भारतीय मानक

Indian Standard

IS 15596 (Part 4) : 2023
IEC 60268- 4 : 2018

ध्वनि तंत्र उपस्कर

भाग 4 अणुभाष

(पहला पुनरीक्षण)

Sound System Equipment

Part 4 Microphones

(First Revision)

ICS 33.160.50

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Audio, Video and Multimedia Systems and Equipment Sectional Committee, LITD 07

NATIONAL FOREWORD

This Indian Standard (Part 4) (First Revision) which is Identical with IEC 60268-4 : 2018 'Sound system equipment — Part 4: Microphones' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendations of the Audio, Video and Multimedia Systems and Equipment Sectional Committee and approval of the Electronics and Information Technology Division Council.

This Standard was originally published in 2016 and was identical to IEC 60268-4 : 2014. The first revision of this standard aligns this Indian Standard with IEC 60268-4 : 2018.

This edition includes the following significant technical changes with respect to the previous edition:

a) Subclause 19.4 on "pop" measurement replaces Annex C; and
b) New Annex D for noise measurements in the digital domain.

This standard (Part 4) is one of the parts of a series of standards on 'Sound System equipment'. The other parts in this series are:

Part 1 General
Part 2 Explanation of general terms and calculation methods
Part 3 Amplifiers (*second revision*)
Part 5 Loudspeakers (*first revision*)
Part 7 Headphones and earphones (*first revision*)
Part 10 Peak Programme Level Meters

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are however not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appears referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current Practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their places, are listed below along with their degree of equivalence for editions indicated. For undated references, the latest edition of the referenced document applies, including any corrigenda and amendment:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60268-1 : 1985 Sound system equipment — Part 1: General AMD1 : 1988 + AMD2 : 1988	IS 15596 (Part 1) : 2005 Sound system equipment: Part 1 General	Identical
IEC 60268-2 : 1987 Sound system equipment — Part 2: Explanation of general terms and calculation methods IEC 60268 2 : 1987/AMD1 : 1991	IS 15596 (Part 2) : 2005 Sound system equipment: Part 2 Explanation of general terms and calculation methods	Identical
IEC 60268-5 : 2003 Sound system equipment — Part 5: Loudspeakers IEC 60268-5 : 2003/AMD1 : 2007	IS 15596 (Part 5) : 2005 Sound system equipment: Part 5 Loudspeakers	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61000-4-2 : 2008 Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test	IS 14700 (Part 4/Sec 2) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 2 Electrostatic discharge immunity test (*first revision*)	Identical
IEC 61000-4-4 : 2012 Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test	IS 14700 (Part 4/Sec 4) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 4 Electrical fast transient/burst immunity test (*first revision*)	Identical
IEC 61000-4-6: 2013 Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields	IS 14700 (Part 4/Sec 6) : 2016 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 6 Immunity to conducted disturbances, induced by radio-frequency fields	Identical
IEC 61000-4-8 : 2009 Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test	IS 14700 (Part 4/Sec 8) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 8 Power frequency magnetic field immunity test (*first revision*)	Identical
IEC 61000-4-16 : 2015 Electromagnetic compatibility (EMC) — Part 4-16: Testing and measurement techniques — Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz	IS 14700 (Part 4/Sec 16) : 2019 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 16 Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz (*first revision*)	Identical
IEC 61000-4-17 : 1999 Electromagnetic compatibility (EMC) — Part 4-17: Testing and measurement techniques — Ripple on D.C input power port immunity test AMD1 : 2001+ AMD2 : 2008	IS 14700 (Part 4/Sec 17) : 2018 Electromagnetic Compatibility (EMC): Part 4 Testing & Measurement Techniques, Section 17 Ripple on D.C input Power Port Immunity Test	Identical
IEC 61260-1 : 2014 Electroacoustics — Octave-band and fractional-octaveband filters — Part 1: Specifications	IS 6964 : 2018 Electroacoustics — Octave-band and fractional-octave band filters Specifications (*first revision*)	Identical
CISPR 35 : 2016 Electromagnetic compatibility of multimedia equipment Immunity requirements	IS/CISPR 35 : 2016 Electromagnetic compatibility of multimedia equipment immunity requirements	Identical

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard. For undated references, the latest edition of the referenced document applies, including any corrigenda and amendment:

International Standard	*Title*
IEC 60268-3 : 2013	Sound system equipment — Part 3: Amplifiers
IEC 60268-11 : 1987	Sound system equipment — Part 11: Application of connectors for the interconnection of sound system components AMD1 : 1989+AMD2 : 1991
IEC 60268-12 : 1987	Sound system equipment — Part 12: Application of connectors for broadcast and similar use AMD1 : 1991+AMD2 : 1994
IEC 61000-43 : 2006	Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test AMD1 : 2007+AMD2 : 2010
IEC 61938 : 2013	Multimedia systems — Guide to the recommended characteristics of analogue interfaces to achieve interoperability
ITU-T	Recommendation P.51 : 1996 Artificial mouth
EN 55103-2 : 2009	Electromagnetic compatibility — Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use — Part 2: Immunity
EN 300422-2 V1.3.1 : 2011	Electromagnetic compatibility and radio spectrum matters (ERM) — Wireless microphones in the 25 MHz to 3 GHz frequency range — Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

CONTENTS

Indian Standard

SOUND SYSTEM EQUIPMENT

PART 4 MICROPHONES

(First Revision)

1 Scope

This part of IEC 60268 specifies methods of measurement for the electrical impedance, sensitivity, directional response pattern, dynamic range and external influences of sound system microphones, and also details the characteristics to be specified by the manufacturer.

