of deviation for measurements shall be the rated maximum system deviation (RMSD) given in Table 2. The deviation shall be stated with the results. Measurements at lower deviations are useful in some cases: where these are carried out the deviation used shall be stated with the results.

1.4.2.2 *Standard modulating frequency*

The standard modulating frequency shall be the standard reference frequency (1 000 Hz). When required, other frequencies may be chosen, if possible, from the one-third octave band centre frequencies given in Table I of IEC 60315-1.

1.4.2.3 *Standard modulation using coloured noise*

The noise weighting is chosen so that the spectrum of the noise resembles that of modern (western European) dance music, which is a particularly critical form of modulation in the case of adjacent channel interference.

The noise signal is obtained from a Gaussian white noise generator by passing the signal through a weighting filter as specified in Figure 5, followed by a low-pass filter with a cut-off frequency of 15 kHz and a slope of 60 dB/octave, and then through a pre-emphasis network (50 µs or 75 µs as appropriate).

The audio-frequency amplitude versus frequency characteristic of the modulation stage of the signal generator should not vary by more than 2 dB up to the cut-off frequency of the low-pass filter.

The accuracy of the measurement depends very much on the precision with which the frequency deviation of the signal generators can be set; this is especially true for the unwanted transmitter. The line-up procedure therefore should be carried out very carefully.

The deviation of the signal shall be adjusted by means of the arrangement shown in Figure 6. The meter V_1 shall be a quasi-peak voltmeter (see Annex A of IEC 60315-1). To obtain the required deviation conditions, the switch S_4 is placed in position 1 and the modulation at 500 Hz from the audio-frequency generator adjusted to ± 32 kHz (± 21,3 kHz) deviation. The meter reading is noted. The switch S_4 is then placed in position 2 and the noise modulation adjusted to give the same reading on the quasi-peak meter.

NOTE The deviation with 500 Hz modulation should be checked with a deviation meter unless the deviation meter, if any, included in the signal generator is known to be accurate.

1.4.2.4 ***Standard modulating signal***

This is the base-band signal with standard modulating frequency (see **1.4.2.2**) and standard value of deviation (see **1.4.2.1**). In case of stereophonic mode measurements, a pilot tone signal with the standard deviation shall be included.

1.4.2.5 ***Standard carrier frequencies***

The standard carrier frequency depends on the frequency allocation(s) for f.m. broadcasting in the region where the receiver is to be used. Receivers within the scope of this standard usually cover the bands given in Table 3. For these bands, the standard measuring frequencies are shown in the table.

Table 3 — Standard measuring frequencies

Band coverage MHz	**Standard measuring frequency** MHz
65,8 to 73,0	69
76,0 to 90,0	83
87,5 to 104,0	94
87,5 to 108,0	98

1.4.2.6 ***Standard radio-frequency test signal***

The standard radio-frequency test signal is a signal at the appropriate standard carrier frequency (see **1.4.2.5**), modulated with the standard modulating signal (see **1.4.2.4**). The available power from the source, at the receiver antenna terminals, shall be 70 dB(fW) [equal to 40 dB(pW)].

1.4.2.7 ***Standard radio-frequency input arrangements***

a) *Antenna simulation networks (artificial antennas)*

Whereas the rated source impedances of signal sources for measurement purposes (signal generators, etc.) are usually resistive and well-defined, the source impedances of antennas have a wide range of values and are neither resistive nor independent of frequency. It is often necessary, therefore, to insert between the signal source and the receiver input an antenna simulation network which matches the signal source correctly and presents to the receiver a source impedance simulating that of the appropriate antenna. Requirements for antenna simulation networks and examples are detailed in IEC 60315-1.

Measurements on receivers with external antenna terminals should be made using a signal generator whose rated output impedance is the same as the rated input impedance of the receiver.

Antenna substitution networks, and combining networks for the injection of more than one signal, should match the appropriate impedance at both ends, so as to allow insertion loss to be defined accurately. Networks with minimum insertion loss should be used while minimizing intermodulation between multiple signal sources. Figure 7 gives simple and practical examples which are suitable for use with signal generators that have a 50 Ω output impedance.

b) *Balanced inputs*

Certain f.m. broadcast receivers are equipped with a balanced antenna input circuit, usually with a rated characteristic impedance of 240 Ω. or 300 Ω. Such receivers shall be measured with an impedance-matched, balanced signal source. Where a balanced source is not available, a balun transformer may be used, allowing for its insertion loss. Care shall be taken that impedance matching is preserved throughout the circuit between the signal source and the antenna terminals of the receiver.

1.4.2.8 ***Standard measuring conditions***

A receiver is operating under standard measuring conditions when:

a) the power supply voltage and frequency are equal to, or within the range of, the rated values;

b) the standard radio-frequency test signal is applied via the appropriate artificial antenna to the antenna terminals of the receiver;

c) the audio-frequency output terminals for connection to loudspeakers, if any, are connected to audio-frequency substitute loads;

d) the receiver is tuned to the applied signal according to **1.4.4.2**;

e) the volume control, if any, is adjusted so that the output voltage at the main audio-frequency output terminals is 10 dB below the rated distortion-limited output voltage. Measurements may also be made at other stated values of output voltage or power;

NOTE If, during the course of measurement, the a.f. output voltage rises to approach the rated output voltage, it is essential to adjust the volume control so that the a.f. amplifier is not driven into overload distortion. Such adjustments should be reported with the results.

f) the environmental conditions are within the rated ranges;

g) for stereo receivers, the balance control or its equivalent, if any, is adjusted so that the output voltages of the two channels are equal;

h) the tone controls, if any, are adjusted for the flattest possible audio-frequency response (e.g. for equal response at 100 Hz, 1 kHz and 10 kHz);

i) the automatic frequency control (AFC) is inoperative, if this can be achieved by means of a user control;

NOTE Where a user control of automatic frequency control operation is provided, measurements should be made both with the automatic frequency control off (which will allow easy analysis of the results), and with automatic frequency control on (which represents the situation when the receiver is in normal use). The two sets of results should be clearly identified.

If the automatic frequency control cannot be made inoperative by means of a user control, it may nevertheless be necessary (or desirable) for the automatic frequency control to be disabled for certain measurements. In this case the automatic frequency control should be disabled by temporarily modifying the receiver, the action taken being detailed with the results (see **1.4.4.1**).

j) the muting control, if any, is in the muting off position.

1.4.3 Power supply and relevant measuring conditions

1.4.3.1 *Types of power supply*

The receiver under test shall be operated by the type of power supply specified by the manufacturer. Some receivers are designed to be operable by more than one type of power supply. Methods of measurement of receiver characteristics relating to the type of power supply are detailed in IEC 60315-1.

1.4.4 Tuning

1.4.4.1 *Effect of automatic frequency control*

All tuning operations shall be carried out, having made arrangements to render the automatic frequency control inoperative, if this is possible, except when the performance of the automatic frequency control is being investigated. When provision is made for the user to render the automatic frequency control inoperative, measurements may be made both with the automatic frequency control in operation and disabled. The results shall clearly show whether the automatic frequency control was in operation or not.

1.4.4.2 *Preferred tuning method*

If the receiver has a tuning indicator, the receiver shall be tuned according to the manufacturer's instructions on the use of the indicator: this corresponds to the way that the receiver is tuned when in use.

If there is no tuning indicator, or the tuning indicator does not function correctly, the receiver shall first be tuned approximately to the signal and the audio output signal observed on an oscilloscope. The deviation shall then be increased until the audio signal becomes distorted, and the receiver shall be tuned for symmetrical clipping of the audio signal, the volume control, if any, being adjusted to prevent overload of the audio-frequency part of the receiver from occurring.

If an alternative method of tuning is used, this shall be stated with the results.

1.5 General notes on measurements

1.5.1 Values for voltage and current

Unless otherwise stated, the terms voltage, current and so on refer to root mean square (r.m.s.) quantities.

1.5.2 Audio-frequency measurement techniques

The characteristics of devices such as loudspeakers and audio-frequency distribution lines, for the connection of which output terminals are provided on receivers, are defined (for example, in IEC 60268-1) in terms of constant input voltage rather than constant input power. This applies not only to audio-frequency outputs but also to other outputs, for example intermediate-frequency outputs and multiplex signal outputs. For this reason, it is at present accepted practice to make most measurements at output terminals in terms of the voltage across a substitute load. From this voltage, the power in the load may be calculated, if required, according to the following formula:

$$P_2 = \frac{{U_2}^2}{R_2}$$

where the suffix 2 refers to output terminals as opposed to input terminals.

Where the output signal is a substantially pure sine wave (with less than 10 % noise and distortion content), measurements may be made with an average-reading meter scaled in r.m.s. values for sinusoidal input. Under any other conditions, a true r.m.s. meter shall be used, unless otherwise stated.

Where several pairs of output terminals are provided, the manufacturer shall state for each pair:

a) the rated value of the substitute load, (see IEC 60315-1);

b) whether the pair of terminals shall be or shall not be connected to a substitute load when measurements are made at another pair of terminals.

NOTE It is usual to connect all terminals intended for loudspeakers to substitute loads for all measurements, while pairs of terminals for other devices are loaded only when measurements are made at those terminals.

1.5.3 Presentation of radio-frequency signal level or voltage

Radio-frequency signal levels may be stated as dB(fW), dB(pW), dB(mW) or e.m.f. in microvolts with stated source or load impedance. The relationship among these values is given in Table 4.

1.5.4 Climatic and environmental conditions

For information on environmental conditions, reference shall be made to section 1 of IEC 60315-1. Measurements and mechanical checks may be carried out at any combination of temperature, humidity and air pressure within the limiting values specified in IEC 60315-1. Furthermore, to prevent unnecessary disturbance from external interfering signals, it is desirable to carry out the measurement in a screened enclosure or room, (see also IEC 60315-3).

Table 4 — Presentation of radio-frequency signal level or voltage

Available power			EMF (75 Ω)		EMF (300 Ω)	
W	dB(fW)	dB(mW)	µV	dB(µV)	µV	dB(µV)
10^{-15}	0	– 120	0,55	– 5	1,1	1
10^{-14}	10	– 110	1,75	5	3,5	11
10^{-13}	20	– 100	5,5	15	11	21
10^{-12}	30	– 90	17,5	25	35	31
10^{-11}	40	– 80	55	35	110	41
10^{-10}	50	– 70	175	45	350	51
10^{-9}	60	– 60	550	55	1 100	61
10^{-8}	70	– 50	1 750	65	3 500	71
10^{-7}	80	– 40	5 500	75	$1,1 \times 10^4$	81
10^{-6}	90	– 30	$1,75 \times 10^4$	85	$3,5 \times 10^4$	91
10^{-5}	100	– 20	$5,5 \times 10^4$	95	$1,1 \times 10^5$	101
10^{-4}	110	– 10	$1,75 \times 10^5$	105	$3,5 \times 10^5$	111
10^{-3}	120	0	$5,5 \times 10^5$	115	$1,1 \times 10^6$	121
10^{-2}	130	10	$1,75 \times 10^6$	125	$3,5 \times 10^6$	131

1.5.5 Preconditioning and preliminary measurements

Before recording the results of measurements, the receiver under test should be maintained for at least 10 min in the state of standard measuring conditions, (see IEC 60315-1).

As the results of the various measurements described in this part may be influenced by other properties of the receiver, the related measurements given in IEC 60315-1 (if applicable) should normally be carried out first.

1.5.6 Test equipment and accuracy of measurements

In general, this standard calls for the use of the simplest test equipment that gives acceptably reliable results. This does not preclude the use of more complex equipment which can be shown to produce the same, or more reliable, results.

For information on the accuracy of measuring instruments, the presentation of results and deviations from the recommended methods, reference shall be made to section 1 of IEC 60315-1.

Care should be taken to ensure that any possible shift of the mean carrier frequency due to modulation is sufficiently small to avoid affecting the measurements.

1.5.7 Rated values

In this part the term rated is used in the special sense of the value specified by the manufacturer. This term is used when describing rated conditions and rated values of characteristics.

1.5.7.1 ***Rated conditions***

To define the conditions under which the performance of the receiver is specified and shall be tested, the manufacturer shall state the following values:

— rated power supply voltage(s) and frequency (or frequency range);

— rated characteristic impedance of the r.f. signal input (where applicable);

— rated value of the substitute load (for each pair of output terminals) (see **1.4.1.2**);

— rated total harmonic distortion at which the rated (distortion-limited) output voltage or power is specified;

— rated environmental conditions (ranges of temperature, pressure and humidity).

These values, by their nature, cannot be determined by measurement.

1.5.7.2 ***Rated values of characteristics***

The climatic and environmental conditions given in **1.5.4** and the electrical conditions given in **1.5.7.1** enable the manufacturer to specify, and the testing authority to verify, the performance characteristics of the receiver. The manufacturer shall specify rated values for important characteristics.

Examples of such characteristics are as follows:

— adjacent and alternate channel selectivity (see **3.2**);

— usable sensitivity for a specified signal-to-noise ratio (see **2.5**);

— ultimate signal-to-noise ratio (see item c) of **2.7.1** and **1.3.10**);

— distortion-limited output voltage or power (see item b) of **5.2.1**);

— maximum usable source available power or e.m.f. (see item c) of **5.2.1**).

The manufacturer shall clearly define whether these rated values are limit values or median values. In the latter case a tolerance shall be given (see IEC 60315-1).

1.5.8 Presentation of measuring results

The relation between two or more quantities may often be more clearly presented as a graph rather than as a table. Values based on theoretical expectation and those based on real measurement shall be clearly distinguished from each other (see IEC 60315-1).

2 Sensitivity and internal noise

2.1 Explanation of terms

The sensitivity of a receiver is a measure of its ability to receive weak signals and produce an audio-frequency output of usable magnitude and acceptable quality. Sensitivities may be defined with respect to many different characteristics of the output signal, including the following:

a) signal-to-noise ratio (see **2.2** and **2.3**);

b) output voltage or power (with the volume control, if any, at maximum) (see **2.4**);

c) limiting level (see item a) of **2.7.1**).

For sensitivity measurements a circuit such as that shown in Figure 8 is used.

2.2 Signal-to-noise ratio (weighted and unweighted) and SINAD

2.2.1 Introduction

The signal-to-noise ratio of a receiver, under specified conditions, is the ratio of the audio-frequency output voltage due to the signal to that due to random noise. The noise may be measured:

a) using the band-pass filter with a 3 dB bandwidth of 22,4 Hz to 15 kHz (see **1.4.1.3** and Figure 2), together with a true r.m.s. meter or an average-responding meter calibrated in r.m.s. values for a sinusoidal signal;

b) using the A-weighting defined in IEC 60651 and a true r.m.s. meter;

c) using the weighting filter and meter defined in Annex A of IEC 60315-1;

d) using a band-pass filter with a 3 dB bandwidth of 200 Hz to 15 kHz (see Figure 1) together with either of the meters given in item a) above.

Since these different methods give significantly different results, it is essential that the method used be clearly stated with the results.

2.2.2 Method of measurement

2.2.2.1 *Sequential method*

Using the circuit of Figure 8, the receiver is brought under standard measuring conditions, with S_1 and S_3 set to the positions introducing the required filter and meter (see **2.2.1**), and the reading of the relevant voltmeter noted. The modulation of the signal is then removed and the reading on the voltmeter being noted as before. The signal-to-noise ratio is then equal to the ratio of the voltmeter readings.

The measurement may be repeated at other signal frequencies and with other settings of the tone control(s), if any. For measurements on stereo receivers in the stereo mode, pilot-tone modulation, where applicable, is retained when the 1 kHz modulation is removed.

2.2.2.2 *Simultaneous method*

The presence of a modulated signal can under certain circumstances increase rather than reduce the noise output of an f.m. receiver. The following method allows for this effect. Using the method of **2.2.2.1**, instead of removing the modulation, S_2 is moved to position 2 so that the output due to the fundamental of the modulation frequency is filtered out. The ratio of the two readings on the voltmeter is then equal to the ratio of the (signal plus noise plus distortion) to the (noise plus distortion) (so-called SINAD measurement).

The measurement should be repeated at other values of deviation.

For stereophonic reception, the two channels shall be modulated in phase opposition. Each output channel is measured in turn, using the circuit of Figure 8.

2.2.3 Presentation of results

Curves are plotted showing the signal-to-noise ratio expressed in decibels, as ordinate on a linear scale, as a function of the input signal level, expressed in decibels, (referred to 1 fW, preferably) as abscissa on a linear scale.

The method employed (see **2.2.2.1** or **2.2.2.2**) shall be clearly stated.

For the simultaneous method, families of curves with deviation as a parameter may be plotted. An example is shown in Figure 9 (see also **2.7**).

2.3 Noise-limited sensitivity

2.3.1 Introduction

The noise-limited sensitivity of a receiver is the minimum value of radio-frequency input signal level producing a specified signal-to-noise ratio at the audio-frequency output. Normally, unweighted, band-limited signal-to-noise ratios of 40 dB (50 dB for high-fidelity receivers) for the sequential method, and 30 dB for the simultaneous method, should be used.

The reference audio-frequency output signal level is that produced by rated maximum system deviation.

Sensitivities are defined according to varied criteria of signal-to-noise (and/or distortion) as follows:

a) noise-limited sensitivity (S/N ratio method);

b) 50 dB quieting sensitivity;

c) noise-limited sensitivity (SINAD ratio method).

2.3.2 Method of measurement

The results can be deduced from the measurements according to **2.2.2**. It is advisable to measure the signal-to-noise ratio for sufficient values of input signal level in order to ensure that rapid changes in the signal-to-noise ratio are fully explored.

The measurement may be repeated at several input signal frequencies.

2.3.3 Presentation of results

The noise-limited sensitivity is plotted linearly in decibels (preferably referred to 1 fW) as ordinate, as a function of input signal frequency plotted linearly in megahertz as abscissa. An example is given in Figure 10. Families of curves may be plotted with signal-to-noise ratio as a parameter. The measurement method used shall be clearly stated as that of **2.2.2.1** or **2.2.2.2**.

2.4 Gain-limited sensitivity

2.4.1 Introduction

A receiver is said to be gain-limited if the audio-frequency output voltage or power, measured selectively at the modulation frequency with a small signal input, is less than the rated distortion-limited output voltage or power.

NOTE The receiver may be capable of producing a reference output voltage or power (e.g. 100 mV or 50 mW) with a very small input signal, but this may be much less than the output claimed by the manufacturer and required to operate correctly with associated equipment.

The gain-limited sensitivity is the least value of radio-frequency input signal level, modulated with a standard modulating signal (see **1.4.2.4**), which produces the rated distortion-limited audio-frequency output voltage or power with the volume control, if any, at maximum.

NOTE A reduced deviation and proportionally reduced output level may be used to avoid overloading effects.

2.4.2 Method of measurement

The method of **2.2.2.2** is used, but keeping the switch S_2 in position 3 so that only the fundamental of the modulation frequency is measured. The input signal level is adjusted to give the rated distortion-limited output.

The measurement may be repeated at other input signal frequencies, and for the stereophonic mode.

2.4.3 Presentation of results

The gain-limited sensitivity is plotted linearly in decibels (preferably referred to 1 fW) as ordinate, as a function of the input signal frequency plotted linearly in megahertz as abscissa.

Pairs of curves may be plotted for monophonic and stereophonic operation. An example is shown in Figure 11.

2.5 Usable sensitivity

2.5.1 Introduction

The usable sensitivity of a receiver is the noise-limited sensitivity or gain-limited sensitivity, whichever is the greater value of the input signal level.

NOTE 1 If the usable sensitivity is equal to the noise-limited sensitivity, the criterion of the noise-limited sensitivity should be stated (see **2.3.1**).

NOTE 2 For some receivers, the distortion caused by insufficient bandwidth at very low input signal levels may present a practical limit to usable sensitivity.

2.5.2 Method of measurement

The noise-limited sensitivity and the gain-limited sensitivity are measured by stated methods chosen from those specified in this standard, and the results are compared. The usable sensitivity is the higher of the two input signal levels.

2.5.3 Presentation of results

Curves are plotted with the noise-limited sensitivity and gain-limited sensitivity expressed in decibels (fW) as ordinate and radio-frequency expressed in megahertz as abscissa, both with linear scales.

The method used should be stated with the results.

2.6 Deviation sensitivity

2.6.1 Introduction

The deviation sensitivity of a receiver is defined in **1.3.9**.

2.6.2 Method of measurement

The standard radio-frequency test signal (see **1.4.2.6**) is applied to the receiver and the deviation is set to zero. The volume control is then set to maximum and the deviation increased until rated output voltage or power is obtained.

2.6.3 Presentation of results

The deviation sensitivity is stated as being the deviation measured according to **2.6.2**. The signal frequency shall also be stated.

2.7 Input-output characteristics

2.7.1 Introduction

One of the most important and informative characteristics of a receiver is the relationship between the audio-frequency output voltage or power and the radio-frequency input available power, particularly if the audio-frequency noise output voltage or power (see **2.2**) is plotted as a function of input signal level on the same graph.