It applies to sound system microphones for all applications for speech and music. It does not apply to measurement microphones, but it does apply to each audio channel of microphones having more than one channel, for example for stereo or similar use. It is also applicable to flush-mounted microphones and to the analogue characteristics of microphones with digital audio output.

For the purposes of this International Standard, a microphone includes all such devices as transformers, pre-amplifiers, or other elements that form an integral part of the microphone, up to the output terminals specified by the manufacturer.

The major characteristics of a microphone are considered in Clauses 6 to 21. Additional characteristics are considered in Annex A and Annex C.

NOTE The characteristics specified in this document do not describe the subjective response of the microphone. Further work is necessary to find new definitions and measurement procedures for a later introduction of objective characteristics for at least some of the subjective descriptions used to describe microphone performance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 35:2016, *Electromagnetic compatibility of multimedia equipment – Immunity requirements*

IEC 60268-1:1985, *Sound system equipment – Part 1: General*
IEC 60268-1:1985/AMD1:1988
IEC 60268-1:1985/AMD2:1988

IEC 60268-2:1987, *Sound system equipment – Part 2: Explanation of general terms and calculation methods*
IEC 60268-2:1987/AMD1:1991

IEC 60268-3:2013, *Sound system equipment – Part 3: Amplifiers*

IEC 60268-5:2003, *Sound system equipment – Part 5: Loudspeakers*
IEC 60268-5:2003/AMD1:2007

IEC 60268-11:1987, *Sound system equipment – Part 11: Application of connectors for the interconnection of sound system components*
IEC 60268-11:1987/AMD1:1989
IEC 60268-11:1987/AMD2:1991

IEC 60268-12:1987, *Sound system equipment – Part 12: Application of connectors for broadcast and similar use*
IEC 60268-12:1987/AMD1:1991
IEC 60268-12:1987/AMD2:1994

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-16:2015, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-4-17:1999, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*
61000-4-17:1999/AMD1:2001
61000-4-17:1999/AMD2:2008

IEC 61260-1:2014, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

IEC 61938:2013, *Multimedia systems – Guide to the recommended characteristics of analogue interfaces to achieve interoperability*

ITU-T Recommendation P.51:1996, *Artificial mouth*

EN 55103-2:2009, *Electromagnetic compatibility – Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use – Part 2: Immunity*

EN 300 422-2 V1.3.1:2011, *Electromagnetic compatibility and radio spectrum matters (ERM) – Wireless microphones in the 25 MHz to 3 GHz frequency range – Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60268-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
far-field microphone
microphone for use mainly at a distance of 1 m or more from the source of sound

Note 1 to entry: The term "far-field microphone" describes a microphone application (see 6.4) and not a type of microphone. A specific microphone may have one or more applications, but the term is helpful in specifying the method of measurement.

3.2
near-field microphone
microphone for use by an individual performer at a distance of approximately 30 cm

Note 1 to entry: The term "near-field microphone" describes a microphone application (see 6.4) and not a type of microphone. A specific microphone may have one or more applications, but the term is helpful in specifying the method of measurement.

3.3
close-talking microphone
microphone for use at a distance of approximately 25 mm from the source of sound

Note 1 to entry: The term "close-talking microphone" describes a microphone application (see 6.4) and not a type of microphone. A specific microphone may have one or more applications, but the term is helpful in specifying the method of measurement.

4 General conditions

4.1 General

Special reference is made to IEC 60268-1, concerning:

- units and system of measurement;
- frequencies of measurement;
- quantities to be specified and their accuracy (see also 5.7);
- marking (see also 7.1);
- ambient conditions;
- filters, networks and measuring instruments for noise specification and measurement;
- individual specifications and type specifications;
- graphical presentation of characteristics;
- scales for graphical presentation;
- personal safety and prevention of spread of fire;
- method of producing a uniform alternating magnetic field;
- search coils for measuring the magnetic field strength,

and to IEC 61938 concerning powering of microphones.

4.2 Measurement conditions

4.2.1 General

For convenience in specifying how microphones shall be set up for measurement, three sets of conditions have been defined in this document, under the title of "rated conditions".

Microphones should be measured in conditions approximating those in which they are intended to be used. Three sets of measurement conditions are specified in this document: free-field, near-field and close-talking. The differences between these sets of conditions are in the distance to the sound source and the sound pressure level of the measurement. Measurements shall be reported using at least one of these sets of conditions. Additional data may be included, provided that the measurement conditions are specified.

Three ratings are basic to the formulation of these concepts:

- rated power supply (see 9.1);
- rated impedance (see 10.2);
- rated sensitivity (see 11.3).

To obtain the correct conditions for measurement, the above-mentioned ratings shall be taken from the specifications supplied by the manufacturer of the equipment.

The term "rated" applied to other characteristics relates to the specification or measurement of the particular characteristic under rated conditions or under conditions unambiguously connected to them. This applies, for example, to the following two characteristics:

- rated output voltage;
- rated equivalent sound pressure level due to inherent noise.

Methods of measurement are given in this document for electrical impedance, sensitivity, directional pattern, dynamic range and external influences. Where alternative methods are given, the chosen method shall be specified.

4.2.2 Rated conditions

The microphone is understood to be working under rated conditions when the following conditions are fulfilled:

- the microphone is connected to the resistive load specified in 5.4, or as specified by the manufacturer;
- if the microphone needs a power supply, this is the rated power supply;
- the microphone (except a close-talking or near-field microphone) is placed in a sound field meeting the free-field conditions in 5.5.2, the waves having zero-degree incidence with respect to the reference direction;
- far-field microphones shall be measured in free-field conditions;
- the undisturbed sound pressure (in the absence of the microphone) in the sound field at the reference point of the microphone is sinusoidal and set at a level of 1 Pa (94 dB SPL);
- for close-talking microphones, the microphone is placed at a stated distance, no more than 25 mm from the artificial mouth complying with ITU-T Recommendation P.51, and the undisturbed sound pressure in the sound field at the reference point of microphone is sinusoidal and set at a level of 3 Pa (104 dB SPL);
- for near-field microphones, the microphone is placed at 30 cm from the artificial mouth complying with ITU-T Recommendation P.51, and the undisturbed sound pressure in the sound field at the reference point of microphone is sinusoidal and set at a level of 1 Pa (94 dB SPL);
- if a special microphone needs a different measurement level or procedure (e.g. Lavalier or boundary layer microphones), it shall be stated in the technical data together with the reason for this. Levels related to the normal reference level of 94 dB by multiples of 10 dB are preferred;
- controls, if any, are set to the position recommended by the manufacturer;
- in the absence of a clear reason to the contrary, the measurement frequency is 1 000 Hz (see IEC 60268-1);
- the ambient pressure, relative humidity and ambient temperature are within the limits given in IEC 60268-1, and shall be stated.

Measurements may be made at a sound pressure of 0,3 Pa if this is necessary due to limitations of the performance of the loudspeaker or other measurement equipment, and only if any change in performance between the level used and the reference level is known with the necessary accuracy for the relevant characteristics.

5 Particular conditions

5.1 Pre-conditioning

A microphone with preamplifier shall be switched on for the period of time specified by the manufacturer, before measurements are made, to allow the components to reach the stationary temperature for rated conditions. If the manufacturer specifies no period, a period of 10 s shall be allowed for stabilization. If the microphone contains a vacuum tube or other heating device the time shall be 10 min.

5.2 Sound source

The sound source shall be capable of producing at the microphone position the sound pressure level as defined for rated conditions. The amplitude non-linearity of the sound source shall be held to such a value that the effect on the measured response does not exceed 0,5 dB. If the conditions of measurement preclude the possibility of securing sufficiently low distortion, a narrow-band filter may be used at the microphone output terminals, which allows the response at the fundamental frequency to be measured.

For free-field calibration and calibration of near-field microphones, the sound source shall be contained in an enclosure which radiates sound from one well-defined opening fulfilling the sound field requirements, preferably by only one being radially symmetrical with respect to the axis of the reference direction of the microphone.

5.3 Measurement of sound pressure

A calibrated reference pressure microphone shall be used to measure the sound pressure. The reference microphone shall be calibrated with an accuracy of ±1 dB at 1 kHz or better.

5.4 Voltage measuring system

The voltage generated by the microphone, when in a sound field, shall be determined by using a voltmeter with an input resistance negligible to the specified microphone load. This load is five times the rated impedance of the microphone, unless otherwise stated by the manufacturer. If external equipment, such as a power supply, applies an impedance in parallel with the microphone, its impedance shall be taken into account.

NOTE Microphones having a rated impedance of 200 Ω often have an actual internal impedance in the order of 50 Ω, and many of them perform best with a minimum load impedance around 1 000 Ω.

5.5 Acoustical environment

5.5.1 General

The microphone can be measured in different acoustical environments:

a) in a free field or similar with negligible boundary effects, e.g. by using special computer-generated sound source signals:
   - spherical waves, or
   - plane waves, or
   - waves produced by a specific sound source (artificial mouth or artificial head);

b) in a diffuse field;

c) coupled to a sound source by means of a small cavity (coupler).

5.5.2 Free-field conditions

5.5.2.1 General

A free-field sound wave is normally divergent in character. In certain circumstances it can approximate an ideal plane wave. Free-field conditions can be obtained:

- in open air, ambient noise and wind permitting, or
- in an anechoic room, or
- in a duct.

A sound source of small dimensions with respect to the wavelength produces a spherical wave in these environments. The spherical wave can be approximated to a plane wave in a region of measurement located at a sufficient distance from the source. Spherical waves can be used to measure pressure microphones but it is necessary to use almost perfect plane waves in the low-frequency range for the measurement of pressure gradient microphones.

For microphones responding both to pressure and to pressure gradient, having a sufficiently flat frequency response in a plane-wave free sound field (i.e. at a sufficient distance from the source), the response as a function of frequency f of distance r from a centre of spherical diverging waves and of angle of incidence θ of the waves at the microphone, can be given in a complex form:

$$(1-B)+B\left(1+\frac{1}{\mathrm{j}kr}\right)\cos\theta$$

where

1 – B is the contribution of the pressure component;

B is the contribution of the pressure gradient component;

k = $2\pi/\lambda$ or $2\pi f/c$ (λ – wavelength, c – speed of sound);

B = 0 for the omnidirectional pressure type;

B = 0,5 for the cardioid type;

B = 1 for the bidirectional pressure gradient type.