Many characteristics of the receiver, such as the following, may be determined from such a graph:

a) – 3 dB limiting level;

b) noise-limited and gain-limited sensitivities;

c) ultimate signal-to-noise (S/N) ratio;

d) amplification reserve;

e) deviation sensitivity;

f) overloading effects not shown by the measurements in **5.2**.

For stereophonic reception, the following characteristics, among others, may also be determined:

g) signal-to-noise (S/N) ratio in the stereo mode;

h) stereo threshold;

i) stereo indicator threshold;

j) muting threshold;

k) muting attenuation.

These terms are defined in **1.3**.

2.7.2 Method of measurement

Using the circuit arrangement of Figure 8, with S_1 in position 3, the receiver is brought under standard measuring conditions (see **1.4.2.8**). The radio-frequency input signal level is then reduced to a low value [for example, 0 dB(fW)] and the audio-frequency output voltage or power measured.

The radio-frequency input signal level is then increased in steps measuring the output voltage or power at each step.

For measurement at low input signal levels where the signal-to-noise ratio is poor, S_2 may be put in position 3, so that the output voltage is measured selectively at 1 kHz. If this is done, it shall be reported in the results. After every increase in input signal level, the receiver shall be retuned (see **1.4.4.2**). Any significant change of tuning in relation to the input signal level shall be reported in the results.

If the receiver has an audio-frequency power amplifier, this may become overloaded as the input signal level is increased above 70 dB(fW). This shall be avoided by increasing the volume control attenuation by a known amount whenever the output voltage or power would otherwise have been greater than one-third of the rated distortion-limited value.

The measurement may be repeated at other values of deviation, particularly 100 % utilization in the stereophonic mode.

2.7.3 Presentation of results

A curve is drawn with the radio frequency input power level (preferably referred to 1 fW), plotted linearly as abscissa and the audio-frequency output voltage or power, expressed in decibels, referred to a stated reference, plotted linearly as ordinate. Corrections shall be made for any increases in the volume control attenuation to avoid overloading. Families of curves may be plotted for different values of deviation, and curves for monophonic and stereophonic reception may be plotted on the same graph, together with the respective signal-to-noise ratio characteristics.

An example is given in Figure 12.

3 Rejection of unwanted signals

3.1 Capture ratio

3.1.1 Introduction

The capture ratio of a receiver describes its ability to receive a stronger signal in the presence of a weaker interfering signal with the same carrier frequency. If the ratio of the signal strengths exceeds the capture ratio the measured audio-frequency signal-to-interference ratio is large (of the order of 30 dB), but if both signals are modulated audible interference may still occur (co-channel hiss).

The capture ratio is defined as half the difference between the signal level of an interfering carrier at the wanted frequency which reduces the receiver audio-frequency output level due to a wanted signal of the standard modulating signal (see **1.4.2.4**) by 1 dB, and the signal level of the interfering carrier which reduces the receiver audio-frequency output by 30 dB, with the receiver in the monophonic mode, the unwanted signal being an unmodulated r.f. signal.

3.1.2 Method of measurement

The wanted and unwanted signals are applied simultaneously by means of a combining network according to IEC 60315-1 or by means of a 2-signal artificial antenna (see **1.4.2.7**).

As a preliminary, the tuning and output levels of the two signal generators shall be cross-calibrated, as the required accuracy for this measurement normally exceeds that of direct calibrations. One signal is set to zero output and the other adjusted to standard r.f. input signal (see **1.4.2.6**).

The receiver is carefully tuned according to **1.4.4.2** and the audio output voltage or power noted (the volume control, if any, may be adjusted to give a convenient value of output). The modulation is then removed and the other, unmodulated, generator adjusted to an output level of 60 dB(fW) and tuned for a low frequency beat note (e.g. 200 Hz) at the receiver audio output.

The second generator output level is then adjusted, preferably by means of a continuously variable attenuator, until the amplitude of the beat note is at a maximum. The frequency of the second generator is then adjusted so as to obtain zero beat. Alternatively, a counter may be used to set the two generators accurately to the same frequency, after the output levels have been cross-calibrated as above.

The output frequencies and levels of the two generators are then equal for the purposes of the following measurement.

The modulation is re-applied and the output signal level of the unmodulated generator is adjusted until the audio output signal level is 1 dB below the previously noted value. The output signal level of the unmodulated generator is noted.

NOTE In this condition the modulated signal has captured the receiver.

The output signal level of the unmodulated generator is then increased until the audio output signal level is 30 dB below the previously noted value, and the output signal level of the unmodulated generator is again noted.

NOTE In this condition, the unmodulated signal has captured the receiver.

The capture ratio is calculated as half the difference between the two previously noted values of generator output signal level.

Since the capture ratio depends on the receiver amplitude modulation suppression and bandwidth, which in turn are functions of the signal level, it may be desirable to repeat the measurement at other input signal levels.

3.1.3 Presentation of results

Curves are plotted with the input signal level, in decibels, of the modulated carrier as abscissa on a linear scale and the capture ratio, in decibels, as ordinate on a linear scale. An example is given in Figure 13.

3.2 Selectivity and nearby channel rejection (two-signal)

3.2.1 Introduction

Receivers are required to reject signals whose carrier frequencies are near to the wanted carrier frequency. This test measures the ratio of the unwanted to wanted r.f. input signal levels at which the audio-frequency signal-to-interference ratio (S/I ratio) is 30 dB. The a.f. output produced by the wanted r.f. signal of the standard modulating signal (see **1.4.2.4**) is the reference level.

Unwanted r.f. input signals having different characteristics give rise to different measures of selectivity, as shown below:

a) Selectivity using sinusoidal signal modulation

The unwanted r.f. input signal is modulated with the standard modulating signal.

b) Selectivity using coloured noise modulation

The unwanted r.f. input signal is modulated with standard coloured noise (see **1.4.2.3**).

NOTE The appropriate method may be selected according to the purpose of the measurement. The method used should be stated with the results.

The wanted signal frequency may be chosen so as to avoid interference from broadcast transmitters.

Measurements shall be made for unwanted signal frequencies spaced each side of the wanted signal frequency by 0 kHz, 100 kHz, 200 kHz, 300 kHz and 400 kHz at least.

Measurements may be made at frequencies ranging between these values if necessary, particularly on receivers intended for use in countries having transmitters with offset frequencies.

3.2.2 Method of measurement

Both the wanted and unwanted signals are applied simultaneously by means of a combining network, according to IEC 60315-1, or by means of a 2-signal artificial antenna (see **1.4.2.7**) to the receiver.

The measurement procedure includes the following steps:

a) bring the receiver under standard measuring conditions (see **1.4.2.8**) and set the switch S_1 (Figure 6) to position 3 (use of 200 Hz to 15 kHz band-pass filter);

b) set the unwanted signal level to the minimum output level and the wanted signal to the standard test signal (see **1.4.2.6**);

c) tune the receiver carefully according to **1.4.4** and then measure the audio output voltage or power. Adjust the volume and/or balance control, if any, for equal output of each channel of a stereo receiver;

d) remove the modulation of the wanted signal, but retain the pilot-tone signal for stereo-mode measurements;

e) modulate the unwanted signal in mono mode with the appropriate modulating signal specified in **3.2.1**;

f) adjust the frequency of the unwanted signal so that the frequency difference between the unwanted signal and the wanted signal is one of the values specified in **3.2.1**. Check the frequency difference using a frequency counter or any other suitable technique;

g) adjust the unwanted signal level to obtain an audio-frequency S/I ratio of 30 dB for unwanted sinusoidal modulation, or 50 dB for noise modulation (if the ultimate signal-to-noise ratio (see **1.3.10**) of the receiver exceeds 60 dB), or other stated value. Thus, the ratio of the unwanted to wanted r.f. input signal levels can be determined. Ensure that the audio- frequency output falls by at least 10 dB when the modulation of the unwanted signal is removed;

h) make measurements for other values of wanted signal level. Measurements may be made using stated audio-frequency S/I ratios other than 30 dB or 50 dB, and/or an unwanted signal modulation of ± 40 kHz deviation if required, the value of deviation, the level of invented signal and the S/I ratio being stated with the results.

3.2.3 Rejection of adjacent and alternate channels

These are the measuring values specifically measured at adjacent and alternate channel frequency separations.

NOTE In ITU Region 1, the channel spacing is 100 kHz. In ITU Regions 2 and 3 it is 200 kHz, but transmitters (even in different countries) covering the same area are not normally allocated adjacent channel frequencies.

3.2.4 Presentation of the results

Curves are plotted with the audio-frequency S/I ratio and the wanted signal level as parameters. The frequency difference between the wanted and interfering signals is plotted linearly as abscissa and the radio-frequency wanted-to-interfering signal ratio expressed in decibels linearly as ordinate (see Figure 14).

3.3 Rejection of intermediate and image frequencies, and spurious responses

3.3.1 Introduction

In addition to the responses to signals at frequencies near to the tuning frequency, superheterodyne and similar receivers respond to unwanted signals at the intermediate frequency (or frequencies, in the case of double or multiple superhets), at the image frequency (or frequencies) and at harmonics of the signal frequency and other frequencies associated with harmonics of the local oscillator frequency (or frequencies).

These responses may be measured by single-signal or two-signal methods, and there are important differences both in the conditions of measurement and in the results obtained. It is essential, therefore, to distinguish clearly in the results which measurement has been made, particularly when a stereophonic receiver is measured in the stereophonic mode.

Thus, the following rejection ratios and responses are defined:

a) rejection ratio of the intermediate frequency (single-signal);

b) rejection ratio of the intermediate frequency (two-signal);

c) rejection ratio of the image frequency (single-signal);

d) rejection ratio of the image frequency (two-signal);

e) spurious responses (single-signal);

f) spurious responses (two-signal);

g) spurious responses using coloured noise modulation (two-signal).

The single-signal method measures the audio-frequency output or noise-suppression at the tuning frequency and at the interfering frequencies (intermediate-frequency, image and spurious response frequencies) sequentially.

The single-signal intermediate-frequency rejection, image-frequency rejection or spurious response rejection ratio shall be determined as the ratio in decibels of the input signal level at interfering frequencies to the input signal level at the tuning frequency for equal values of audio-frequency output voltage or power. The equal value of noise suppression may be used to separate effects of the deviation multiplication in some cases.

The input signal level at the tuning frequency shall be below the – 3 dB limiting level (**1.3.7**).

The two-signal method measures an audio-frequency beat note due to two r.f. input signals.

The two-signal intermediate-frequency rejection, image-frequency rejection or spurious response rejection ratio is the ratio, in decibels, of the interfering signal level, at the intermediate frequency, image-frequency or spurious response-frequency, to the input signal level, at the tuning frequency, which fulfills the following conditions:

— the interfering signal frequency and level are such that the unwanted a.f. signal, due to intermodulation, is at a frequency of 1 kHz and at a level 40 dB below that due to the standard r.f. input signal;

— the wanted signal level is such that the audio-frequency signal-to-noise ratio, in the absence of the unwanted signal, is at least 40 dB.

The audio-frequency output shall be measured selectively if the signal-to-noise ratio is low.

If the receiver has a balanced input circuit, two values of each of the above characteristics may be measured, one with the intermediate frequency signal applied in the unbalanced mode, and one with the intermediate frequency signal applied in the balanced mode. The former is usually more important in practice when the receiver is connected directly to an antenna not shared with another receiver.

The image frequency of a superheterodyne or similar receiver is equal to the tuning frequency plus or minus twice the intermediate frequency according to whether the local heterodyne oscillator is higher or lower, respectively, in frequency than the signal frequency.

Double and multiple superhet receivers have several image frequencies for each tuning frequency.

NOTE The automatic frequency control, if any, will not function correctly with an input signal at image frequency.

Spurious response frequencies are those frequencies f_s related to the oscillator frequency f_o and the intermediate frequency f_i by the following equations:

$$f_s = f_o \pm f_i/n \quad (1)$$

where n is an integer greater than 1.

NOTE 1 The responses for values of n greater than 2 are often, but not always, insignificant. The image-frequency corresponds to $n = 1$.

$$f_s = f_o \quad (2)$$

NOTE 2 This response can only be measured by a two-signal method (see **3.3.2.3**). A significant response is usually found only from simple receivers using a self-oscillating mixer. However, many simple receivers show a significant response, so it is necessary to take this into account when assigning frequencies to broadcast transmitters: no two transmitters serving the same area should have carrier frequencies which differ by the i.f. (usually 10,7 MHz).

$$f_s = n\, f_o \pm f_i \quad (3)$$

where n is zero or an integer greater than 1.

NOTE 3 The intermediate frequency corresponds to $n = 0$.

3.3.2 Methods of measurement

3.3.2.1 *Single-signal method using a modulated signal*

The receiver is brought under standard measuring conditions and the – 3 dB limiting level measured (see **2.7**), together with the corresponding value of audio-frequency output voltage or power. The signal frequency is then changed approximately to the appropriate intermediate, image or spurious response frequency, the input signal level increased and the input frequency adjusted for maximum audio-frequency output. The input signal level is then adjusted for the same audio-frequency output voltage or power as produced in the measurement of – 3 dB limiting level.

When measuring the single-signal intermediate-frequency rejection in the unbalanced mode, the input signal shall be applied through the artificial antenna for the appropriate frequency range. If the receiver has a balanced input circuit, the intermediate-frequency signal shall be applied between the two input terminals connected together and the signal earth of the receiver, the method of connection being fully described in the results.

3.3.2.2 *Single-signal method using noise-suppression*

The method of **3.3.2.1** is used, but instead of adjusting the measuring signal to obtain equal audio-frequency outputs due to a modulated input signal, under reference and measuring conditions, the measuring signal is unmodulated and the receiver noise output measured, the input signal level being adjusted for equal noise outputs under reference and measuring conditions and the noise output level reduced by the presence of the signal. This method can be used for stereophonic receivers in the stereo mode where pilot-tone modulation only is applied. Some of the spurious responses of a receiver are due to mechanisms that produce deviation multiplication. For these responses, the results of the modulated signal and noise-suppression methods will be significantly different.

3.3.2.3 *Two-signal (beat note) method*

The wanted and unwanted signals are applied simultaneously by means of a combining network according to IEC 60315-1, or by means of two-signal artificial antenna (see **1.4.2.7**) to the receiver under test.

The measurement procedure includes the following steps:

a) bring the receiver under standard measuring conditions (see **1.4.2.8**) and set the switch S_1 (see Figure 6) to position 3 (use of 200 Hz to 15 kHz band-pass filter), S_2 to position 1 and S_3 to position 3;

b) set the unwanted signal level to the minimum output level and the wanted signal to the standard test signal (see **1.4.2.6**);

c) tune the receiver carefully according to **1.4.4**. Adjust the wanted signal level to obtain an audio-frequency signal-to-noise ratio of 40 dB, and measure the audio output voltage or power. Adjust the volume and/or balance-control, if any, for equal output from each channel of a stereo receiver;

d) note the audio-frequency output power or voltage, then remove the wanted signal;

e) apply the unwanted signal. Adjust the unwanted signal frequency at the approximate intermediate, image, or spurious response frequency, and adjust for maximum audio-frequency output. Then remove the modulation;

f) set switch S_2 position 3, so that the a.f. output is measured selectively at 1 kHz, and then re-apply the unmodulated wanted signal. Adjust the unwanted signal frequency to obtain a beat-note frequency of 1 kHz;

g) adjust the unwanted signal level to produce a beat-note output power or voltage 40 dB below the output power or voltage noted at step d);

h) the difference, expressed in decibels, between the unwanted signal level and the wanted signal level is the unwanted signal rejection ratio.

This method is suitable for the measurement of response to a signal at oscillator frequency, which cannot be measured by a single-signal method.

Difficulties in using this method have been reported for high-performance receivers. It is essential that the signal generators are extremely stable in frequency.

3.3.2.4 *Two-signal method using a coloured noise modulated signal*

The method of **3.3.2.3** is used, but S_2 is set in position 1 (see Figure 6) and the unwanted signal is modulated with the standard modulation using coloured noise and the unwanted signal level to obtain 50 dB audio-frequency S/I ratio shall be determined, using the meter V_3 (see Figure 6).

NOTE If a signal-to-noise ratio greater than 55 dB cannot be obtained even in the absence of the unwanted signal, then a lower, stated value of a.f. signal-to-interference ratio should be used.

3.3.3 Presentation of results

a) The single-signal intermediate frequency and image frequency rejection ratios for a given signal frequency may be tabulated, or plotted in decibels, as ordinate on a linear scale as a function of the tuning frequency as abscissa on a linear scale. An example is shown in Figure 15.

b) The results of measurements of individual spurious responses may be reported in the same way. Spectra showing all significant spurious responses with a single tuning frequency should also be shown. An example is shown in Figure 16. It shall be made clear that the results were obtained by a single-signal method and which method was used.

c) The two-signal intermediate, image, and spurious frequency responses may be presented in the same way as the single-signal responses (see item a) above). It shall be made clear that the results were obtained by two-signal methods.

3.4 Suppression of amplitude modulation

3.4.1 Introduction

The amplitude modulation suppression ratio of a receiver represents the ability of the receiver to reject amplitude modulation of the input signal. Such modulation may result from fading, multi-path signals, aircraft flutter, amplitude modulation at the transmitter and amplitude modulation introduced in the receiver by pass-band limitations and mistuning.

3.4.2 Methods of measurement

3.4.2.1 *Simultaneous method*

The circuit arrangement for this measurement is given in Figure 8. The receiver is brought under standard measuring conditions. Care should be taken when adjusting the volume control, if any, to prevent overload in the a.f. part of the receiver. With switch S_1 in position 3, S_2 in position 3 and S_3 in position 1, the output voltage U_1 due to the 1 kHz modulation is measured on voltmeter V_4.

With the frequency modulation maintained, the carrier is then amplitude modulated 30 % at 400 Hz. It is essential that no spurious frequency modulation is introduced thereby.

With S_2 in position 4, the output voltage U_2 is measured. This output is due to the 400 Hz modulation and the intermodulation components at 600 Hz and 1 400 Hz due to both modulation frequencies.

The amplitude modulation suppression ratio is then given by:

$$20 \, l_g \, U_1/U_2$$

The measurement may be repeated at other values of the amplitude modulation factor and other radio-frequency input signal levels.

3.4.2.2 *Sequential method*

The receiver is brought under standard measuring conditions. Care should be taken when adjusting the volume control, if any, to prevent overload in the a.f. part of the receiver. The output voltage U_1 is then measured.

The modulation is then changed to 30 % amplitude modulation at 1 kHz and the output voltage U_2 measured.

The amplitude modulation suppression ratio is then given by the following formula:

$$20 \lg U_1/U_2$$

The measurement may be repeated at other values of the amplitude modulation factor and other radio-frequency input signal levels.

NOTE 1 In this method the input signal is either amplitude or frequency modulated, which does not represent the conditions that occur in practice. In some cases the errors of this method may be large, and whenever possible the results should be compared with those obtained by the simultaneous method (see **3.4.2.1**). However, with modern receiver designs, in which the i.f. amplifier provides hard limiting, even of a deeply amplitude-modulated signal, this method gives reliable results.

NOTE 2 This method is suitable for comparing the performance of several samples of the same circuit design, but not so reliable when comparing different designs of simple receivers, for which the method of **3.4.2.1** should be used as a check.

3.4.3 Presentation of results

Curves are plotted with the input signal level, in decibels, as abscissa on a linear scale and the amplitude modulation suppression ratio, in decibels, as ordinate on a linear scale. Amplitude modulation factors may be presented as parameters.

3.5 Rejection of r.f. signal intermodulation products

3.5.1 Introduction

Strong signals entering the receiver may result in spurious responses by several mechanisms. One or more of the signals may be at a frequency outside the tuning range of the receiver. Some of these responses can be measured by two-signal methods, but some can be measured only by three-signal methods. Particularly important responses occur when the interfering signal frequencies and the tuning frequency are equally spaced, and methods of measurement for these responses are given.

It is essential that the signal generator(s) used for these measurements have adequately low outputs at frequencies other than that intended. Preferably they should be checked for spectral purity with a spectrum analyzer, and suitable filters employed to remove any spurious output which could cause errors.

Several of the following characteristics are significant:

a) rejection of r.f. signal intermodulation (two-signal);

b) rejection of r.f. signal intermodulation (three-signal);

c) rejection of r.f. signal intermodulation using coloured noise modulation (three-signal);

d) spurious responses due to a single amplitude-modulated signal at a frequency just outside the normal tuning range.

3.5.2 Methods of measurement: two-signal methods

3.5.2.1 *Two-signal method using modulation*

This method measures the effects of intermodulation produced in the radio-frequency part of the receiver when two signals of frequencies f_1 and f_2 are sufficiently strong to generate an unwanted radio-frequency signal at the tuning frequency f_s (intermodulation of the type $2f_1 - f_2 = f_s$).

The signal frequencies f_1, f_2 shall be adjusted so that they satisfy one of the following equations:

$$f_1 = f_s \pm \Delta f$$

$$f_2 = f_s \pm 2\Delta f$$

where

like signs are taken together;

f_s is the tuning frequency.

When these equations are satisfied, f_1, f_2 and f_s are equally spaced. To avoid the effects due to selectivity, the spacing Δf should usually be not less than 300 kHz.

The wanted and unwanted signals are applied simultaneously, by the arrangement shown in Figure 6, to the receiver under test.

The measurement procedure includes the following steps:

a) bring the receiver under standard measuring conditions (see **1.4.2.8**) and set the switch S_1 (see Figure 6) to position 3 (use of 200 Hz to 15 kHz band-pass filter), S_2 to position 3 and S_3 to position 1;

b) set the unwanted signal level to the minimum output level and the wanted signal to the standard test signal (see **1.4.2.6**);

c) tune the receiver carefully according to **1.4.4**. Adjust the volume and/or balance-control, if any, for an equal output from each channel of a stereo receiver and measure the audio output voltage or power;

d) adjust the wanted signal level to obtain – 3 dB limiting audio-frequency output. Note the audio-frequency output voltage and the wanted signal level, then change the wanted signal frequency to f_2;

e) apply the unmodulated unwanted signal at frequency f_1;

f) adjust either one of the frequencies carefully to obtain maximum audio-frequency output;

g) the input signal levels at the two frequencies shall be equal and shall be adjusted to obtain an audio-frequency output voltage equal to that obtained at step d);

h) the difference between the unwanted signal level and the wanted signal level, measured at step b), expressed in decibels, is the unwanted signal rejection ratio;

i) frequency separations Δf ranging from ± 400 kHz to at least ± 2 200 kHz should be used for measurement.

3.5.2.2 ***Two-signal method using noise suppression***

This method measures the effects of the same type of intermodulation in the radio-frequency part as described in **3.5.2.1**.

The procedure of **3.5.2.1** is followed except that in the first part of the test, the wanted signal level shall be the noise-limited sensitivity for a signal-to-noise ratio of 20 dB (see **2.3**), and instead of adjusting the measuring signals to obtain equal audio-frequency outputs under reference and measuring conditions, the measuring signals are unmodulated and the receiver noise output is measured, the input signal levels being adjusted for equal noise outputs under reference and measuring conditions and the noise output reduced by the presence of the signal.

3.5.2.3 ***Presentation of results***

The ratio in decibels of the unwanted signal level to the wanted signal level is plotted linearly as ordinate with the difference between the wanted and unwanted signal frequencies plotted linearly as abscissa. The method used shall be clearly stated, together with the tuning frequency.

3.5.2.4 ***Rejection of amplitude modulated signals in nearby (out of band) channels***

This subject is considered in CISPR 20 as a matter of electromagnetic compatibility (EMC) and reference is required to that standard for the method of measurement.

3.5.3 Methods of measurement: three-signal methods

3.5.3.1 ***Method intended to simulate cable reception and other conditions where a large number of signals of approximately equal level are applied to the r.f. input***

3.5.3.1.1 *Introduction*

This method measures the effects of intermodulation produced in the r.f. part of the receiver when two input signals at frequencies f_1 and f_2 generate an unwanted signal at the tuning frequency f_s (third-order intermodulation of the types $f_1 + f_2 - f_s = f_s$ or $2f_1 - f_2 = f_s$). In its basic form, sinusoidal modulation of the unwanted signals is used.

3.5.3.1.2 *Method of measurement*

The measurement procedure includes the following steps:

a) the set-up for the basic method is shown in Figure 17. First, the a.f. output voltage produced by the standard input signal is measured, and this is taken as reference. The measurements are seriously affected by the action of automatic frequency control, which shall therefore be switched off or disabled. The action taken shall be recorded with the results. Measurements can also be made with the automatic frequency control in operation (see **1.4.4.1**);

b) the a.f. modulation of the wanted signal is then switched off (leaving any required pilot-tone or other modulation present), and its r.f. level set to 70 dB(fW) at the receiver input;

c) the two unwanted signals are then switched on and are set, with equal output levels, at frequencies of $f_s + \Delta f$ and $f_s - \Delta f$, where f_s is the wanted signal frequency. The unwanted signal with the higher frequency is unmodulated, and the signal of lower frequency is modulated at 1 kHz with one third of RMSD.

NOTE 1 This procedure measures the effect due to intermodulation of the type $f_1 + f_2 - f_s = f_s$. The wanted signal is involved in the intermodulation process.

NOTE 2 A reduced deviation is used in step c) because meaningful results are not obtained with RMSD.

d) the levels of both unwanted signals are increased simultaneously until the level of the a.f. output due to intermodulation components is 30 dB below the a.f. reference, measured with the filter described in Figure 2 and a true r.m.s. voltmeter. If noise affects the measurement, the a.f. output may be measured selectively;

e) the difference between the r.f. level in decibels of the unwanted signals and that of the wanted signal is recorded as a result, together with the frequencies used for the measurement;

f) the measurement is repeated for values of Δf ranging from 400 kHz to 5 MHz, and for wanted signal levels of 90 dB(fW). Measurements may also be made for other, stated values of a.f. S/I ratio, and for other wanted signal levels.

NOTE Measurements need not be made for unwanted signal levels above 140 dB(fW). The directional coupler shown in Figure 17 is used to reduce interaction between the signal generators while minimizing losses.

3.5.3.2 ***Method for simulating the effect of two strong signals on the reception of a weaker signal***

3.5.3.2.1 *Introduction*

This procedure measures the effect due to intermodulation of the type $2f_1 - f_2 = f_s$. The wanted signal is not involved in the intermodulation process.

3.5.3.2.2 *Method of measurement*

The procedure specified in **3.5.3.1.2** is followed, except that measurements are made with the two unwanted signals at frequencies of $f_s + \Delta f$ and $f_s + 2\Delta f$ or $f_s - \Delta f$ and $f_s - 2\Delta f$, the signal closer in frequency to f_s being modulated at RMSD and the other being unmodulated.

3.5.3.3 ***Method using coloured noise modulation***

3.5.3.3.1 *Introduction*

This method is more searching than that described in **3.5.3.1** or **3.5.3.2**, but requires a very complex test set-up.

3.5.3.3.2 *Method of measurement*

The measurement procedure includes the following steps:

a) the set-up shown in Figure 18 is used. The frequency response of the modulator of each signal generator for the unwanted signals should not vary by more than ± 1 dB from 22,4 Hz to 15 kHz;

b) it is essential to adjust the deviations of the signal generators very precisely (see **1.4.2.3**);

c) the frequency difference between the wanted and unwanted signals shall be measured with a frequency counter or similarly accurate method. The direct calibrations of the signal generators may not be of the accuracy required for this measurement (better than ± 1 kHz);

d) for the determination of the a.f. reference level with the quasi-peak meter, the wanted signal is modulated sinusoidally at 500 Hz (to avoid effects due to pre-emphasis), and the switches S_4 and S_5 set to position 1, S_1 to position 3, S_2 to position 1 and S_3 to position 3. Volume and balance controls should be set for equal a.f. outputs from both a.f. channels of stereophonic receivers;

e) for the measurement of the a.f. output due to intermodulation, both unwanted signals are noise-modulated and the measurements are made on voltmeter V_3 with S_3 in position 2.

3.5.3.4 ***Presentation of results***

The results should be presented as graphs with the wanted signal level as parameter. The difference, in decibels, between the unwanted and wanted signal levels is plotted linearly as ordinate, with the value of Δf plotted linearly as abscissa.

The method used should be clearly reported with the results.

NOTE As an alternative to observing the audio-frequency output signals in the above measurements, the amplitude of the intermediate-frequency signal, at a stage in the receiver before limiting occurs, and produced by the standard radio-frequency input signal may be compared with that produced by the signal defined in the relevant clause above. This comparison may be carried out using a radio-frequency wave analyzer or a spectrum analyzer.

3.6 Tuning and automatic frequency control (AFC) characteristics

3.6.1 Introduction

The tuning characteristic of a receiver shows the relation between the audio-frequency output voltage and the operating frequency when the applied signal frequency is varied each side of the frequency to which the receiver is tuned.

The tuning characteristic is modified by the action of automatic frequency control. The characteristic measured with automatic frequency control in operation shows the pull-in and hold-in ranges.

3.6.2 Method of measurement

The receiver is brought under standard measuring conditions and then the input signal level reduced so that the receiver is operating below limiting level (see **1.3.7**). Under these conditions the signal-to-noise ratio may be very low; if so, the audio-frequency output at 1 kHz should be measured selectively (e.g. with a wave analyzer or third-octave filter), this being stated with the results. The input signal level used shall also be stated. The input signal frequency is then varied in step either side of the original frequency and the output voltage (or power) is measured at each step.

The measurement may be repeated at other input signal levels. If automatic frequency control is fitted, the measurements shall be repeated with the control in operation. The input signal frequency is first varied stepwise away from the original frequency until a sudden drop in audio frequency output occurs, and then varied stepwise towards and beyond the original frequency until the output suddenly drops again. The input signal is then varied back towards the original frequency again. From these measurements the hold-in and pull-in ranges of the automatic frequency control may be determined (see Figure 19).

Alternatively, instead of measuring the audio output level, the local oscillator frequency may be measured with a frequency counter at each value of input signal frequency (see Figure 20).

The measurements may be repeated at other signal levels.

NOTE 1 Some types of automatic frequency control do not function satisfactorily if the pull-in range is wide, because the receiver is detuned from a weak, wanted signal in the presence of a strong signal on a nearby frequency. Other types of automatic frequency control can have a very wide hold-in range associated with a narrow pull-in range and these are less affected by strong signals. Because of the wide variety of effects that may occur, it is difficult to standardize a method of measurement; a method based on that of **3.2.2** is often suitable but with the unwanted signal unmodulated and the wanted signal modulated. The change of audio-frequency output when the unwanted carrier is applied is a measure of its interference with the automatic frequency control action.

NOTE 2 These measurements may conveniently be combined with those given in item e) of **5.2.1**.

3.6.3 Presentation of results

The output voltage (or power) is plotted in decibels on a linear scale, the reference voltage or power being stated. The difference between the input signal frequency and the original frequency (the detuning) is plotted linearly as abscissa; a logarithmic scale may be used if the detuning range is large. An example is given in Figure 19. If the local oscillator frequency is measured, its frequency shall be plotted in megahertz linearly as ordinate. An example is given in Figure 20.

4 Interference due to internal sources

4.1 Single-signal whistles

4.1.1 Introduction

Whistles (any type of audible beat-note) may be generated by several processes within the receiver. The action, within the receiver, of non-linearities on harmonics of the intermediate frequency or of any internal oscillator, together with wanted or unwanted signals, can give rise to such a.f. signals. In receivers using digital techniques, harmonics and subharmonics of a clock frequency and of the local oscillator frequency may be present.

4.1.2 Method of measurement

The measurement procedure includes the following steps:

a) with no signal input, tune the receiver slowly over the tuning range while listening to the audio output. Note the frequencies at which audible whistles occur. Particular attention should be given to frequencies near harmonics of the intermediate frequency, and of any clock frequency (such as for a tuning synthesizer), which fall within the tuning range;

b) apply an unmodulated r.f. signal at the level corresponding to the noise-limited sensitivity and tune the receiver slowly over the tuning range while listening to the audio output. If any audible zero beat occurs (that is, as low an audio output frequency as possible), note the input frequency;

c) measure the noise-limited sensitivity at each of these frequencies and at a nearby frequency at which there is no audible whistle, for comparison.

4.1.3 Presentation of results

The results are presented in the form of a table showing the input signal frequency, the receiver tuning frequency and the reduction in noise-limited sensitivity due to the whistle, expressed in decibels.

4.2 Modulation hum (interference at power supply frequency)

4.2.1 Introduction

The radio-frequency stages, particularly mixer stages, of a receiver may give rise to hum, due to amplitude or frequency modulation of the signal by low audio-frequency voltages from the supply mains or elsewhere, or electric or magnetic fields. Automatic frequency control circuits, in particular, can cause hum due to frequency modulation of the local oscillator.

4.2.2 Method of measurement

The receiver is brought under standard measuring conditions, (see **1.4.2.8**) but without using the 200 Hz to 15 kHz band-pass filter described in **1.4.1.3**, and the modulation frequency is then changed to 80 Hz so that comparison of the signal and hum is less influenced by the frequency response of the audio-frequency stages. The modulation is then removed and the hum output is measured as separate spectral components with a wave analyzer or as total hum output with a true r.m.s. meter. The measurement is then repeated, with no signal input, and the antenna terminals, if any, short-circuited.

The measurement should be repeated at other input signal levels, and with automatic frequency control in operation.

NOTE Care should be taken that the input signal is sufficiently free from hum modulation and that there are no unintentional earth-loops from the antenna input to the mains supply or audio-frequency output terminals. For example, a check may be made with either the signal source, the receiver or both supplied from batteries.

4.2.3 Presentation of results

The hum can be expressed as a spectrum, or as the r.m.s. sum of the spectral components, in decibels, referred to a stated reference value. Curves may be plotted of hum output as a function of the input signal level.

4.3 Unwanted self-oscillations

4.3.1 Introduction

A receiver should be investigated for unwanted radio-frequency or intermediate frequency self-oscillation, with every possible combination of control settings, except for combinations specifically excluded by the manufacturer in the user instructions. Varieties of combination include, with or without an applied signal, an earth connection and antenna, with different lengths of antenna, especially indoor antennas, if permitted by the manufacturer, and loudspeaker and external audio-frequency input leads.

Anomalies in the performance under any of these conditions should be noted, due allowance being made for the likelihood of the combination of control settings in question being achieved in normal use.

NOTE In addition to instability, hum may be produced by the receiver with some abnormal combinations of control settings; for example, if a record-playing unit is included in the same case as the receiver, hum may be induced from the motor to a ferrite antenna but the motor would not normally be operating when the ferrite antenna was in use.

4.3.2 Method of measurement

The range of parameters to be varied is given in **4.3.1**. It is not possible to describe the method of measurement more specifically, since it depends very much on the features and characteristics of the receiver.

4.3.3 Presentation of results

The results should be presented as one or more tables, detailing the values of parameters for which an undesirable effect was observed, and the nature of the effect, which should be expressed numerically if possible.

4.4 Acoustic feedback

4.4.1 Introduction

Unwanted effects can be produced in electronic equipment as a result of mechanical vibration of components, including wiring. Such components are said to be microphonic. The vibration may arise from an external source or from the loudspeaker used with the receiver.

4.4.2 Method of measurement

A circuit arrangement similar to that shown in Figure 21 is suitable for this measurement. The receiver is first brought under standard measuring conditions with the gain of the amplifier/attenuator combination A set to unity. The modulation is then removed, the volume control, if any, set at maximum and the receiver detuned slightly in each direction, slowly in order to provoke acoustic self-oscillation if possible. The gain of the combination A is then varied until it is just possible to provoke acoustic self-oscillation, and the value of gain of the combination A noted.

The measurement may be repeated with other values of input signal level, and other input frequencies, particularly those which may be critical with respect to vibration of variable capacitors, for example between one-third and one-half rotation from the low-capacitance position.

NOTE 1 During the detuning process the receiver may be tapped to induce oscillation.

NOTE 2 If the receiver has a built-in loudspeaker, the nature of the surface on which the receiver stands and the acoustic properties of the surroundings may affect the results.

4.4.3 Presentation of results

The results shall be expressed as the stability reserve against acoustic feedback which is equal to the voltage gain in decibels of the combination A.

5 Overall audio-frequency characteristics

5.1 Fidelity

The fidelity of reproduction of a receiver depends on the characteristics of the radio-frequency and intermediate-frequency parts, in addition to those acoustic and audio-frequency characteristics which are dealt with in IEC 60315-1 (directly or by reference to IEC 60268-3).

The fidelity of stereophonic reproduction depends also on the similarity of the overall amplitude and phase response versus frequency characteristics of the output channels (see **5.4**), on the crosstalk between channels (see **5.7**) and on cross-intermodulation effects (see **5.3**).

Distortion may arise in the receiver where the signal exists in its frequency-modulated form, and in its multiplex form in the case of stereophonic reception. In the latter case both non-linearity distortion of the channel signals and non-linear crosstalk usually result. Some of the significant intermodulation products produced are often in the ultrasonic frequency range.

Distortion arising after decoding does not normally cause non-linear crosstalk.

To ensure that distortion measurements are not invalidated by noise, the output obtained with an unmodulated carrier shall be noted and shown in the results at each stage. Measurements of distortion components will be valid only if appreciably higher (e.g. 10 dB) than the measured noise (see note 1 of **5.2.2.1**).

5.2 Harmonic distortion

5.2.1 Introduction

a) *Distortion as a function of the output voltage or power*

The overall total harmonic distortion is the total harmonic distortion of the audio-frequency output signal, measured with a specified radio-frequency input signal and a specified modulation frequency. It is a function of the audio-frequency output voltage or power.

From the results, the overall distortion-limited output voltage or power and other output characteristics may be determined.

b) *Distortion limited output power*

For measurements via a.f. input terminals, see IEC 60268-3.

c) *Distortion as a function of the input signal level*

Significant distortion of the modulation may occur in the radio-frequency, intermediate frequency and detector stages of the receiver, both at very low and at very high values of radio-frequency input power. Where an audio-frequency volume control (or controls) is provided, it should be adjusted for these measurements, so that the distortion introduced by the audio-frequency stages is as low as possible. But for some receivers, particularly with high output audio amplifiers, the audio-frequency noise and distortion may not under any conditions be negligible compared with the distortion due to the other stages of the receiver. In such a case, measurements should be made at the low-level audio output terminals, if any.

d) *Distortion as a function of the deviation*

The shape of the amplitude and phase versus frequency responses of the radio-frequency and intermediate frequency parts of the receiver, and of the detector, may introduce distortion which is a function of the deviation. Undesired audio-frequency feedback via the automatic frequency control circuits may also produce this effect.

e) *Distortion as a function of the detuning frequency*

When measuring distortion according to **5.2.2.1**, **5.2.2.3** or **5.2.2.4**, the receiver is tuned by the preferred method, which may not correspond to minimum distortion at all values of deviation and input power. To assess this effect the distortion may be measured at several values of carrier frequency within the pass-band of the receiver.

For receivers with pre-set or automatic-search tuning systems, (see IEC 60315-1), the permissible departure of the actual tuning position from the correct position is determined by the extra harmonic distortion introduced thereby.

f) *Distortion as a function of the modulating frequency*

The finite bandwidth of the receiver, and the characteristics of the stereo decoder, if provided, may cause significant non-linear distortion which is a function of the frequency of the modulating signal.

g) *Distortion as a function of the power supply voltage and ambient temperature*

Generally, measurements of these and similar characteristics are mostly used in the process of receiver design, rather than for the verification of specifications. Therefore, it is usual to choose a method of measurement which is particularly suitable for investigating the precise design feature being investigated. The methods given are therefore no more than a guide.

5.2.2 Method of measurement

5.2.2.1 *Distortion as a function of the output voltage or power*

The receiver is brought under standard measuring conditions (see **1.4.2.8**), and the total harmonic distortion of the audio-frequency output signal at the terminals under consideration is measured.

The measurement may be repeated for other modulation frequencies within the audio frequency range, but not exceeding 5 kHz in the case of stereophonic receivers. If a volume control is provided, measurements may be made at other settings of this control, and at other settings of the tone controls. Measurements may also be made with various values of deviation up to and including the RMSD (see item d) of **5.2.1**).

For a stereophonic receiver, each channel shall be measured separately, with the other channel unmodulated. Measurements may be made with both channels modulated at the same frequency and with various phase relationships. These results give information on the influence of the power supply on distortion.

An example of a circuit arrangement for these tests is shown in Figure 22. For monophonic measurements, the circuit can be simplified.

The measurements are carried out with S_1 in position 3 (and then 4), and S_2 in position 1 (and then 2).

NOTE 1 For these measurements and those described in **5.2.2.3** to **5.2.2.7**, a total harmonic distortion meter, which measures all audio-frequency components except those close to or equal to the fundamental frequency, is recommended. Individual components may be measured, if required, by means of a wave or spectrum analyzer.

NOTE 2 Where channel balance controls are provided, or an equivalent arrangement, they should be adjusted so that each channel gives approximately the same output voltage.

5.2.2.2 ***Distortion limited output power***

See IEC 60268-3.

5.2.2.3 ***Distortion as a function of the input signal level***

The receiver is brought under standard measuring conditions (see **1.4.2.8**). The input signal is then reduced to equal the noise-limited sensitivity (see **2.3**). Where provided, the volume control is adjusted so that the noise plus distortion due to the audio-frequency part of the receiver is minimized. The optimum setting of the volume control may be determined from the results of the measurements described in **5.2.2.1**. The input signal level is then increased in steps of, for example, 10 dB, adjusting, where provided, the volume control to keep the audio-frequency output voltage approximately constant. The receiver tuning is checked at each stage.

The value of total harmonic distortion in the audio-frequency output signal of the channel being measured is noted for each value of input power.

For stereophonic receivers each channel may be measured separately.

The measurements may be repeated for other modulation frequencies and other values of deviation. Measurements may also be made at the input to the audio-frequency amplifier, particularly if terminals are provided at this point.

5.2.2.4 ***Distortion as a function of the deviation***

The method is described in **5.2.2.1**. Where provided, the volume control should be adjusted as described in **5.2.2.3** so that the noise plus distortion of the audio-frequency stages is minimized. The optimum setting of the volume control may be determined from the results of the measurements described in **5.2.2.1**.