At low frequencies, it becomes difficult to realize plane wave conditions in an anechoic room. A plane wave at low frequencies, below the cut-off frequency of the anechoic room, can therefore be better produced under other conditions.

Free-field conditions are considered to be sufficiently realized in the region around the microphone if the following conditions are met:

- within a distance of 200 mm in front, behind, right, left, above and below the position of the microphone the sound pressure level is measured at every measuring frequency by means of a pressure transducer;
- the axis of the transducer shall point towards the reference point of the loudspeaker (see IEC 60268-5);
- the corresponding sound pressure levels on axis positioned at different distances from the loudspeaker shall not differ by more than 0,5 dB from the calculated levels in the ideal sound field;
- the values at a nearly constant distance to the sound source, right, left, above and below the microphone shall not differ by more than 1 dB from the level at the reference point of the microphone.

5.5.2.2 Spherical waves

The sound pressure generated in a free field by an omnidirectional sound source varies inversely with the distance from the acoustic centre of the source.

The output voltage of the microphone varies inversely with the distance between the source and the microphone when the relevant dimensions of both are small compared with the wavelength, allowing the results from the measurements made at a certain distance r to be converted by calculation to results which would be obtained at the reference distance.

When either the circumference of the radiating surface of the source or the circumference of the principal acoustic entry of the microphone exceeds the wavelength, this computation applies only when the measuring distance conforms to:

$$r \geq d$$

$$r \geq d^2/\lambda$$

where

r is the distance from the source to the measuring point;

d is the effective diameter of the sound source;

λ is the sound wavelength.

It is advisable for the distance from the source to the measuring point to exceed three times the largest dimension of the radiating surface of the source.

5.5.2.3 Plane progressive waves

A plane progressive wave can be obtained either in a duct or in a free field.

a) In a duct

   In designing a duct capable of producing useful results, there are many problems to be solved such as the design of the terminating impedance, the avoidance of cross-modes, the shape of the original wavefront and the relative dimensions of the duct and the microphone.

b) In a free field

   A spherical wave at a distance of at least half the wavelength from the centre of curvature at the lowest frequency of measurement is a practical approximation to a plane progressive wave.

For measurement of "shotgun" types and pressure zone microphones, determining the smallest permitted distance is complicated and no exact rules can be given. Therefore, in these cases the measuring distance used shall be stated.

5.5.2.4 Use of an artificial mouth

In order that the conditions of test are similar to those of actual use, it can be necessary to introduce extensions of the measurement setup, such as a head and torso simulator when measuring close-talking and near-field microphones by means of an artificial mouth (see 4.2.2). If measurements are made in such conditions, i.e. in other than with the artificial mouth in approximately anechoic conditions, details of the measurement shall be provided.

5.5.3 Diffuse field conditions

Some measurements can be made in a diffuse field in which sound waves are propagated with random incidence. In this case, bands of noise of third-octave width or broadband signals together with suitable filtering shall be used.

A diffuse sound field can be approximately realized in a reverberant room characterized by a sufficiently long duration of reverberation at a sufficiently large distance from the source and the walls, and above a limiting frequency (see also ISO 354).

The reverberation time T of the empty room is specified in Table 1.

Table 1 – Reverberation time of the empty room

T >	5 s	5 s	5 s	4,5 s	3,5 s	2 s
At	125 Hz	250 Hz	500 Hz	1 000 Hz	2 000 Hz	4 000 Hz

For the determination of the lower frequency limit, the following equation can be used:

$$f \geq \frac{500}{V^{1/3}}$$

where

V is the volume of the room, in cubic metres;

f is the frequency, in hertz.

The region of measurement shall be chosen at such a distance from the source that the direct sound of the source is negligible.

When an omnidirectional source is used, the minimum distance r (in metres) from the source to the measuring points is given by:

$$r \geq 0{,}06(V/T)^{1/2}$$

where

V is the volume of the room, in cubic metres;

T is the Sabine reverberation time at the frequency f.

NOTE Multiple uncorrelated noise sources are used successfully to generate stationary diffuse sound fields under non-reverberant conditions.

5.5.4 Microphone coupled to a sound source by means of a small cavity coupler

To determine the pressure sensitivity of a microphone, a rigid cavity is used to couple the sound source to the microphone. This method is useful for obtaining the pressure sensitivity of a microphone by comparison with the sensitivity of a calibrated reference microphone. In order to obtain a sufficiently uniform sound pressure inside the cavity, this method shall only be used within the limits of the frequency range where the linear dimensions of the cavity are less than one-tenth of the wavelength. At low frequencies care shall be taken to eliminate air leakage.

5.6 Methods of measuring frequency response

5.6.1 Point-by-point and continuous sweep frequency methods

Response curves may be prepared point-by-point, or through the use of a slow continuous sweep frequency method, or automatically.

a) Point-by-point method

   Great care shall be taken to ensure that all significant peaks and troughs of the frequency response curve are explored. The graph should clearly indicate the measurement points.

b) Continuous sweep frequency method

The rate of traversing the frequency range shall be slow enough to ensure that the resulting curve does not deviate from that which would be obtained under steady state conditions. Stopping the trace at any instant shall not change the indicated response by more than ±1 dB.

The following additional apparatus may be used:

– equipment capable of automatically maintaining the requisite sound pressure level over the frequency range concerned;

– an automatic level recorder as output indicator.

c) Special computer-based signals and procedures

Computer algorithms are available to generate signals and to evaluate responses in the time domain, as well as in the frequency domain. Some of them are just digital procedures that replace their analogue ancestors, such as the Fast Fourier Transform for spectral analysis. Other algorithms provide new types of test signals and responses. Most of them are applicable if the user takes into account their inherent limitations and requirements. In cases where existing specified procedures are replaced by new ones for the evaluation of the same characteristic, the user shall ensure that the result is at least as accurate as with the old procedure. While new techniques are considered for standardization when basic matters of background and their relationship to known properties have been determined, any technique may be used for frequency response measurement if it produces the same result as the point-by-point or continuous sweep frequency methods.

5.6.2 Calibration methods

Irrespective of the choice of the point-by-point or automatic method, there are two methods of conducting the calibration.

a) Substitution method

A method of measurement of the response of a microphone in which the microphone to be calibrated and the standard microphone employed to measure the requisite sound pressure are placed alternately at the same test points in the sound field. This method leads to the highest accuracy.

b) Simultaneous comparison method

For reasons of convenience an alternative method for measuring the response of a microphone is sometimes employed in which the microphone to be calibrated and the standard microphone employed to measure the requisite sound pressure are placed simultaneously at two different points normally not widely separated. Care shall be taken that one microphone is not placed at a more favourable point in the sound field than the other. The points chosen shall be such that the results of a response test carried out by the comparison method agree within ±1 dB with the corresponding results obtained by the substitution method. The simultaneous method may be used only after checking that this requirement is met. Compliance with this requirement can be assumed when

– the sound pressures, measured at the two different points in the free sound field by means of a calibrated microphone, corresponds within ±1 dB, and

– the distance between the microphones is such that the sound pressure at each of the two microphone points is independent within ±1 dB of the presence of the second microphone at the other point.

5.7 Overall accuracy

An overall accuracy of ±2 dB or better shall be obtained for the measurement of all types of microphones.

5.8 Graphical presentation of results

The graphical presentation of measurement results shall conform to the provisions of IEC 60268-1.

6 Type description (acoustical behaviour)

6.1 Principle of the transducer

The manufacturer shall specify the principle of the transducer, for example electrostatic (condenser), electrodynamic, electromagnetic or piezoelectric.

6.2 Type of microphone

The manufacturer shall specify the type of microphone, for example pressure, pressure-gradient (with acoustical phase shift network, if any), or combination of a pressure and pressure-gradient microphone, or velocity microphone.

6.3 Type of directional response characteristics

The manufacturer shall specify the type of directional response characteristics of the microphone, for example omnidirectional, unidirectional, bidirectional (e.g. sphere, cardioid, supercardioid, hypercardioid, hemisphere or half-cardioid of revolution).

6.4 Application

The manufacturer shall specify the intended application or applications of the microphone to indicate the primary use for which it is intended, such as far-field, near-field or close-talking.

- Far-field microphones are intended to be used and are measured in approximately plane progressive wave conditions.
- Near-field microphones are typically hand-held by the user and are measured using an artificial mouth as the sound source, at a distance of 30 cm.
- Close-talking microphones are used at very short distances and are measured using an artificial mouth as the sound source, at a distance of 25 mm.

Other applications (e.g. for boundary layer or body-contact/Lavalier microphones) may be used if details are provided for measurement and specification.

7 Terminals and controls

7.1 Marking

Recommendations for marking the terminals and controls are given in IEC 60268-1:1985, Clause 5, and IEC 61938:2013, 9.4.6 and 9.5.5, with the addition of the following requirement, if the microphone conforms to the requirements of IEC 61938, Clause 9.

The polarity shall be indicated by a mark, preferably a coloured dot or a connector pin number designated in the instruction manual, at that output terminal at which a positive instantaneous voltage is produced by an inward movement of the diaphragm or equivalent, that is an increase in sound pressure at the principal entry. Marking for safety shall be in accordance with IEC 60065 or other appropriate safety standard.

Marking of the polarity is recommended if the microphone conforms to the requirements of IEC 61938. If the polarity is not in accordance with IEC 61938, the polarity shall be marked on the microphone.

7.2 Connectors and electrical interface values

Connectors and their wiring shall be in accordance with IEC 60268-11 or IEC 60268-12. Interface values (voltages and impedances) shall be in accordance with IEC 61938.

8 Reference point and axis

8.1 Reference point

In the absence of clear reason to the contrary, the reference point shall be the centre of the principal sound entry. Otherwise it shall be stated.

In order to allow unambiguous specification of the reference point, reference axis and polarity, the manufacturer shall designate a principal sound entry even for a bidirectional microphone.

8.2 Reference axis

The reference axis is a line passing through the reference point indicating a recommended direction of sound incidence specified by the manufacturer. The microphone shall be so designed that the recommended direction of sound incidence is obvious to the user.

The reference axis should preferably be perpendicular to the plane of the principal acoustic entry of the microphone and should pass through the centre of the entry.

9 Rated power supply

9.1 Characteristics to be specified

The following information shall be specified by the manufacturer for each microphone interface port to be connected to the power supply and for each position of the power supply adaptor, if any:

- the type of power supply (phantom, A-B, etc.; see IEC 61938);
- power supply voltage and its upper and lower limits;
- current drawn from the power supply, expressed in amperes;
- for multi-voltage microphones, the voltage-current characteristic.