For stereophonic receivers measurements may be made with the channels modulated equally in phase and equally in phase opposition.

NOTE Measurements at values of deviation greater than the rated maximum system deviation may be of value in some cases.

5.2.2.5 ***Distortion as a function of the detuning frequency***

The receiver is brought under standard measuring conditions (see **1.4.2.8**). Where provided, the volume control shall be adjusted as described in **5.2.2.3** to minimize the noise plus distortion of the audio-frequency stages. The total harmonic distortion of the audio-frequency output signal is noted. The input signal frequency is then varied within the pass-band of the receiver, and the total harmonic distortion measured at each frequency, adjusting the volume control, where provided, to keep the audio-frequency output voltage approximately constant.

Measurements may be repeated at other values of input power. The results obtained are considerably affected by automatic frequency control, if provided. If the automatic-frequency control can be switched off, measurements should be made with and without automatic-frequency control.

For pre-set tuned receivers measurements should be made with each pre-set adjusted so that collectively they cover the whole tuning range of the receiver.

NOTE These measurements may conveniently be combined with those described in **3.6.2**.

5.2.2.6 ***Distortion as a function of the modulating frequency***

The measurement is performed as described in **5.2.2.1** but with the volume control, if provided, adjusted to minimize the noise plus distortion of the audio-frequency stages as described in **5.2.2.3**.

Measurement should be made at the standard value of deviation and at ± 22,5 kHz (± 15 kHz) deviation, and may also be made at other stated values of deviation.

For stereophonic receivers measurements should be made:

a) with both channels modulated in phase (S_1 in Figure 22 in position 1);

b) with both channels modulated in phase opposition (S_1 in Figure 22 in position 2);

c) with each channel in turn, only, modulated (S_1 in Figure 22 in position 3 or 4).

The results represent mainly harmonic distortion for modulation frequencies up to about 5 kHz. For monophonic receivers, the results for modulation frequencies above 7,5 kHz represent noise, while for stereophonic receivers, the results for these modulation frequencies are mostly difference-frequency distortion products (see item c) of **5.3.2**).

5.2.2.7 *Distortion as a function of the power supply voltage and ambient temperature*

The measurement is made according to **5.2.2.1**, with the power supply voltage set at various values within the range, if any, given by the manufacturer, or according to Table II of IEC 60315-1. The output voltage or power at which measurements are made shall be stated with the results.

To assess the influence of ambient temperature the measurement is made according to **5.2.2.1**, with the ambient temperature set at various values within the range, if any, given by the manufacturer, or according to IEC 60315-1.

Care should be taken to distinguish between effects due to ambient temperature and effects due to self-heating in the receiver which are largely independent of ambient temperature.

5.2.3 Presentation of results

a) *Distortion as a function of the output voltage or power*

The distortion characteristics may be expressed graphically with total harmonic distortion plotted as ordinate on a linear scale, either as a percentage or in decibels, preferably referred to the level of the fundamental. The abscissa may be the output voltage or power plotted logarithmically, or linearly in decibels referred to a stated reference, or modulation frequency plotted logarithmically (see Figure 23).

The output voltage or power for a stated value of total harmonic distortion may also be plotted, in decibels, as ordinate on a linear scale, with modulation frequency as abscissa on a logarithmic scale (an example is given in Figure 24).

b) *Distortion-limited output power*

See IEC 60268-3.

c) *Distortion as a function of the input signal level*

Curves showing the total harmonic distortion as a function of the radio-frequency input power are plotted on linear scales: with the total harmonic distortion either as a percentage or in decibels, preferably referred to rated distortion-limited output voltage or power, as ordinate and the input signal level in dB(fW) as abscissa (see Figure 25).

d) *Distortion as a function of the deviation*

Curves showing harmonic distortion as a function of the deviation are plotted, with the total harmonic distortion, expressed either as a percentage or in decibels, preferably referred to rated distortion-limited output voltage or power, linearly (as ordinate and the deviation in kilohertz linearly as abscissa (see Figure 26).

e) *Distortion as a function of the detuning frequency*

Curves showing the distortion arising from inaccuracy of tuning are plotted, with the distortion expressed either as a percentage or in decibels, referred to the level of the fundamental frequency, linearly as ordinate, and the difference between the nominal tuning frequency and the input carrier frequency linearly as abscissa (see Figure 27).

If a special tuning method is used (see **1.4.4.2**), this should be stated with the results.

f) *Distortion as a function of the modulating frequency*

The results are presented graphically as described in item a). An example is shown in Figure 28.

g) *Distortion as a function of the power supply voltage and ambient temperature*

The results may be expressed graphically with power supply voltage or ambient temperature as abscissa, or as families of curves with these variables as parameters.

5.3 Intermodulation distortion

5.3.1 Introduction

Intermodulation distortion in the detected or decoded audio-frequency signal may be caused by non-linearity in the radio-frequency, intermediate-frequency and detector stages of the receiver, particularly by the effects of a limited intermediate frequency bandwidth and detector non-linearity. Where an audio-frequency amplifier is provided, its intermodulation distortion may not be negligible, so that measurements are often best made at the input to this amplifier, particularly if terminals are provided at this point. For stereophonic receivers difference-frequency distortion products from the modulating frequency and the pilot tone or subcarrier or their harmonics may fall within the audio-frequency band. For the pilot-tone system, this occurs for second-order intermodulation between a modulating signal at 4 kHz, or above, with the 19 kHz pilot-tone frequency.

5.3.2 Method of measurement

a) *Intermodulation within the channel*

The receiver is brought under standard measuring conditions and the volume control, if any, adjusted according to **5.2.2.3**. Two equal amplitude signals at 1 kHz and approximately 1,2 kHz are applied to an audio input terminal (left L or right R) of the stereo signal generator and adjusted to obtain maximum (peak) deviation of ± 67,5 kHz (± 45 kHz). The output voltage or power shall be measured at each modulation frequency, at approximately 200 Hz and multiples thereof, and at any other frequency below 15 kHz at which significant output is obtained. Measurements are repeated with other pairs of modulation frequencies separated by approximately 200 Hz, up to 14,8 kHz and 15 kHz. A difference-frequency of approximately 200 Hz is chosen for convenience of measurement when using a selective voltmeter, the exact frequency being chosen to avoid interference from power-supply harmonics.

Measurements may be repeated at other values of deviation. For stereo receivers measurements shall be made first with equal modulations applied to both channels in phase, second with equal modulations in phase opposition, with pilot tone or subcarrier present in each case, and third with equal, in-phase modulations without pilot-tone or subcarrier. These measurements show the effects of decoder operation on intermodulation distortion. Measurements shall not extend beyond 100 % modulation.

b) *Cross-intermodulation between the channels of a stereo receiver*

Modulation is applied at the stereo encoder with a frequency of 8,7 kHz to one channel and at a frequency of 11 kHz to the other channel. The amplitudes are adjusted so that each produces a peak-to-peak deviation of ± 67,5 kHz (± 45 kHz) in the absence of the other.

NOTE These frequencies are known to be suitable for the pilot-tone system (and acceptable for other systems). They are chosen in preference to two of the standard frequencies given in IEC 60315-1 so that intermodulation products arising from different mechanisms have easily distinguishable frequencies.

The output voltage or power at each modulation frequency and of each significant intermodulation product present in the output of each channel within the audio-frequency range shall be measured with a selective voltmeter, including products due to ultrasonic components of the composite signal.

Measurements may be repeated with the channel modulations reversed, also at ± 22,5 kHz (± 15 kHz) deviation. To measure the intermodulation distortion at lower modulation frequencies, measurements may be made with other pairs of frequencies such as 900 Hz and 1 100 Hz. Full details of the frequencies, deviations, etc., shall then be given with the results.

c) *Additional measurement for intermodulation due to ultrasonic components*

The receiver is brought under standard measuring conditions and the volume control, if any, then adjusted according to **5.2.2.3**. The modulation is then changed to be equal and in-phase in both channels, at ± 67,5 kHz (± 45 kHz), and the output voltage or power of each channel at 1 kHz measured selectivity. The measurement is repeated with modulation frequencies of 13 kHz, 10 kHz and 6,67 kHz in turn for the pilot-tone system, and 15 kHz and 10 kHz for the polar-modulation system, all these frequencies being chosen so that their harmonics lie 1 kHz for the former system and 1,25 kHz for the latter system from ultrasonic components of the composite signal; the output is measured selectively at 1 kHz or 1,25 kHz respectively. The results may be shown in a table, the outputs due to intermodulation being expressed in decibels relative to the output produced by 1 kHz modulation, equal and in phase in both channels at ± 67,5 kHz (± 45 kHz) deviation.

5.3.3 Presentation of results

The results shall be expressed as spectra in the form of a table. The reference value shall be the output (of one channel in the case of stereo) produced by the standard radio-frequency input signal. Products due to ultrasonic components of the composite signal shall be identified. An example of the results of measurements according to item b) of **5.3.2** is given in Figure 29.

5.4 Inter-channel characteristics

5.4.1 Introduction

a) *Stereophonic identicality factor*

The overall stereophonic identicality factor is the ratio expressed in decibels of the algebraic sum of the outputs of the two audio channels, when the modulating signals applied to the stereo encoder are equal and in phase, to the algebraic sum of the outputs when the modulating signals are equal and in phase opposition.

b) *Inter-channel phase difference*

The overall inter-channel phase difference is the phase difference between the outputs of the two channels, when the modulating signals applied to the stereo encoder are equal and in phase.

5.4.2 Method of measurement

a) *Stereophonic identicality factor*

The receiver is brought under standard measuring conditions in a circuit arrangement as shown in Figure 22, with S_1 in position 2 and S_2 in either position 1 or 3. Then S_2 is switched to position 2 and where a balance control or equivalent arrangement is provided, this is adjusted to the minimum indication on the meter. Next, meter readings are noted with S_1 in position 1 and S_1 in position 2. The overall stereophonic identicality factor is then as follows:

$$20 \lg \frac{(\text{output with } S_1 \text{ in position 1})}{(\text{output with } S_2 \text{ in position 2})}$$

The measurement is repeated for frequencies from 200 Hz up to at least 3 kHz, keeping a constant deviation.

Normally, it is not necessary to use a selective voltmeter but in case of doubt whether hum, noise or distortion is affecting the results, selective measurement should be used.

The measurements may be repeated at other values of deviation and of input signal level.

b) *Inter-channel phase difference*

The phase angle between the two output signals may be measured by connecting the two inputs of a phase meter to the points A and B of the receiver output in Figure 22. The switch S_1 shall be in position 1 or 2.

If a phase meter is not available, the phase difference between the channels can be calculated from the following equation:

$$\phi = \arccos \frac{V_1^{\,2} + V_3^{\,2} - 4V_2^{\,2}}{2V_1V_3}$$

where

V_1, *V*2 and V_3 are the voltages measured on the meter of Figure 22 with S_1 in position 2 and S_2 in positions 1, 2 and 3, respectively. The band-pass filter shall be removed from the circuit for this measurement, but since f is normally small it is advisable to use a selective voltmeter to minimize errors.

Measurement should be made over the frequency range 40 Hz to 15 kHz.

5.4.3 Presentation of results

Curves showing the overall stereophonic identicality factor as a function of modulation frequency are plotted with modulation frequency as abscissa on a logarithmic scale and the stereophonic identicality factor as ordinate in decibels on a linear scale. The overall inter-channel phase difference may be shown on the same graph, with degrees plotted linearly as ordinate.

5.5 Characteristics of the volume control

5.5.1 Introduction

The audio-frequency volume control characteristic may be measured for each channel of a stereophonic receiver according to IEC 60268-3. An overall measurement may be more convenient, especially if the receiver has no a.f. input terminals, or if the results using these terminals might be different from those of the overall measurement.

5.5.2 Method of measurement

The receiver is brought under standard measuring conditions and the output voltage or power from each channel is measured for various known settings of the volume control without further adjustment of the balance control or equivalent arrangement. The output level from the left-hand channel shall be conventionally taken as reference and the output level from the right-hand channel, expressed in decibels, referred to it. Measurements should extend to a volume control attenuation of 46 dB and may be made at other modulation frequencies if required.

5.5.3 Presentation of results

The results shall be expressed graphically, with the volume control setting in degrees, millimetres or percentage of total travel as abscissa on a linear scale and the left-hand channel output power in dB(mW) or voltage in dB(mV) linearly as ordinate. It is recommendable to express on the same graph the inter-channel gain difference in decibels linearly as ordinate.

Alternatively, the left channel volume control attenuation may be plotted in decibels as abscissa, with the inter-channel gain difference in decibels linearly as ordinate.

NOTE Where two separate volume controls are fitted, it is assumed that at each setting the user adjusts for balance aurally.

5.6 Residual output

5.6.1 Introduction

The residual output is the minimum audio-frequency output due to modulating signal or noise. This is a measure of the ability of the volume control(s) to reduce the audio-frequency output to inaudibility.

5.6.2 Method of measurement

The receiver is brought under standard measuring conditions. Then input signal level shall be increased to 100 dB(fW) and the output measured with the volume control set at the minimum output position.

5.6.3 Presentation of the result

The result shall be expressed in microvolts.

5.7 Crosstalk attenuation

5.7.1 Introduction

Crosstalk exists if signals originating in one channel only of a stereophonic system give rise to audio-frequency components in the output of the other channel of the receiver. The crosstalk attenuation is the ratio expressed in decibels of the output of a channel due to a signal intended for that channel to the output of the other channel due to the same signal.

NOTE The output voltage of a channel X due to an input intended for channel Y may be denoted by $(U_X)_Y$.

The crosstalk attenuation from channel A to channel B is then defined as follows:

$$20 \lg(U_A)_A/(U_B)_A$$

The separation of channel A from channel B is defined as follows:

$$20 \lg(U_A)_A/(U_A)_B$$

(See IEC 60268-3 and IEC 60098.)

These quantities are normally of the same order but not equal. With some types of stereo receiver they may differ considerably because $(U_B)_A$ and $(U_A)_B$ are different.

The following characteristics are significant:

a) crosstalk attenuation as a function of the modulating frequency;

b) crosstalk attenuation as a function of the input signal level.

5.7.2 Method of measurement

The receiver is brought under standard measuring conditions in a circuit according to Figure 22. The switch S_1 is then set to position 3, giving modulation in the A channel only at ± 67,5 kHz (± 45 kHz) deviation, and the outputs from the two channels are noted. The measurement is repeated at other modulation frequencies. S_1 is then set to position 4, giving modulation in the B channel only, and the outputs from the two channels again noted. The measurement is repeated at other modulation frequencies.

Selective measurements may be made in order to eliminate the effects of noise or to separate linear crosstalk from non-linear crosstalk. The total crosstalk measured selectively is the r.m.s. sum of the individual crosstalk components.

The measurements may be repeated for other values of deviation, pilot-tone level and input signal power.

5.7.3 Presentation of results

Curves of crosstalk attenuation are plotted with modulation frequency as abscissa on a logarithmic scale and crosstalk attenuation in decibels as ordinate on a linear scale.

NOTE The first set of results from the method of **5.7.2** gives $(U_A)_A$ and $(U_B)_A$, i.e. the crosstalk from channel A into channel B. Results of measurements at other pilot-tone levels should include details of the pilot-tone deviation used.

5.8 Overall audio-frequency response

5.8.1 Introduction

The overall audio-frequency response may be influenced by the properties of the intermediate-frequency stages, the detector, decoder and de-emphasis circuits.

5.8.2 Method of measurement

The receiver is brought under standard measuring conditions but without using the 200 Hz to 15 kHz band-pass filter (see **1.4.1.3**) and then the output voltage or power is measured with several modulation frequencies, either by keeping a constant deviation of the rated maximum system deviation (RMSD) and allowing for the effects of de-emphasis by correcting the results according to the relevant standard pre-emphasis (50 µs or 75 µs), or by setting the deviation at RMSD with a modulation frequency of 15 kHz and including an accurate pre-emphasis network in the modulation chain.

For stereophonic receivers, each channel shall be measured in turn, also with equal modulation in each channel, and in both mono and stereo modes.

If a loudness control (physiologically-compensated volume control) is fitted, and the compensation cannot be switched off, measurements shall be carried out with the loudness control set at minimum attenuation and the deviation reduced to avoid overload of the audio-frequency part of the receiver. This shall be stated with the results.

5.8.3 Presentation of results

Curves showing the output voltage or power as a function of modulation frequency are plotted with modulation frequency as abscissa on a logarithmic scale and output in decibels as ordinate on a linear scale.

The reference level shall be clearly stated. Curves for the two channels of a stereo receiver may be plotted on the same graph, the channels being clearly identified.

6 Effect of additional modulations of the input signal

6.1 Rejection of signals in the ranges 16 kHz to 22 kHz and 54 kHz to 99 kHz

6.1.1 Introduction

Broadcast stereophonic signals may include monitoring signals for use by the broadcasting authority and several types of additional subcarrier modulation, including, for example, special signals for traffic broadcasting and the so called Subsidiary Communications Authorization (SCA) system. Receivers are required to reject these signals except when it is intended by the user that they should be received, and the receiver is operated in the appropriate special mode.

6.1.2 Method of measurement

The receiver is brought under standard measuring conditions (see **1.4.2.8**) in the stereo mode. The modulation is then removed from one channel only. An additional monophonic modulation at ± 7,5 kHz (± 5 kHz) deviation of frequency variable between 16 kHz and 22 kHz or 54 kHz and 75 kHz is added to the composite signal. The output of the channel, which has no 1 kHz modulation input, is noted as the frequency of the additional signal is varied.

Measurements may be repeated at other values of input signal level, and at other values of deviation due to the additional signal. The deviation of the additional signal required to operate the stereo decoder may also be measured at each frequency.

6.1.3 Presentation of the results

The results may be expressed in form of a spectrum or a table of output voltage or power, in decibels, as a function of frequency.

6.2 Rejection of signals in the range 62 kHz to 73 kHz (SCA rejection)

6.2.1 Method of measurement

The receiver is first brought under standard measuring conditions and the modulation changed to a pilot tone of 19 kHz at ± 7,5 kHz deviation together with a 67 kHz subcarrier at ± 7,5 kHz deviation, the subcarrier itself being frequency-modulated at 2,5 kHz with ± 6 kHz deviation. This test signal is chosen because a modulation frequency of 2,5 kHz produces maximum interference in the normal programme channels. The output signals from the normal programme channels are measured. The measurement may be repeated at other input signal levels.

6.2.2 Presentation of the results

The output of each channel due to interference is expressed as a ratio in decibels referred to the output produced under standard measuring conditions but with ± 75 kHz deviation at 1 kHz.

6.3 Measurement of interference caused by RDS signals

6.3.1 Introduction

A receiver may produce audible signals due to the RDS clock frequency and intermodulation products between the 19 kHz pilot-tone and the RDS signal. These signals are measured selectively at the audio output terminals as a function of the deviation of the main carrier by the RDS signal.

6.3.2 Method of measurement

The measurement procedure includes the following steps:

a) the receiver is brought under standard measuring conditions in the stereo mode. The audio modulation is then switched off and an RDS standard signal, (see IEC 60315-9) is added to the multiplex signal in phase relative to the third harmonic of the 19 kHz pilot-tone;

b) the RDS test generator is then switched into the test mode with modulation logic 0, thus generating only two discrete frequencies, at 57 kHz ± 1,1875 kHz. The frequency deviation of the main carrier by the RDS signal shall be ± 2,0 kHz;

c) the a.f. output voltages of both channels shall be measured selectively at the RDS clock frequency (1,1875 kHz) and its harmonics, and at 17,8125 kHz (19 kHz – 1,1875 kHz);

NOTE For some receivers, the output at 17,8125 kHz is greater than at the harmonic frequencies.

d) the measurements shall be repeated, first with RDS frequency deviations of ± 1 kHz, ± 4 kHz and ± 7,5 kHz, and then for each frequency deviation with the RDS signal in quadrature phase with the third harmonic of the pilot-tone;

e) the measurements may be repeated with the addition of an ARI signal (for receivers to be used in countries that have an ARI service, see IEC 60315-9), causing a frequency deviation of the main carrier of ± 3,5 kHz, while the RDS deviation is ± 1,2 kHz, in quadrature with the third harmonic of the pilot tone.

6.3.3 Presentation of results

The results shall be presented as the maximum output of both stereo channels for each frequency present at the a.f. output, as a ratio in decibels referred to the output produced under standard measuring conditions. The results shall be presented as a table, with RDS frequency deviation and phase as parameters.

6.4 Suppression of the fundamental, harmonics and sidebands of the subcarrier and the pilot-tone signal

6.4.1 Introduction

Ultrasonic frequencies may appear at the outputs of the receiver causing incorrect operation of the receiver itself, or of associated equipment, notably tape-recorders. These effects are minimized by designing the stereo decoder so as to suppress certain subcarrier frequencies, by incorporating filters in the receiver, or both.

6.4.2 Method of measurement

The receiver is brought under standard measuring conditions and then the modulation is changed to pilot tone only. The residual output voltage is then measured without using the 200 Hz to 15 kHz band-pass filter (see **1.4.1.3**). Selective measurements, at the pilot-tone frequency and its harmonics, may also be made with 1 kHz modulation in phase-opposition in the two channels and with a frequency deviation of ± 22,5 kHz (± 15 kHz). Measurements shall also be made at frequencies 1 kHz above and below multiples of the pilot-tone frequency in order to include sideband components.

NOTE The sideband components are usually of similar magnitude to that of the pilot-tone harmonics and should be measured with various modulation frequencies up to 15 kHz.

Measurements should be made at all sets of audio-frequency output terminals provided on the receiver.

6.4.3 Presentation of the results

The output of each channel due to the pilot-tone, subcarrier, sideband and their harmonics is expressed as a ratio in decibels, referred to the output produced under standard measuring conditions but with RMSD at 1 kHz.

The results of selective measurements may be expressed as spectra.

6.5 Suppression of interference due to adjacent channel signals with a stereophonic receiver using the pilot-tone system

6.5.1 Introduction

Interference can be caused in a stereophonic receiver due to beats between a harmonic of the subcarrier and a difference-frequency signal present in the output of the detector from an adjacent channel signal. Restriction of the bandwidth at the detector output by means of a low-pass filter, or a special decoding technique, or both, are required to suppress this interference.

NOTE This interference is also shown by the method of item b) of **3.2.1**.

6.5.2 Method of measurement

The receiver is brought under standard measuring conditions and then the modulation changed to pilot tone only, a second r.f. signal also being applied according to IEC 60315-1 or **1.4.2.7**. This second signal is unmodulated and its frequency separation from the first input signal is adjusted to ± (38 n + 1) kHz where n is an integer greater than 2. Beats resulting from these frequencies and harmonics of the subcarrier are thus at a frequency of 1 kHz, and the level of the second signal is adjusted to produce an audio-frequency output 30 dB below that which would be produced under standard measuring conditions, but with a deviation equal to the rated maximum system deviation. This latter level may not be achievable due to overloading but may be easily calculated.

6.5.3 Presentation of the results

The level of the interfering signal is tabulated for each value of frequency difference.

7 Sensitivity, antenna gain and directional response of receivers using rod, telescopic or built-in antennas

7.1 Introduction

The measurement of the directional responses of receivers, and of the sensitivity and antenna gain of receivers with antennas enclosed in the cabinet, involves the use either of an open-air test site (OATS) or an r.f. anechoic room. However, the use of an OATS is usually not possible due to interference from broadcast transmissions and legal restrictions on the radiation of test signals in the broadcast band, while r.f. anechoic rooms of the required characteristics are not generally available. If either of these facilities is available, a correlation between measurements with directly-injected signals and with radiated signals can be established by comparing the r.f. signal levels which give the same a.f. signal-to-noise ratio. The same procedure may be used to compare r.f. input levels for the method described below.

7.2 Method of measurement of sensitivity and antenna gain for a receiver using a rod or telescopic antenna by the absorbing clamp described in CISPR 16-1

Under consideration: see Annex D.

8 Characteristics whose methods of measurement are specified in IEC 60315-1

8.1 Introduction

For ease of reference those general characteristics of receivers which are considered in IEC 60315-1 are listed here.

8.2 List of characteristics and cross-references

	IEC 60315-1
Drift of r.f. operating frequency	
General explanation	**23.1**
Variation of operating frequency with time	**23.2**, **23.3**
Variation of operating frequency with ambient temperature	**23.8**, **23.9**
Variation of operating frequency with input signal level	**23.6**, **23.7**
Variation of operating frequency with supply voltage	**23.4**, **23.5**
Variation of characteristics with supply voltage	
Variation of the distortion with supply voltage	**13**
Variation of the output power with supply voltage	**13**
Miscellaneous	
General mechanical properties of tuning systems	**25**
Tuning frequency range	**25.1**
Calibration error	**25.3**
Toleration of surge discharges	**14**

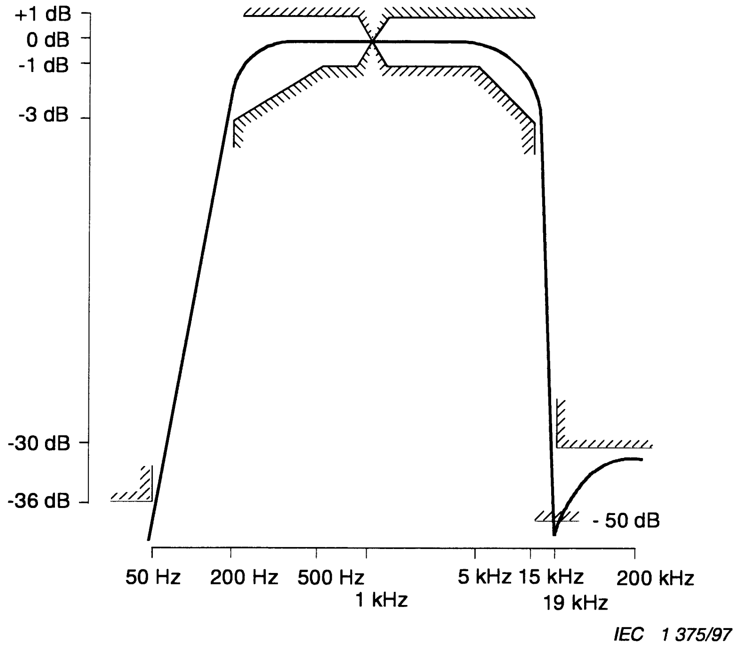


Figure 1 — Frequency response limits of band-pass filter 200 Hz to 15 kHz

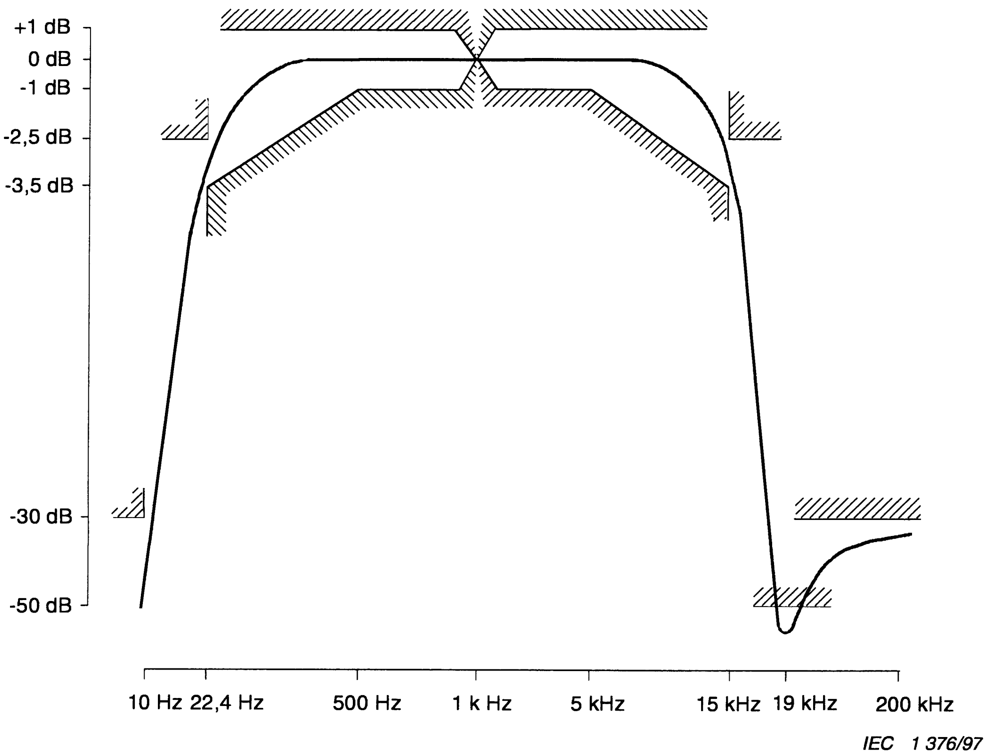


Figure 2 — Frequency response limits of band-pass filter 22,4 Hz to 15 kHz

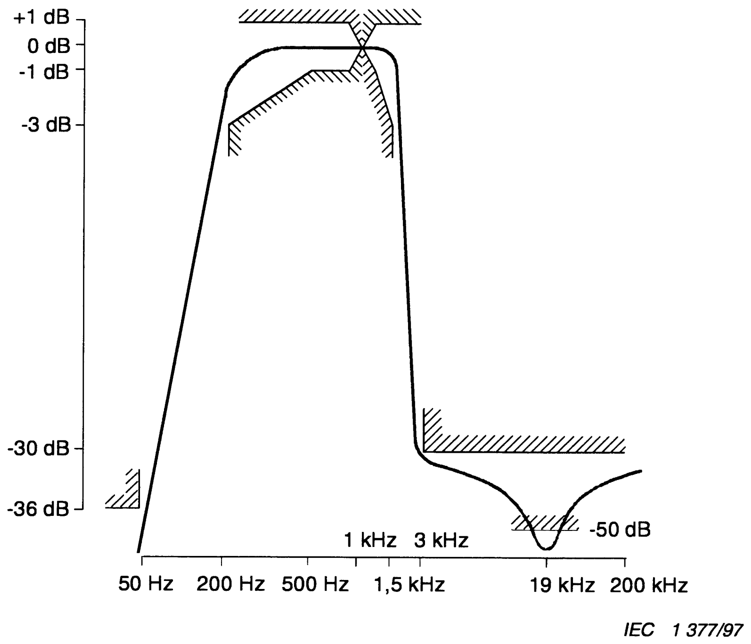


Figure 3 — Frequency response limits of band-pass filter 200 Hz to 1,5 kHz

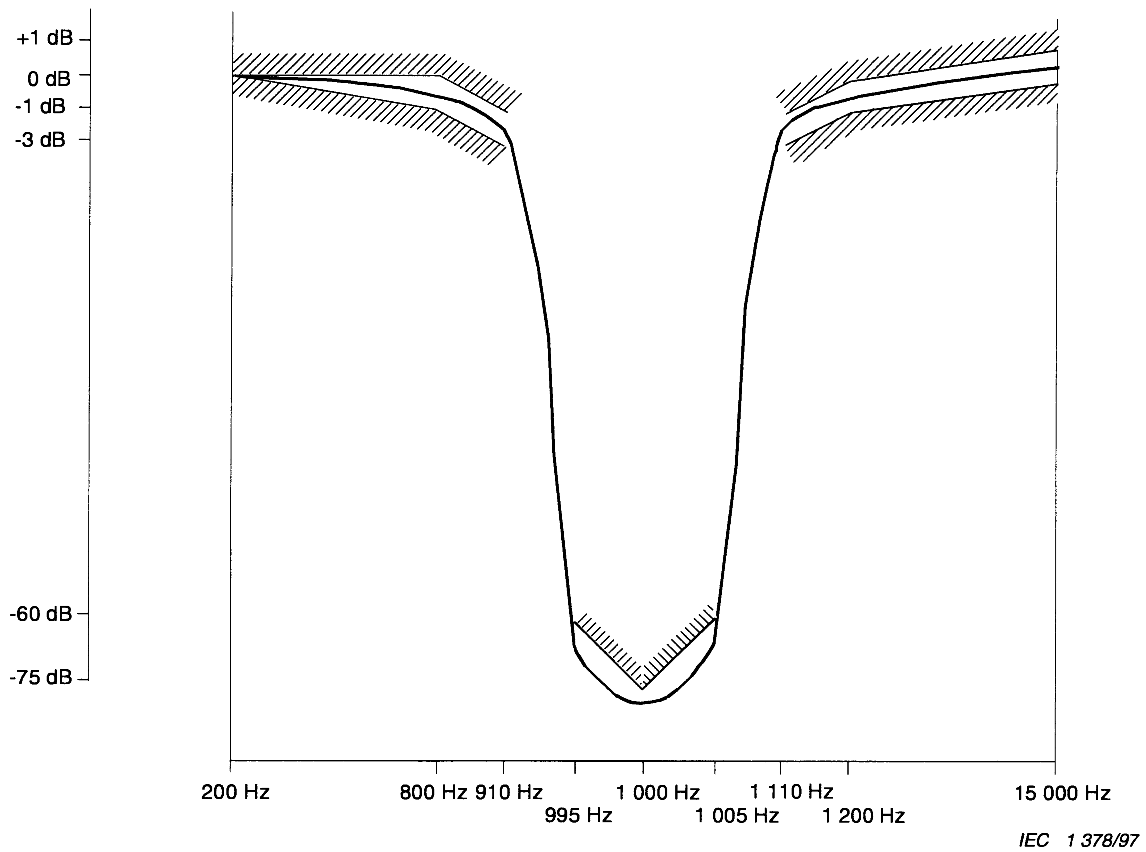
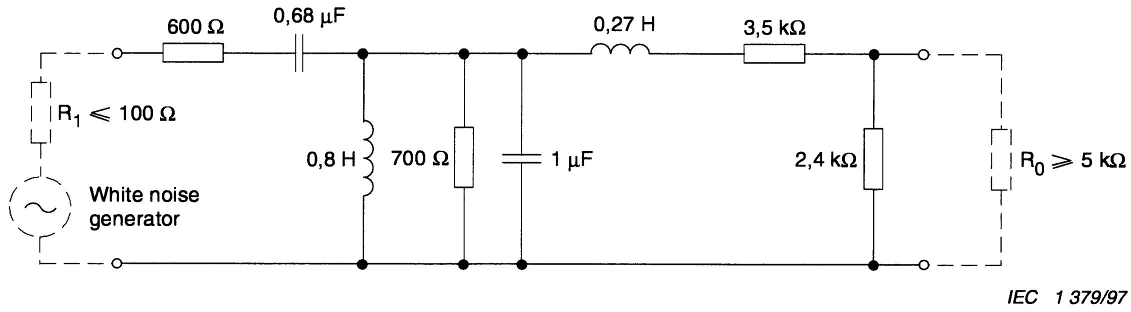


Figure 4 — Frequency response limits of the 1 kHz band-stop filter



NOTE White noise of bandwidth 10 Hz to 15 Hz is attenuated by 32 dB.

Figure 5 — Weighting filter for converting white noise into special coloured noise for selectivity measurements

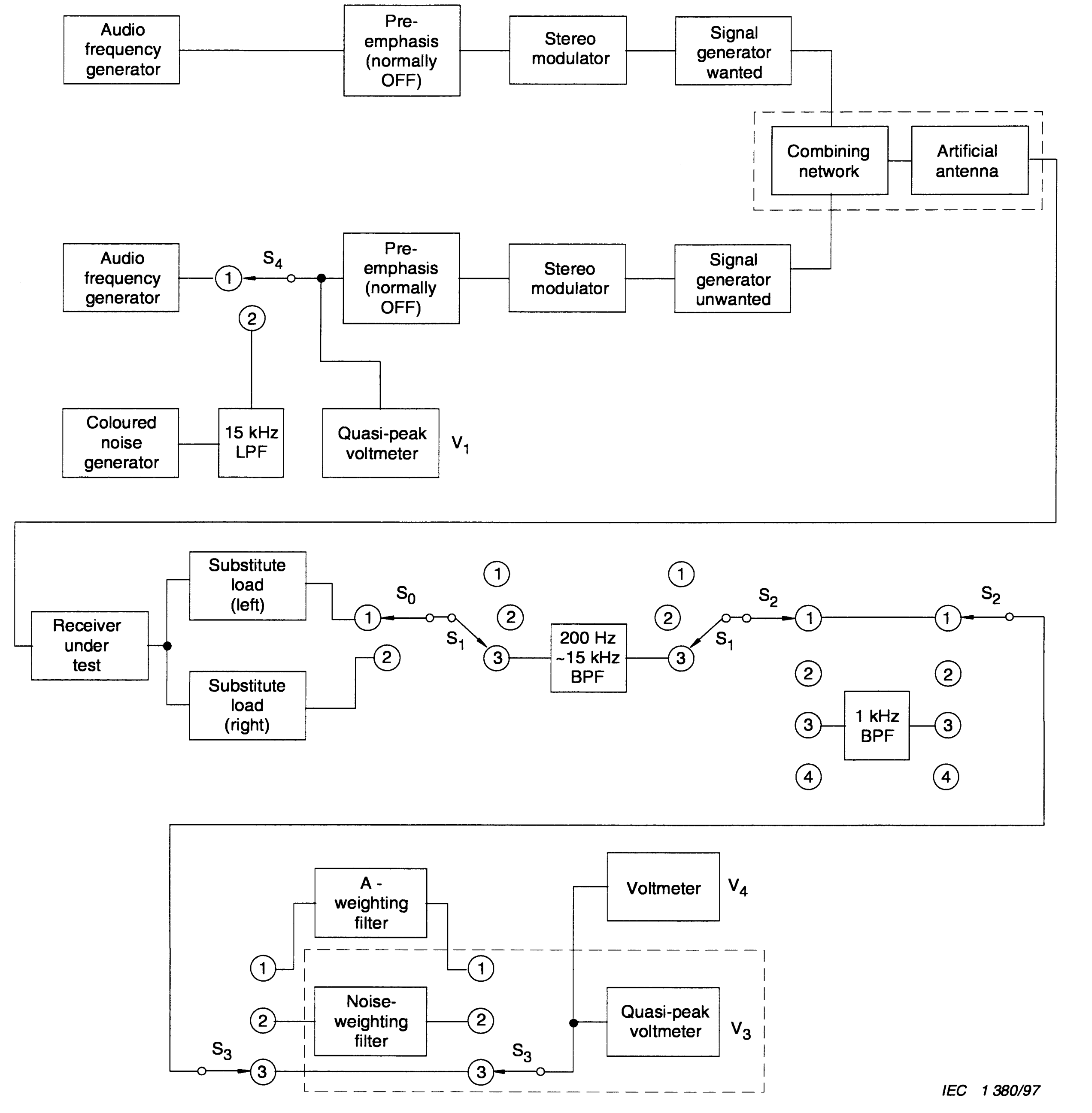
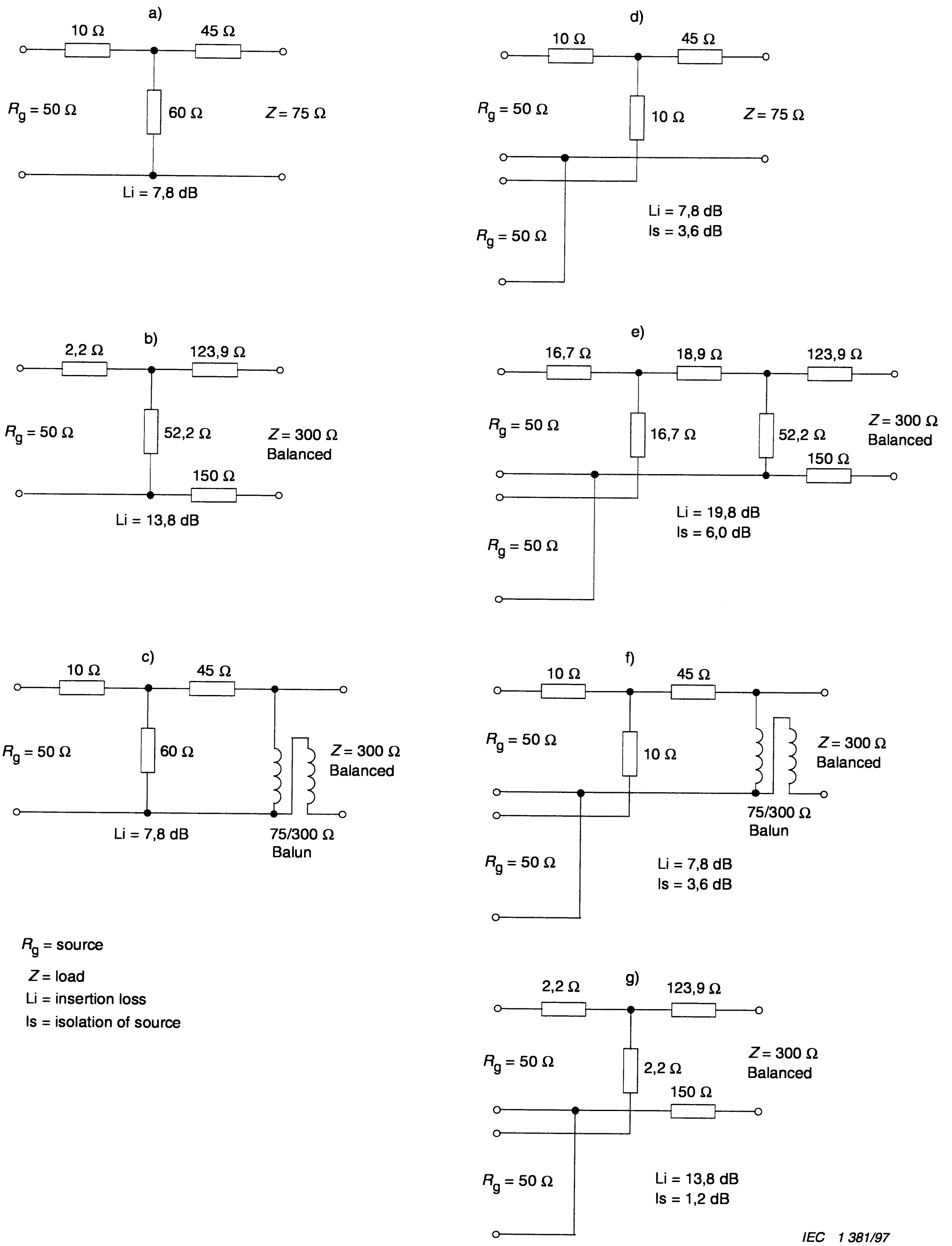


Figure 6 — Arrangement for various measurements with two r.f. input signals



NOTE Insertion loss = 10 lg (available output power of signal generator/available output power of antenna substitution network). Isolation of source = 10 lg (available output power of signal generator 1/available output power at the terminals of signal generator 2 when it is replaced by a suitable load R_g.