9.2 Method of measurement

For measurements, proceed as follows.

a) The microphone is operated under rated conditions.
b) The current drawn from the power supply is measured in amperes.

10 Electrical impedance

10.1 Internal impedance

10.1.1 Characteristic to be specified

The modulus of the internal impedance of the microphone measured between the output terminals.

If the impedance can be satisfactorily represented by that of a simple network, the values of the network components may be given. If this is not applicable, the impedance should be specified as a function of frequency.

10.1.2 Methods of measurement

The internal impedance may be measured by the comparison method or by applying a sound pressure and measuring the output voltage under different load conditions. Both methods are indicated below.

a) Method 1

The impedance can be measured by means of a measuring bridge. An alternative method is that of comparison with a known impedance. In the latter case, a constant current from a high-impedance source is passed through the microphone and the voltage across its terminals is measured.

The microphone is then replaced by a known resistance, and the procedure repeated. Comparison of the two values gives the modulus of the impedance directly.

The voltage applied at the microphone terminals shall not exceed the output voltage generated by the microphone at the overload sound pressure level.

NOTE While the internal impedance of microphones is often assumed to be resistive, and the load impedance to be resistive, in many cases the internal impedance is complex, such as when there is an output coupling capacitor, and the input impedance is also complex, such as when there is a transformer. The combination of these impedances can result in resonance within the audio band and exacerbation of negative effects such as wind noise.

b) Method 2

The internal impedance can also be computed from the output voltages occurring under three different conditions of load. Generally speaking, this procedure requires very accurate measuring apparatus.

If the internal impedance is approximately a pure resistance, the following simple procedure may be used to obtain approximate results, which are sufficiently accurate for normal practice:

- the microphone is operated under rated conditions;
- sound pressure is applied to the microphone and the impedance is deduced from the output voltage obtained for different loads. For example, the impedance Z may be calculated from the no-load output voltage U'_2 and the output U_2 obtained when a load impedance R_2 is applied by using the formula:

$$Z = \frac{U'_2 - U_2}{U_2} R_2$$

10.2 Rated impedance

The rated impedance shall be specified by the manufacturer. Microphones are generally designed to be connected to a load impedance much higher than the rated impedance (see 5.4 of this document and 9.1 of IEC 61938:2013), and should not be used with loads below the minimum permitted load impedance.

NOTE The recommendations of IEC 61938 are based on the assumption that a value of 5 times the rated impedance is suitable in most cases. This load causes the output voltage level to be 1,6 dB below the no-load voltage.

10.3 Rated minimum permitted load impedance

The rated minimum permitted load impedance is the minimum impedance, specified by the manufacturer, by which the microphone may be terminated.

NOTE The minimum permitted load impedance is a compromise leading to negligible effect on performance.

11 Sensitivity

11.1 General

The sensitivity is the ratio of the output voltage of the microphone to the sound pressure to which it is exposed.

The sensitivity M is expressed in volts per pascal. If the microphone is not loaded with a resistance equal to five times the rated impedance, this shall be stated with the results.

NOTE 1 Normally the ratio gives a complex value, but usually only the amplitudes (with sinusoidal signal) are considered.

NOTE 2 For practical reasons, values for sensitivity are typically expressed in mV/Pa.

The sensitivity level L_M, is the ratio, expressed in decibels, of the sensitivity M to the reference sensitivity M_r.

$$L_M = 20\lg\frac{M}{M_r}$$

The reference sensitivity is M_r = 1 V/Pa. The following types of sensitivity may be specified:

– free-field sensitivity (see 11.2.1) referring to the sound pressure of the undisturbed free field (in the absence of the microphone);
– diffuse-field sensitivity (see 11.2.2) referring to the sound pressure of the undisturbed diffuse field;
– close-talking sensitivity and near-field sensitivity (see 11.2.3) referring to the sound pressure of the undisturbed field at a specified short distance from the human or artificial mouth;
– pressure sensitivity (see 11.2.4) referring to the actual sound pressure at the principal acoustic entrance of the microphone.

These types of sensitivity may be given, if appropriate, either at specified frequencies, within a specified frequency band, for octave/third-octave bands, or for complex signal inputs. In the latter case, the characteristics of the signal and the measuring system shall be specified. Definition and figures for the sensitivity of microphones should be related to the purpose for which the microphones are used.

11.2 Sensitivities with respect to acoustical environment

11.2.1 Free-field sensitivity

11.2.1.1 Characteristic to be specified

At a specific frequency or within a specified frequency band and for a specified direction of sound incidence with respect to the reference axis, the ratio of the output voltage to the sound pressure in the undisturbed free field.

Unless otherwise specified, the undisturbed free field shall be a plane progressive wave with the wavefront perpendicular to the reference axis of the microphone.

11.2.1.2 Method of measurement

The conditions for measurement are specified in Clauses 4 and 5. A free-field calibration of the standard microphone employed to measure the sound pressure is required. It is important to ensure that the orientation of the standard microphone agrees with the orientation used during its calibration.

For omnidirectional microphones (pressure type only), the free-field sensitivity in a plane-wave and that in a spherical wave do not differ from each other, and are equal to the pressure sensitivity, provided that diffraction effects in the field can be neglected. This is the case when the lateral dimensions of the microphone are small compared to the wavelength. At low frequencies, therefore, a spherical wave is sufficient to measure the plane-wave sensitivity of an omnidirectional microphone (pressure type only). At very low frequencies, free-field sensitivity and pressure sensitivity can be different owing to the effect of a pressure equalization vent. For the higher frequency range, the microphone should be measured in the relevant sound field. If a cone loudspeaker with a diameter not larger than 0,3 m is used as a sound source, a suitable minimum distance for the free-field calibration of omnidirectional microphones (pressure type only) in the audio frequency range is 1 m.