Figure 7 — Antenna substitution networks for injecting one or two signals, for 50 Ω signal generators and 75 Ω unbalanced and 300 Ω balanced receiver inputs

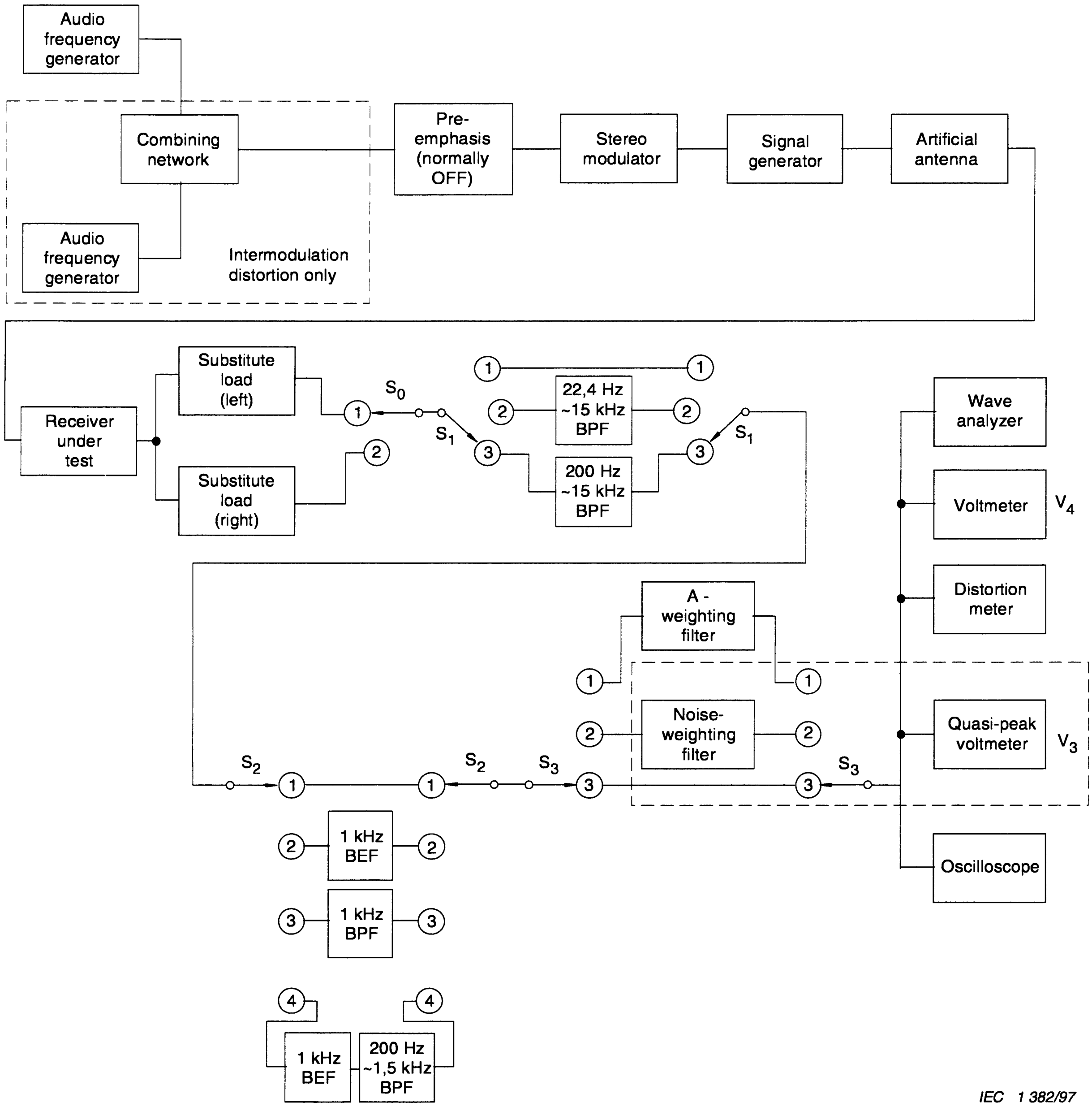
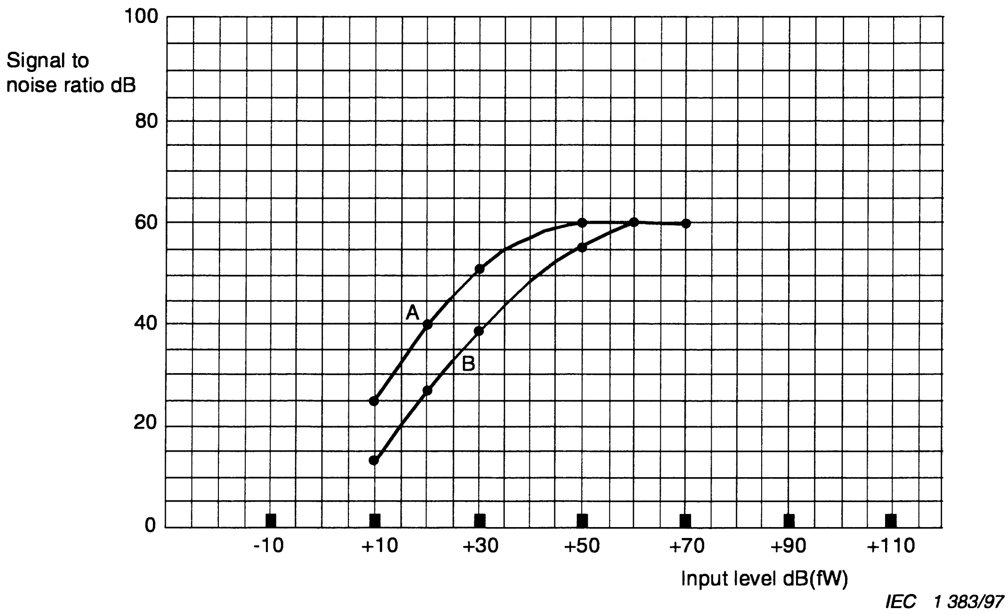
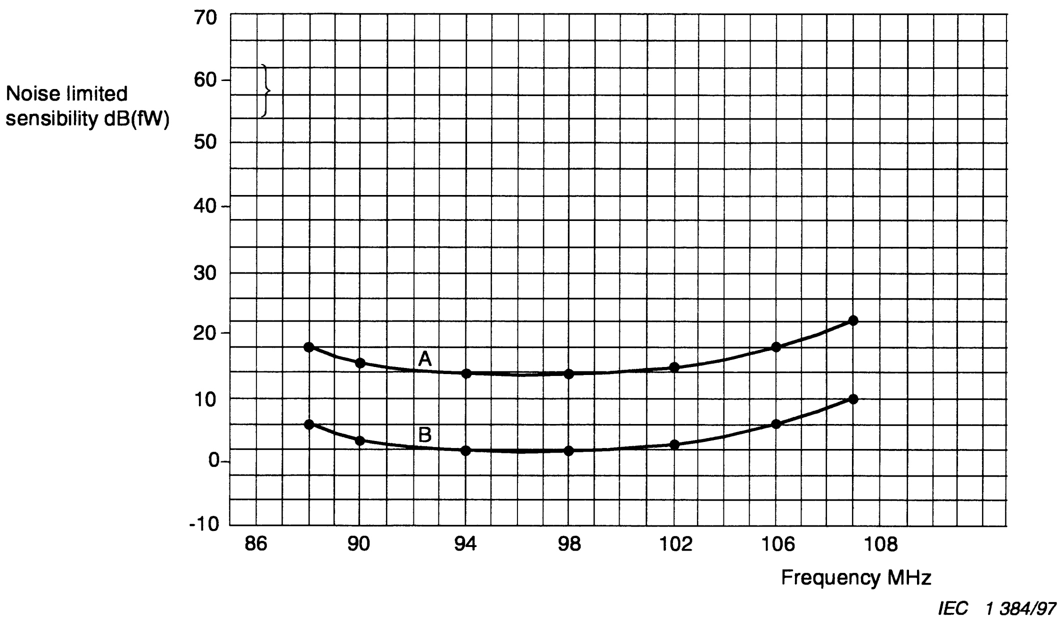


Figure 8 — Arrangement for various measurements with one r.f. input signal



A = mono
B = stereo
Method of 2.2.2.1

Figure 9 — Signal-to-noise ratio



A = signal-to-noise ratio: 40 dB
B = signal-to-noise ratio: 30 dB
method of 2.3

Figure 10 — Noise-limited sensitivity as a function of signal frequency

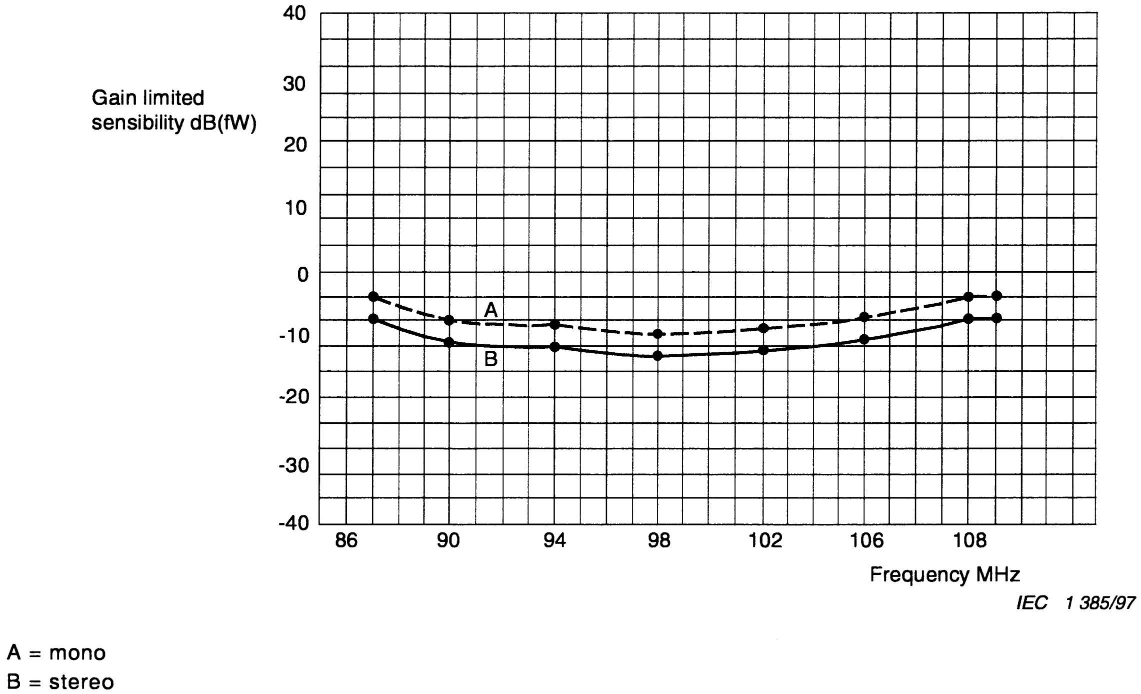
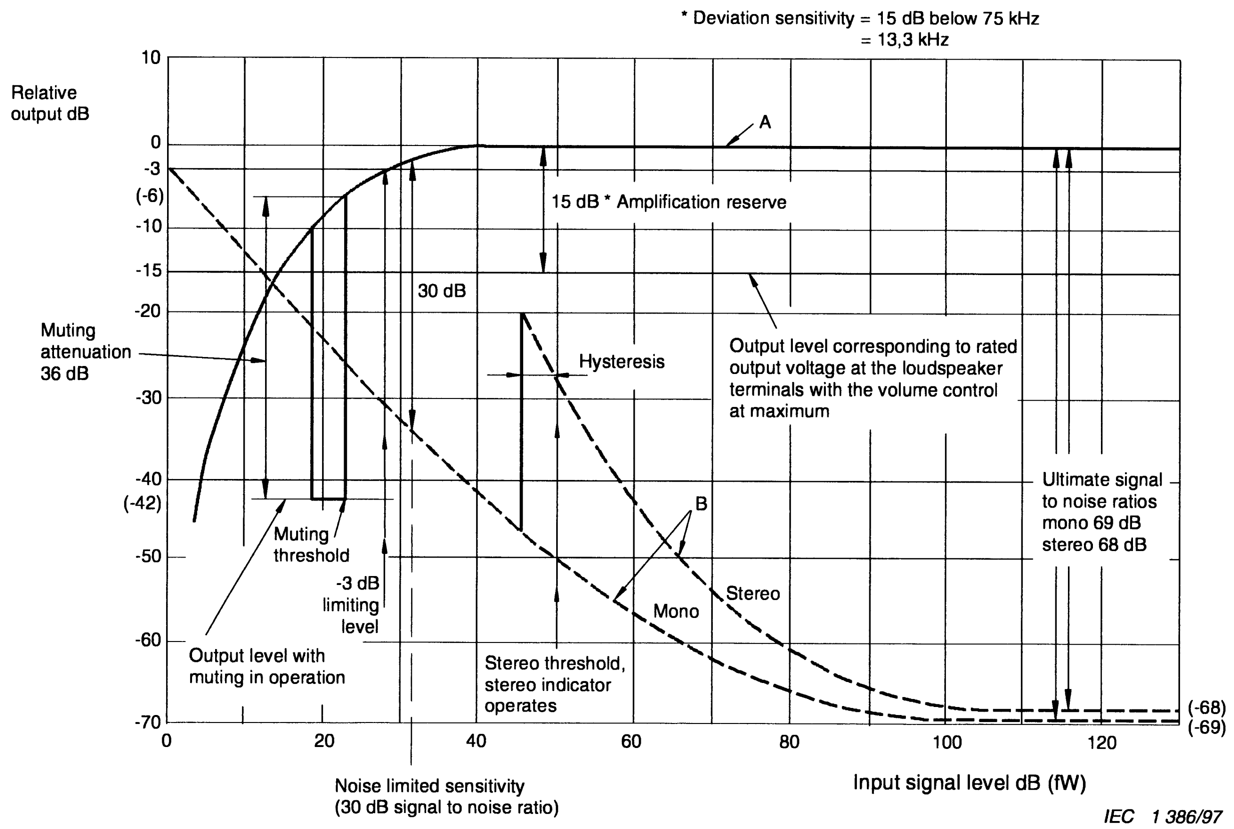


Figure 11 — Gain-limited sensitivity as a function of signal frequency



Measured at the low-level audio output terminals

A = signal output (±75 kHz deviation)

B = noise output

Figure 12 — Output/input characteristics and noise output curves showing terms defined in 1.3

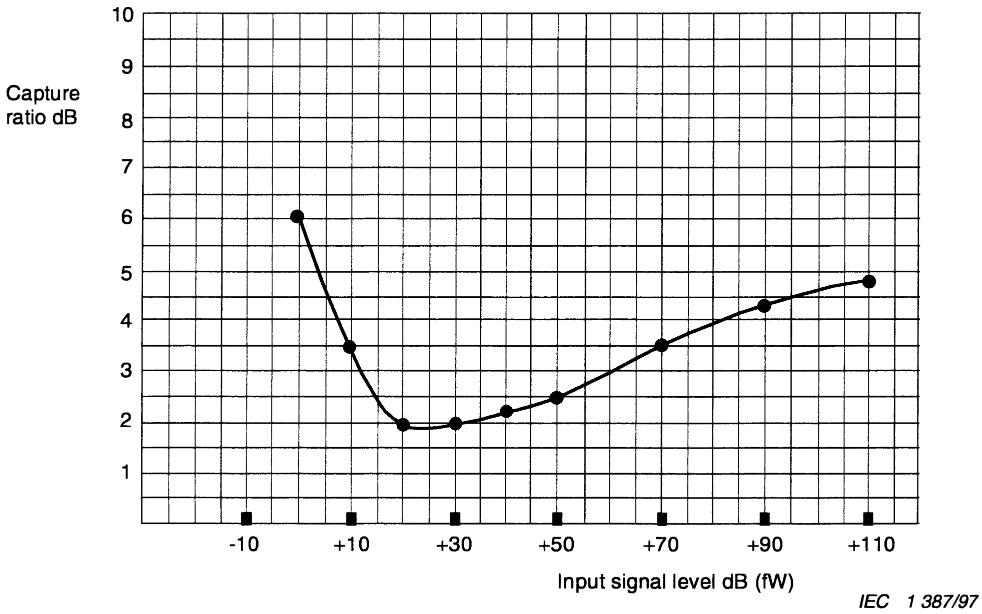


Figure 13 — Capture ratio

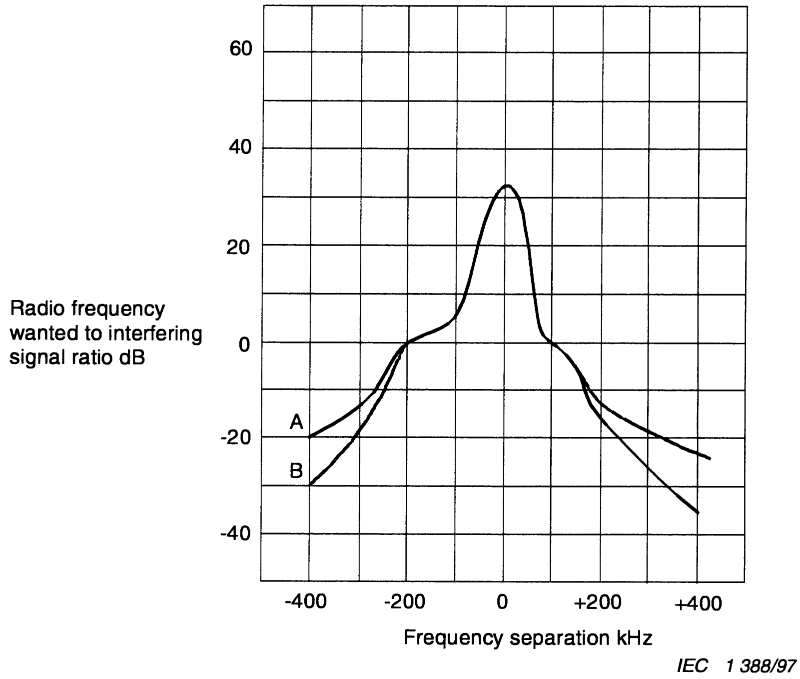


Figure 14a – Mono mode

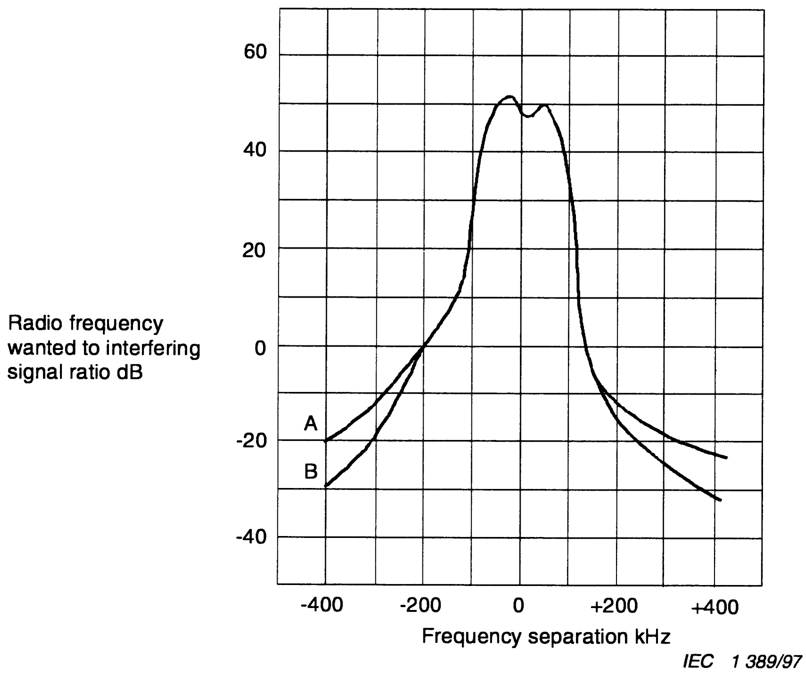


Figure 14b – Stereo mode

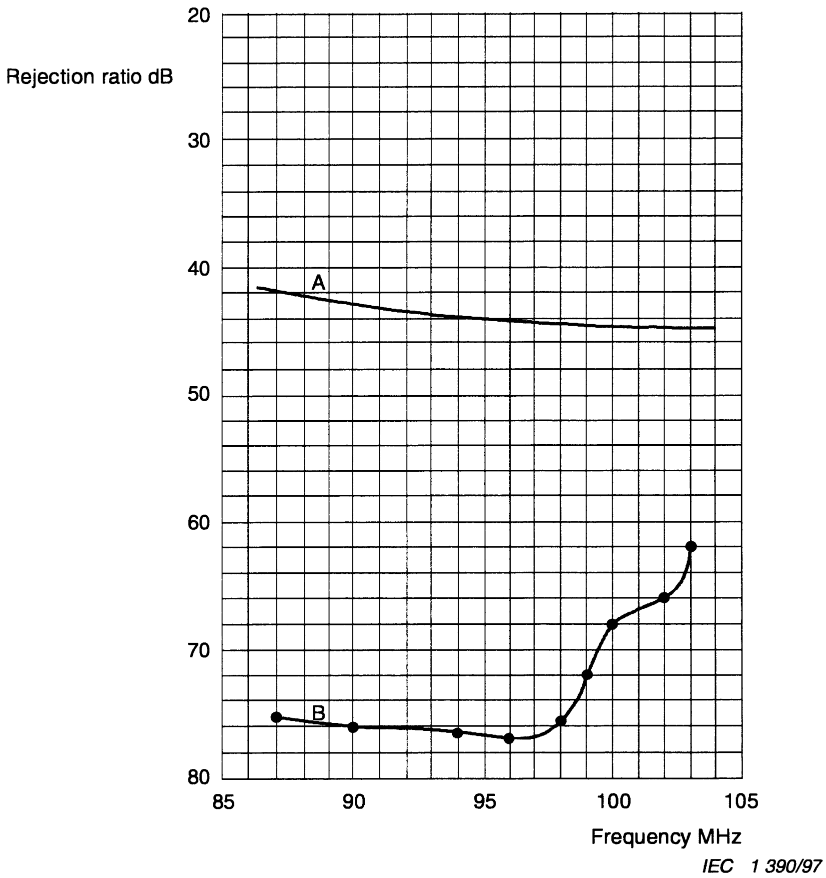
Available power of the wanted signal:

Curve A: 80 dB(fW)

Curve B: 50 dB(fW)

Signal-to-noise ratio 50 dB weighted quasi-peak referred to the a.f. output due to rated maximum system deviation

Figure 14 — Selectivity curves



A = mono Image frequency rejection (single-signal method)

B = stereo Intermediate frequency rejection (single-signal method)

Figure 15 — Image and intermediate frequency rejection ratios

Frequency MHz	**Response** dB
94,0	0
99,35	– 40
88,65	– 45
101,1	– 55
86,9	– 60
115,4	– 37

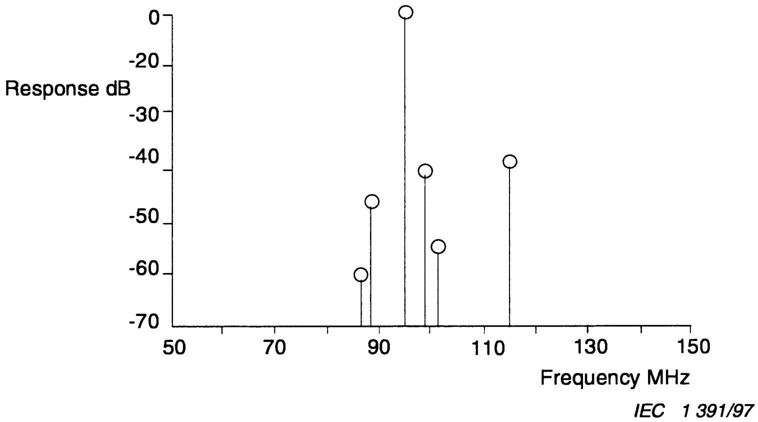


Figure 16 — Spurious responses at a tuning frequency of 94 MHz (single-signal method)

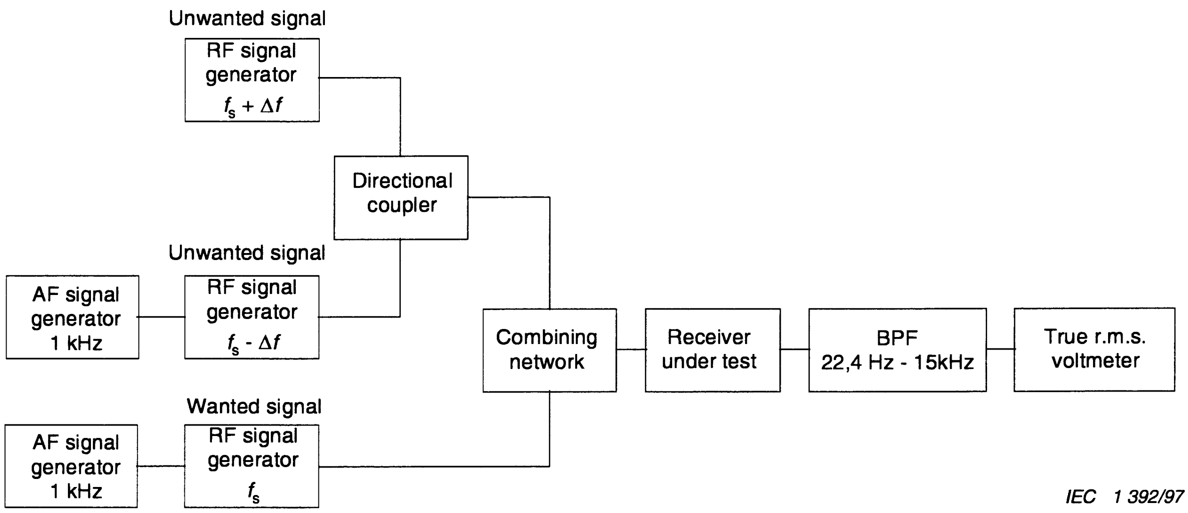


Figure 17 — Arrangement for measuring rejection of unwanted signals simulating cable reception, using sinusoidal modulation

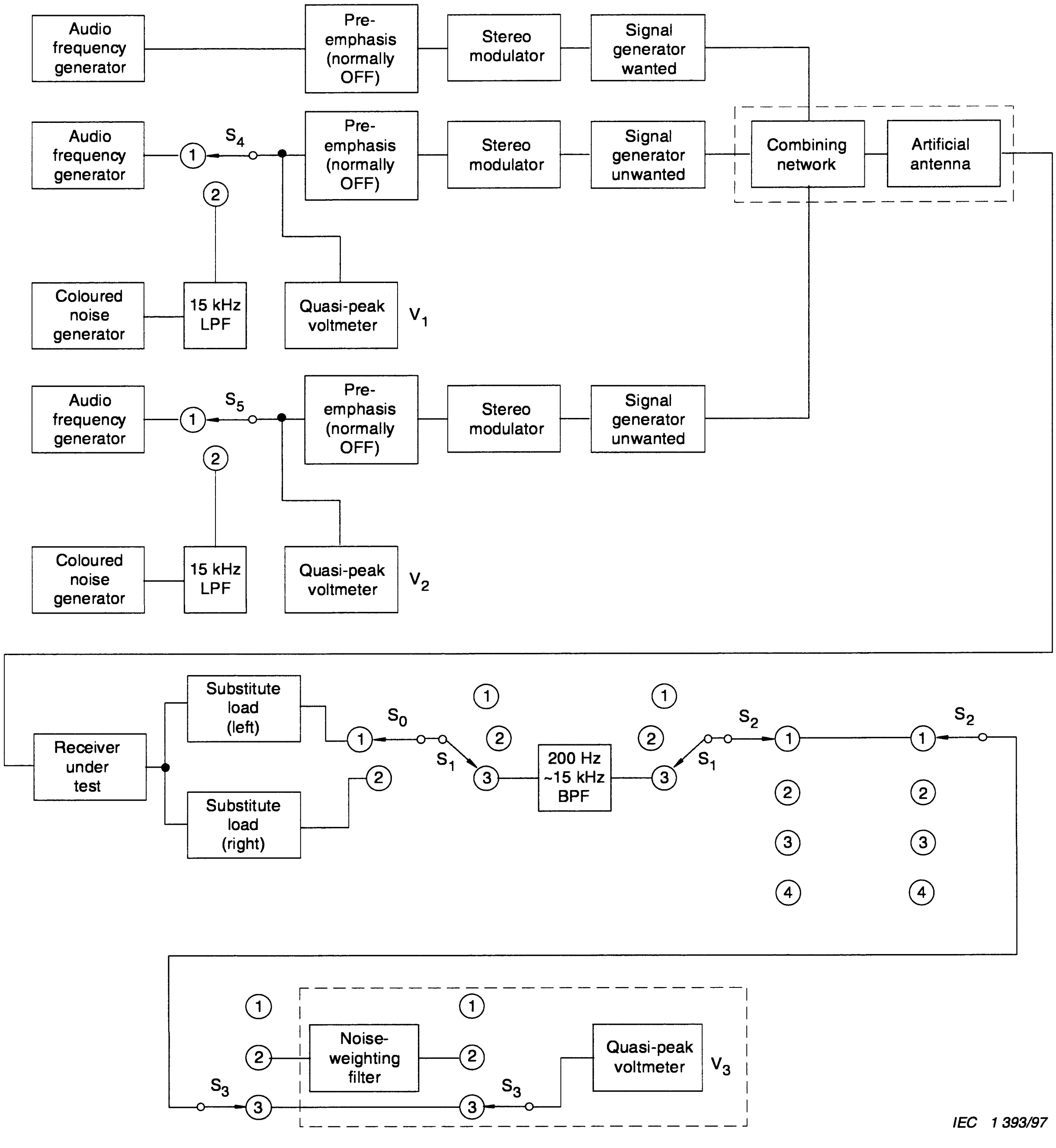
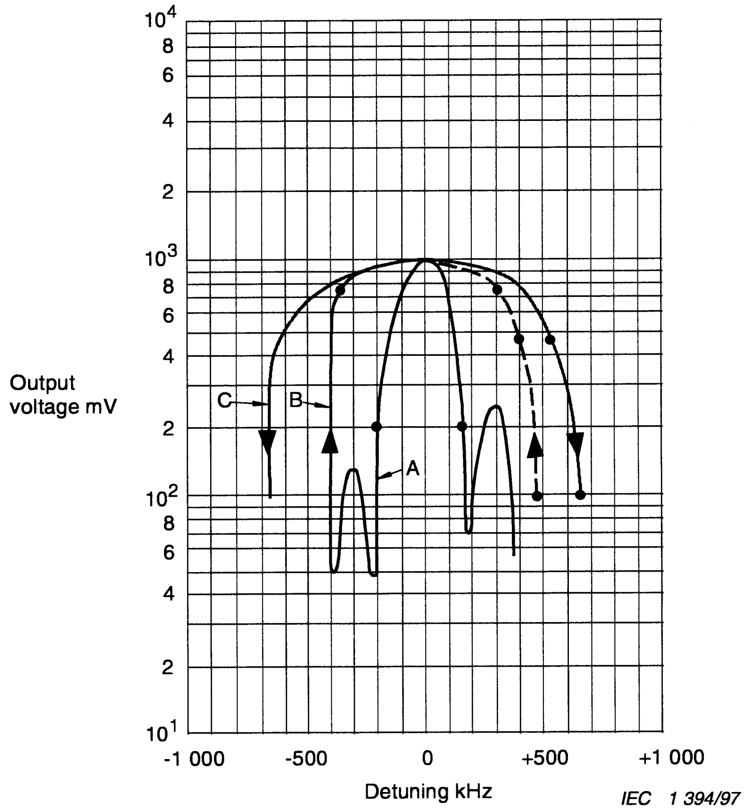


Figure 18 — Arrangement for various measurements using three r.f. input signals



A = without automatic frequency control
B = pull-in range with automatic frequency control
C = holding range with automatic frequency control

Figure 19 — Tuning characteristics

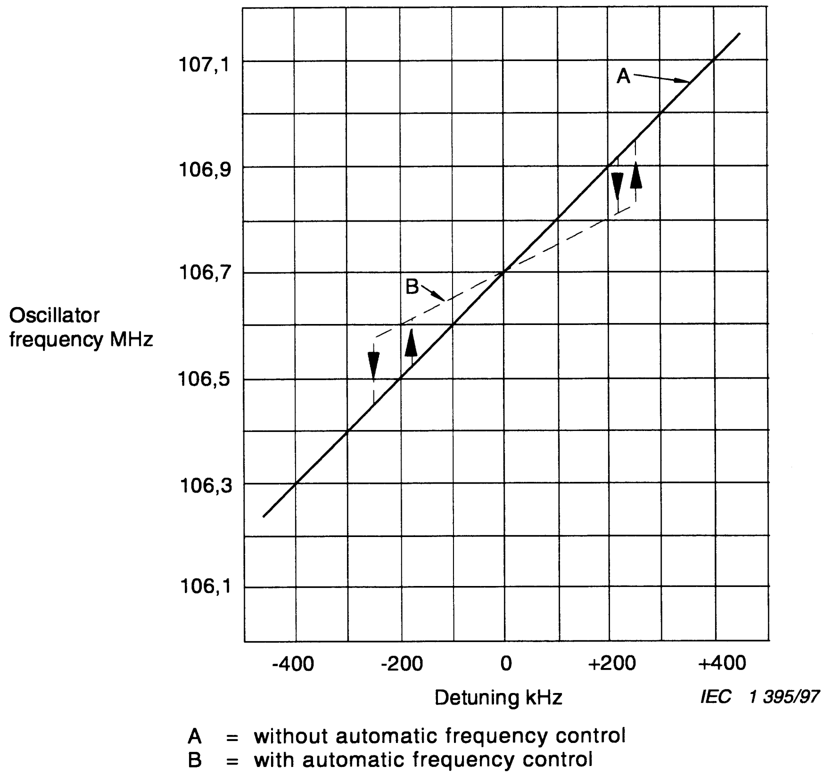
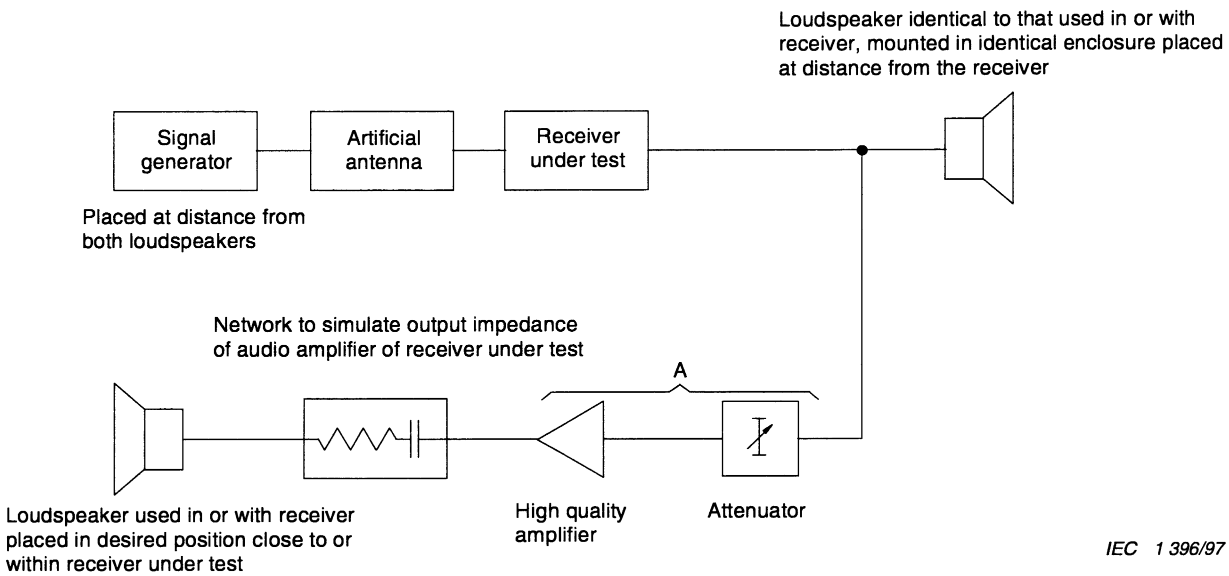
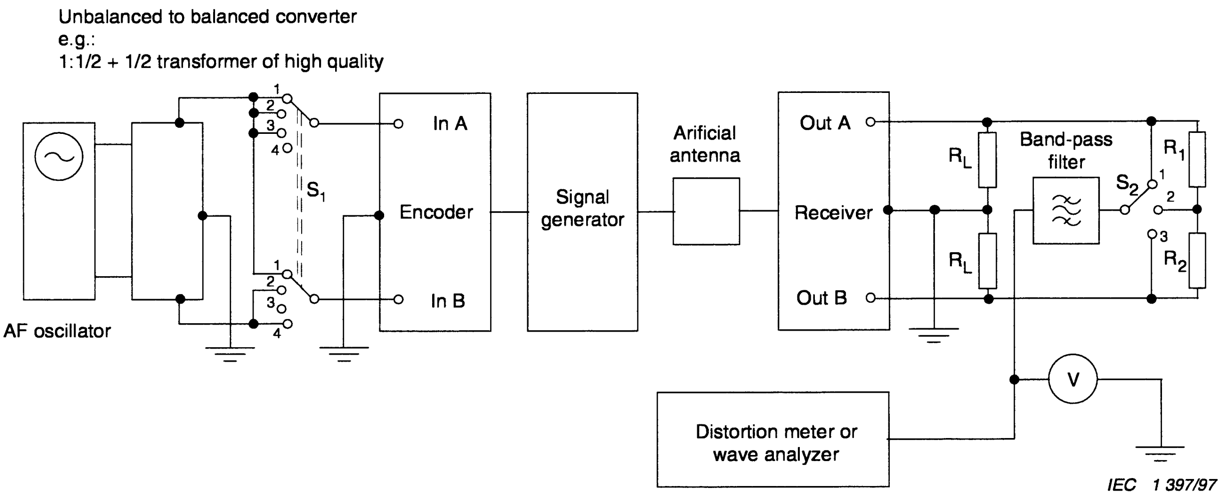


Figure 20 — Tuning characteristics obtained by measuring the local oscillator frequency



NOTE The attenuator input impedance shall be high compared to the output impedance of the receiver under test and of the loudspeaker.