11.2.2 Diffuse-field sensitivity

11.2.2.1 Characteristic to be specified

At a specified frequency or within a specified frequency band, the ratio of the output voltage to the sound pressure in the undisturbed diffuse field. The diffuse-field sensitivity is equal to the RMS value of the free-field sensitivities for all directions of sound incidence. The diffuse-field sensitivity level equals the free-field plane-wave sensitivity level (see 11.2.1) minus the directivity index (see 13.2).

NOTE The diffuse field is characterized by the fact that sound waves with random phase are randomly distributed over all directions (random incidence).

Instead of the diffuse-field sensitivity, the manufacturer may state the free-field plane-wave sensitivity and the front-to-random sensitivity index at the same frequency or within the same frequency band.

11.2.2.2 Methods of measurement

The diffuse-field sensitivity can be obtained in two different ways:

a) The diffuse-field sensitivity for a given frequency can be calculated from the free-field sensitivity (see 11.2.1) and the directional pattern (see 13.1) of the microphone in a plane progressive wave.

   If the directional pattern has rotational symmetry the relationship between the diffuse-field sensitivity and the sensitivities at other angles of incidence θ is:

$$M_{\text{diff}}^2 = \frac{1}{2}\int_0^{\pi} M^2(\theta)\sin\theta\,\mathrm{d}\theta$$

   NOTE Modern computation algorithms allow easy calculation of the integral to any desired accuracy, thus allowing the replacement of earlier proposals for calculation with fixed steps every 30°.

b) The diffuse-field sensitivity for a band of frequencies can be measured in a reverberant room if the conditions laid down in Clauses 4 and 5 are fulfilled. An omnidirectional sound source should preferably be used. A diffuse-field calibration of the standard microphone employed to measure the sound pressure is required.

11.2.3 Close-talking and near-field sensitivity

11.2.3.1 Characteristic to be specified

At a specified frequency or within a specified frequency band, the ratio of the output voltage to the sound pressure in the undisturbed sound field produced by a special source. This source shall simulate the human head and mouth (artificial mouth) and the reference point of the microphone shall be placed at a stated distance from the reference point of the source, the reference axis of the microphone being in a stated orientation with respect to the reference axis of the source.

11.2.3.2 Method of measurement

An artificial mouth is used as sound source (see 4.2.2). The distance between the reference point of the source and the reference point of the microphone, unless otherwise stated, shall be 25 mm for close-talking microphones and 30 cm for near-field microphones. The reference axis of the microphone shall be coincident with the reference axis of the sound source. If a different distance and/or orientation is used, it shall be stated with the measurement.

The standard microphone employed to measure the sound pressure shall be calibrated at the same distance used in the measurement. It is important that the orientation of the standard microphone shall be in accordance with the orientation used at the calibration laboratory. Unless otherwise specified, the diameter of the mouth opening shall be 20 mm.

11.2.4 Pressure sensitivity

11.2.4.1 Characteristic to be specified

At a specified frequency or within a specified frequency band, the ratio of the output voltage to the actual sound pressure at the acoustic entry of the microphone. This definition is relevant only to microphones with one sound entry.

The amplitude and phase of the sound pressure shall be kept constant over the sound entry.

11.2.4.2 Method of measurement

The pressure sensitivity can be measured in a small chamber (coupler, sound calibrator). The calibrator produces the sound pressure, for example, by means of an oscillating piston. For the exact calculation of the sound pressure the equivalent volume of the microphone shall be added to the coupler volume. The upper frequency limit with this calibration is determined by the dimensions of the pressure chamber. The pressure sensitivity can be derived from the microphone output voltage with known sound pressure in the chamber.

Omnidirectional condenser microphones can be measured by exciting the diaphragm with an electrostatic actuator designed for use with the microphone being measured. The grid of the actuator carries a DC voltage on which is superimposed the audio-frequency test voltage. Without the DC voltage, the microphone output signal is at twice the frequency of the test voltage. The electrostatic actuator method may be used only when the results differ from coupler or free-field conditions by less than ±1 dB. This typically requires the use of a correction curve.

11.3 Rated sensitivity

Rated sensitivity is the free-field, diffuse-field, close-talking, or pressure sensitivity assigned by the manufacturer. The rated sensitivity corresponds to the response at the standard reference frequency of 1 000 Hz. If the frequency response is not flat, it is recommended that the rated sensitivity corresponds to the arithmetic average over a one-octave band of the logarithmically plotted response, centred on the standard reference frequency of 1 000 Hz.

Unless otherwise specified, the rated sensitivity is understood to refer to the microphone under rated conditions. The manufacturer may specify the rated sensitivity for a specified load impedance (see 5.4 and 11.1).

12 Response

12.1 Frequency response

12.1.1 Characteristic to be specified

For stated conditions, the ratio, expressed in decibels, of the output voltage as a function of frequency of a sinusoidal signal to the output voltage at a stated frequency (or to the mean output voltage over a narrow band of frequencies) at a constant sound pressure and stated angle of incidence.