Figure 21 — Measurement of acoustic feedback



R_1 and R_2 = balancing resistor >> R_L

R_L = audio-frequency substitute load resistor

Filter input impedance >> R_2

For band-pass filter characteristics, see figure 1

Figure 22 — Arrangement for measuring fidelity

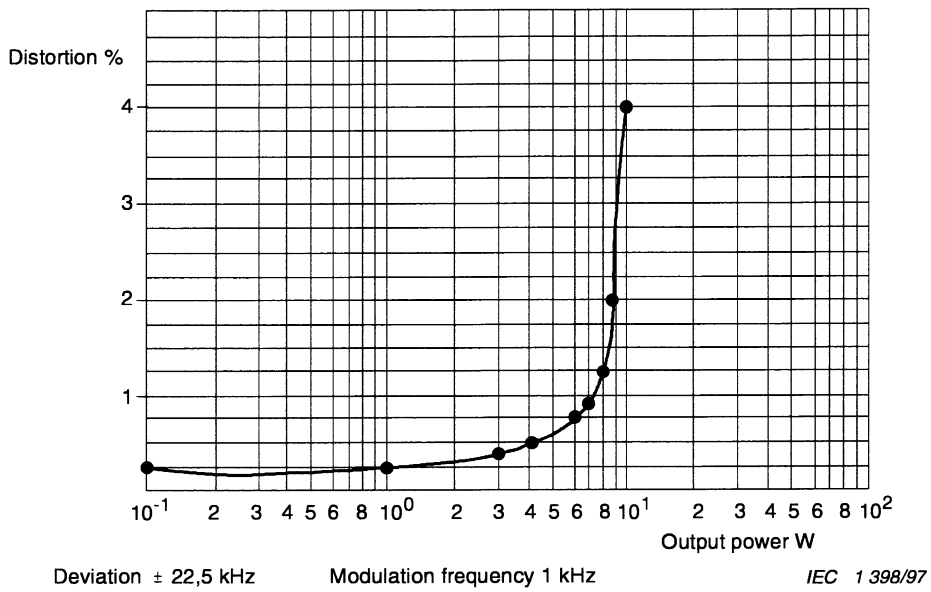


Figure 23 — Overall total harmonic distortion as a function of a.f. output power

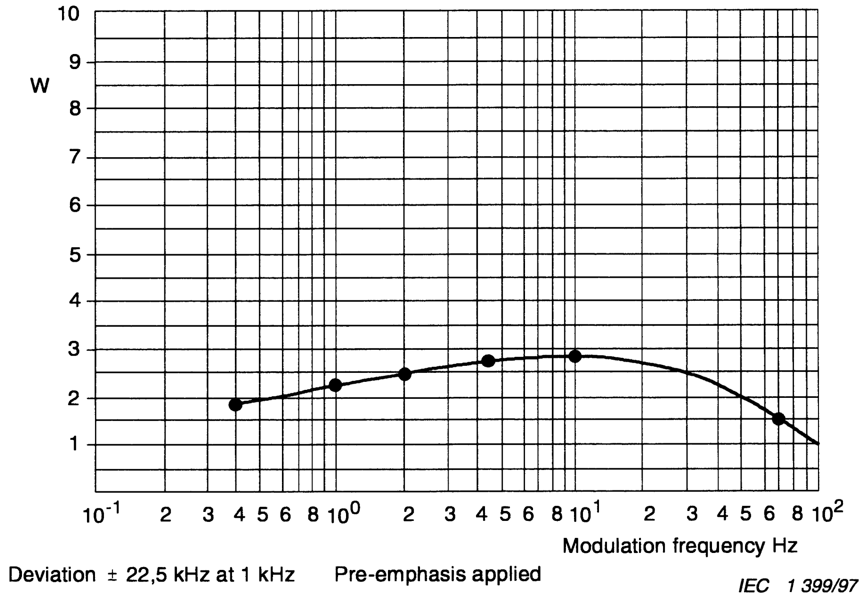
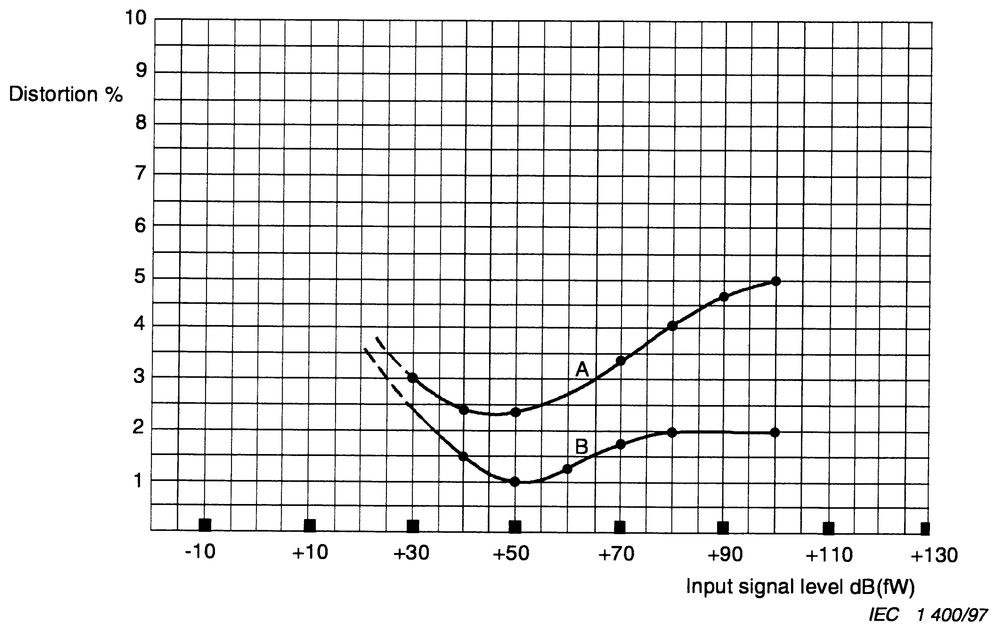


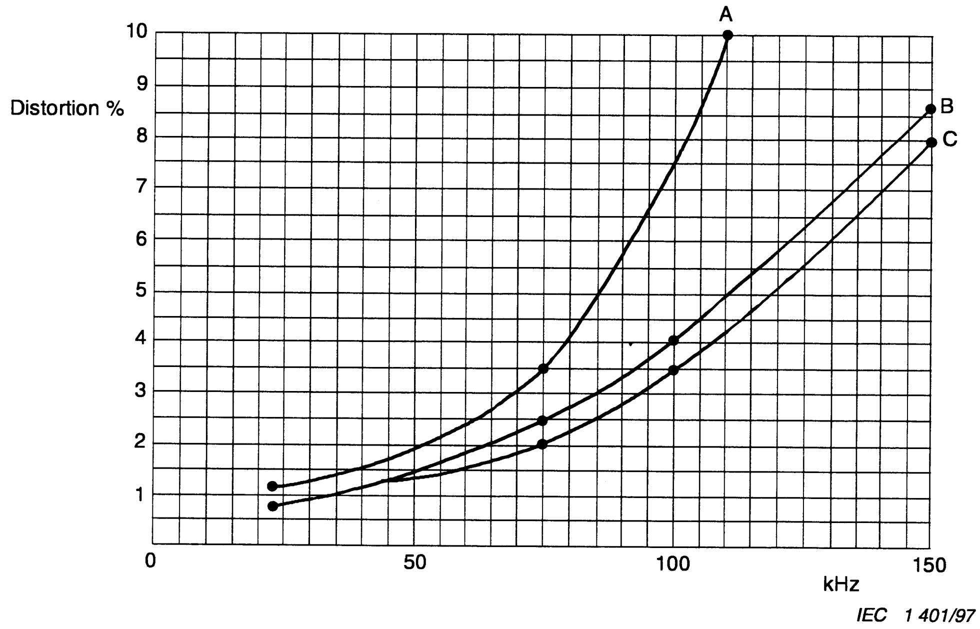
Figure 24 — Distortion-limited output power as a function of modulation frequency



A = ±50 kHz deviation

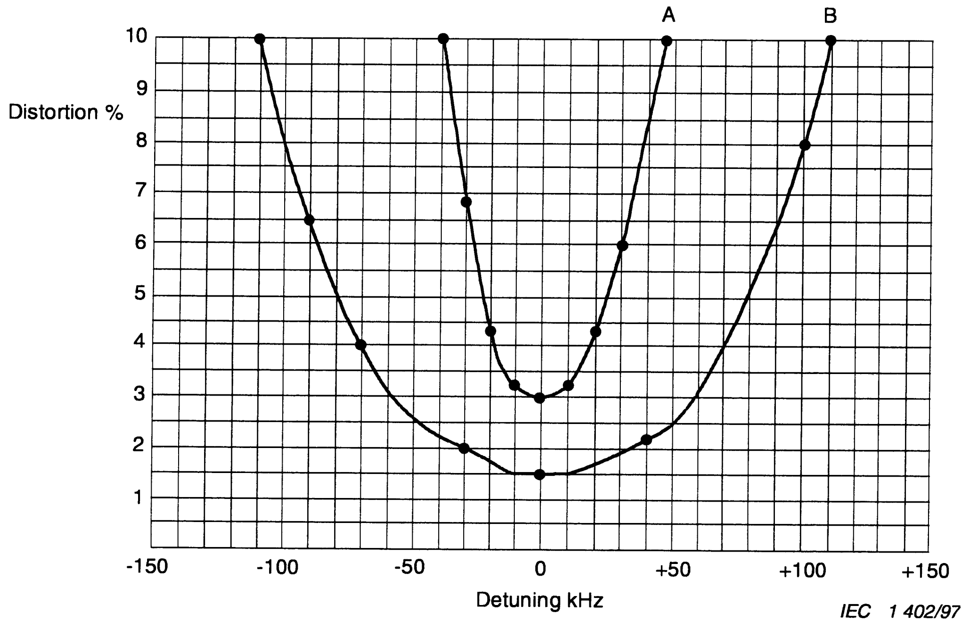
B = ±15 kHz deviation

Figure 25 — Total harmonic distortion as a function of r.f. input signal level



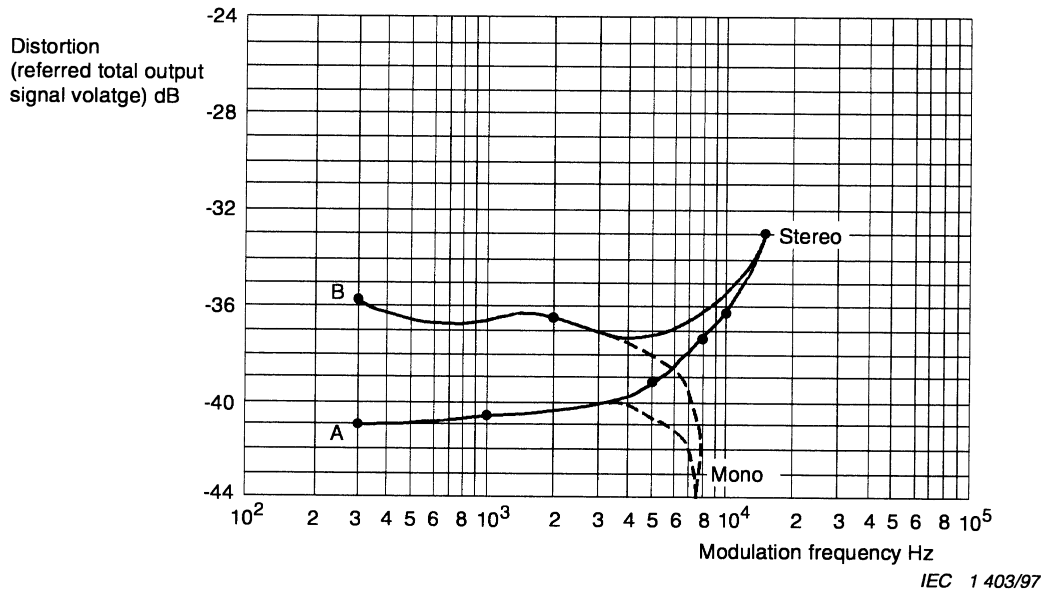
A = Input signal level 40 dB(fW)
B = Input signal level 50 dB(fW)
C = Input signal level 70 dB(fW)

Figure 26 — Total harmonic distortion as a function of the deviation



A = 30 dB(fW)
B = 70 dB(fW)
Deviation ±75 kHz

Figure 27 — Variation of distortion with detuning



A = ±22,5 kHz deviation

B = ±75 kHz deviation

Figure 28 — Total harmonic distortion as a function of the a.f. modulation frequency

Output frequency kHz	Type of response	Response dB
1,6	X	– 35
1,8	0	– 45
2,3	0	– 36
3,0	X	– 40
3,1	0	– 43
3,2	□	– 35
5,0	□	– 40
6,0	□	– 50
6,2	X	– 45
6,4	0	– 40
7,8	0	– 45

0 = Intermodulation between channel signals.
X = Intermodulation between one channel signal and 19 kHz.
□ = Intermodulation between one channel signal and 38 kHz.
Left-hand channel only. 0 dB = output produced by a standard radio-frequency input signal.
Left channel input frequency 8,7 kHz. ± 67,5 kHz deviation.
Right channel input frequency 11,0 kHz. ± 67,5 kHz deviation.

Figure 29 — Cross-intermodulation between the channels of a stereo receiver (pilot-tone system)

Annex A (informative) Example of a 1 kHz band-elimination filter

The frequency response limits specified in Figure 4 can be met by a third-order Butterworth passive band-stop filter, provided that the Q of the inductors exceeds 100, which can be achieved with RM10-1000 pot cores. The component values are shown in Figure A.1, and polypropylene or polycarbonate dielectric capacitors should be used.

For very high performance receivers a much higher stop-band attenuation can be obtained with a fourth-order passive filter, with some relaxation of the requirement for high Q inductors and lowpass capacitors.

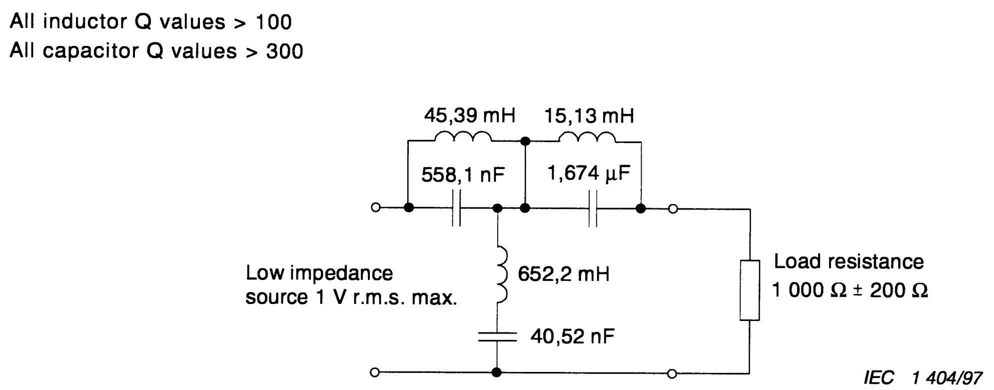


Figure A.1 — Example of a passive 1 kHz band-stop filter capable of meeting the limits shown in Figure 4

Annex B (informative) Standard deviations for supplementary services[1)]

Service	RMSD = ± 50 kHz	RMSD = ± 75 kHz
RDS	(under consideration)	± 2,0 kHz
ARI	(under consideration)	± 3,5 kHz
RDS (with ARI)	(under consideration)	(see note) ± 1,2 kHz

NOTE This deviation is also used for certain transmissions without ARI.

Annex C (informative) Measurement of crosstalk between stereo channels

In discussions on methods of measurement for high fidelity tuners and receivers, to be selected from this standard, the question has arisen whether crosstalk should be measured with or without pre-emphasis of the modulating signals. At present, this standard, by specifying that the deviation shall be ± 67,5 kHz (see **5.7.2**), requires no pre-emphasis. However, this results in the reference output of the wanted channel following the de-emphasis characteristic, whereas for some purposes it would be more convenient if the reference output were substantially the same at all frequencies. If the measurement is carried out with pre-emphasis, however, the deviation at low frequencies has to be restricted to a low value, approximately ± 12 kHz for 50 µs pre-emphasis or ± 8 kHz for 75 µs pre-emphasis (depending on the frequency at which 100 % utilization is allowed to occur). If the crosstalk attenuation decreases with increasing deviation, as is likely, such a measurement may give an optimistic result. On the other hand, real programme signals rarely involve such a large ratio of difference signal to sum signal as is represented by even a low-deviation test signal in one channel only.

[1)] Derived from ITU-R Recommendations, where available.

One possible alternative method is to retain the present method of measurement without pre-emphasis, but to restrict the deviation to, say, ± 40 kHz instead of ± 67,5 kHz, and to add pre-emphasis networks at the a.f. output of the receiver, so that a reference output which is substantially independent of frequency is obtained, and with which the pre-emphasized crosstalk signal can be compared.

Annex D (informative)
Characteristics of rod and telescopic antennas — method of measurement under study

D.1 The test set-up is shown in Figure D.1. The receiver is placed on a non-conducting table, in such a position that its antenna passes through the centre of the absorbing clamp. A telescopic antenna shall be fully extended. A flexible antenna shall be stretched taut. The clamp shall be placed as close to the receiver as possible, with the feed converter end of the clamp nearest to the receiver. The source impedance of the signal generator shall be 50 Ω.

If the receiver has a functional earth terminal, it shall be earthed close to the absorbing clamp. If the receiver has a mains lead or a power supply lead from a separate transformer unit, it is likely to be between ¼ and ¾ wavelengths long at the measuring frequencies, and its position may affect the results. The length and position shall therefore be recorded. If the receiver is powered by internal batteries, with no external connections except for headphones, in normal use, no external connections except that for the headphones shall be made to the receiver during measurements.

NOTE The impedance to earth of the receiver body is part of the measuring circuit, and may affect the results. If the receiver normally has no external connections, or none other than for headphones, the impedance is that of a small capacitance, and any increase in this capacitance due to the measuring method would strongly influence the results of measurements of noise-limited sensitivity.

D.2 To adjust the wanted r.f. signal level, replace the receiver and antenna by a substitute antenna of similar diameter and length, and an r.f. level meter with 50 Ω input impedance. Adjust the output level of the signal generator to obtain the wanted signal level on the meter.

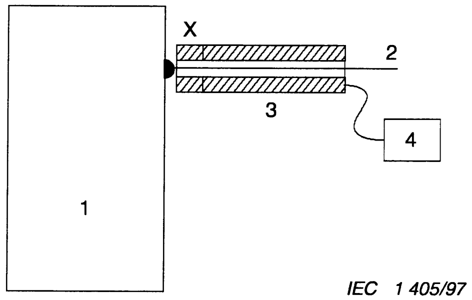
NOTE The normal insertion loss of the clamp is 17 dB (see CISPR 16-1).

D.3 Depending on the diameter of the antenna, the correction shown by the graph in Figure D.2 has to be applied.

D.4 Measurements of sensitivity may then be made as described in **2.3**. If the receiver has no external connections in normal use, the audio output measurements shall be made by placing a sound level meter (or equivalent) close to the loudspeaker. If the receiver is intended for use only with headphones, the audio output shall be measured with a suitable coupler, (see IEC 60268-7).[2)]

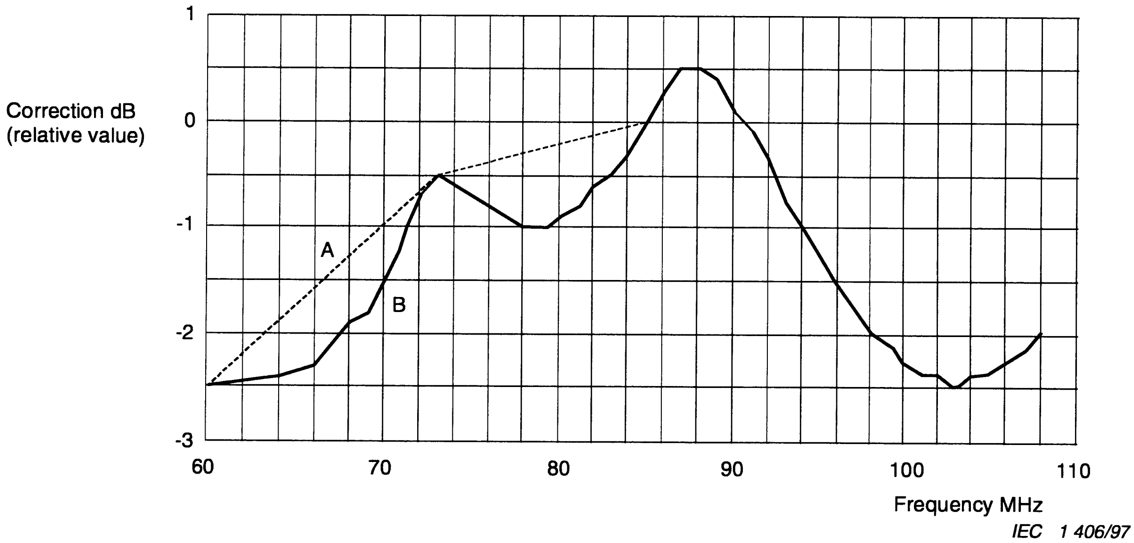
In general, measurements of the other characteristics described in this standard may also be made, using the capacitive clamp to inject the signal. Care is necessary, however, to take into account the dependence on frequency of the characteristics of the clamp.

[2)] IEC 60268-7:1996: *Sound system equipment — Part 7: Headphones and earphones.*



X = Feed converter of the absorbing clamp
1 = Receiver
2 = Telescopic antenna
3 = Absorbing clamp
4 = RF signal generator

Figure D.1 — Arrangement for r.f. signal injection into the antenna with an absorbing clamp



Curve A = antenna diameter approximately 7 mm
Curve B = antenna diameter approximately 1 mm

Figure D.2 — Correction curves for the insertion loss of the absorbing clamp

Annex ZA (normative)
Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60098	1987	Analogue audio disk records and reproducing equipment	HD 337 S3	1989
IEC 60268-1	1985	Sound system equipment Part 1: General	HD 483.1 S2[a]	1989
IEC 60268-3	1988	Part 3: Amplifiers	HD 483.3 S2[b]	1992
IEC 60315-1	1988	Methods of measurement on radio receivers for various classes of emission Part 1: General considerations and methods of measurement, including audio-frequency measurements	HD 560.1 S1	1990
IEC 60315-3	1989	Part 3: Receivers for amplitude-modulated sound-broadcasting emissions	HD 560.3 S1	1992
IEC 60315-7	1995	Part 7: Methods of measurement on digital satellite radio (DSR) receivers	EN 60315-7	1995
IEC 60315-9	1996	Part 9: Measurement of the characteristics relevant to radio data system (RDS) reception	EN 60315-9	1996
IEC 60651	1979	Sound level meters	EN 60651	1994
IEC 61260	1995	Electroacoustics — Octave-band and fractional-octave-band filters	EN 61260	1995
CISPR 16-1	1993	Specification for radio disturbance and immunity measuring apparatus and methods Part 1: Radio disturbance and immunity measuring apparatus	—	—
CISPR 203[3)]	1996	Limits and methods of measurement of immunity characteristics of sound and television broadcast receivers and associated equipment	—	—
ITU-R Recommendation 468-4	1990	Measurement of audio-frequency noise voltage level in sound broadcasting (Vol. X-1)	—	—
ITU-R Recommendation 559-2	1990	Objective measurement of radio-frequency protection ratios in LF, MF and HF broadcasting	—	—

[a] HD 483.1 S2 includes A1:1988 to IEC 60268-1.

[b] HD 483.3 S2 includes A1:1990 and IEC 60268-3.

[3)] Instead if CISPR 20:1996, EN 55020:1994 + A11:1996 + corr. Dec. 1997, *Electromagnetic immunity of broadcast receivers and associated equipment*, applies.

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