Unless otherwise stated, measurements shall be made in free-field conditions, and the frequency response refers to a plane progressive wave with the wavefront perpendicular to the reference axis of the microphone. It is strongly recommended that free-field response be given to allow evaluation of response to distant sound sources, even if the intended use is closer than this would imply. If free-field conditions apply but the sound field is not a plane progressive wave, sufficient further details shall be specified.

If the microphone is intended for near-field or close-talking applications (see 6.4) the close-talking or near-field frequency response shall be specified. It shall refer to the same source and to the same geometrical configuration of source and microphone as those for the specification of close-talking or near-field sensitivity (see 11.2.3).

Any other frequency response characteristic specified in this document may also be given, such as sound pressure response or diffuse-field response. Frequency responses not specified in this document may also be given, for an acoustical environment specified in 5.5, provided that no confusion is caused.

Technical specifications supplied by the manufacturer shall include frequency response over the effective frequency range (12.2) with the manufacturer's guaranteed tolerance either as a numerical value or as graphics superimposed on the response curve.

12.1.2 Method of measurement

The conditions for obtaining frequency response curves are specified in Clauses 4 and 5.

12.1.3 Graphical presentation of results

The graphical presentation of measurement results shall be in accordance with IEC 60268-1:1985, Clause 10.

12.2 Effective frequency range

12.2.1 Characteristic to be specified

The frequency range over which the response of the microphone does not deviate by more than a specified amount from an 'ideal' response for the given purpose.

NOTE The response regarded as 'ideal' by the manufacturer might not be constant with respect to frequency. From artistic considerations, this might even apply to microphones of the highest quality. For speech-only microphones, the 'ideal' response can be chosen to achieve maximum intelligibility.

12.2.2 Method of measurement

For specified deviations relative to the specified required frequency response curve, the effective frequency range is obtained from the curve referred to in 12.1.1.

13 Directional characteristics

13.1 Directional pattern

13.1.1 Characteristic to be specified

Curve representing the free-field sensitivity level of the microphone as a function of the angle of incidence of the sound wave, for a stated frequency or narrow band of frequencies.

The characteristic directional pattern for plane progressive waves shall be stated. Other measurement conditions such as spherical sound waves may also be used in addition, when sufficient details are specified. Directional curves shall be provided at a sufficient number of frequencies or bands of frequencies in order to present adequately the frequency dependence of the directional pattern. The bands of frequencies shall be the preferred octave or third-octave bands of frequencies specified in IEC 61260-1.

NOTE It is often useful to specify in addition the ratio, in decibels, of the response at certain specified angles to the response on axis.

13.1.2 Methods of measurement

The conditions for measurement are specified in Clauses 4 and 5. The microphone shall be placed in an essentially plane progressive wave (see 5.5.2). Care shall be taken when measuring the directional characteristic of a highly directional microphone in an anechoic room. The inevitable reflections from the boundaries of the room can influence the results, particularly when the output voltage of the microphone is measured for an angle of sound incidence for which the sensitivity is low.

NOTE In order to obtain correct results for microphones of large dimensions it might be necessary to measure these in the open air (see 5.5.2).

The measurement can be carried out in two different ways.

a) Directional response pattern:
   1) the microphone is operated under rated conditions;
   2) the distance between the reference point of the sound source and the reference point of the microphone is kept constant during the measurement;
   3) the sound pressure is kept constant during the measurement;
   4) the frequency is kept constant during the measurement;
   5) the angle θ of sound incidence, measured with respect to the microphone reference axis, is varied continuously or step by step, including the angle zero; for the step-by-step method the angle of sound incidence is varied in steps, with each step small enough that the measured level difference between any two steps is less than 3 dB;
   6) for each angle θ the corresponding output voltage $U(\theta)$ is measured or recorded;
   7) the ratio $\Gamma(\theta)$ of the sensitivity of the microphone at the angle θ to the sensitivity at the angle zero is expressed as direct:

$$\Gamma(\theta) = \frac{U(\theta)}{U(0)}$$

   or $G(\theta)$ in decibels:

$$G(\theta) = 20 \lg \frac{U(\theta)}{U(0)}$$

   8) the measurement is repeated for a number of frequencies, preferred frequencies being the octave centre-frequencies 125 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz, 4 000 Hz, 8 000 Hz and 16 000 Hz;
   9) if the microphone has no rotational symmetry, measurements of the directional characteristic in different planes through the reference axis of the microphone can be necessary;
   10) the results shall be presented as a family of polar response curves for the frequencies given under item 8). The polar response curves shall be drawn in accordance with IEC 60268-1. The origin of the polar characteristic of the directional pattern shall be the reference point of the microphone. Unless otherwise specified, the reference axis of the microphone shall be in the direction zero degree of the polar diagrams.

b) directional frequency characteristic:
   1) the microphone is operated under rated conditions;
   2) the angle of sound incidence θ, measured with respect to the microphone reference axis, is kept constant during the measurement;
   3) the distance between the reference point of the sound source and the reference point of the microphone is kept constant during the measurement;

4) the sound pressure is kept constant during the measurement;
5) the output voltage $U(\theta)$ of the microphone is measured as a function of the frequency for a number of discrete angles of sound incidence θ, including the angle zero;
6) the results shall be presented as a family of frequency response curves for the various angles of incidence θ with respect to the reference axis;
7) from these curves, it is possible to derive the ratio of the sensitivity of the microphone at the angle θ to the sensitivity at the angle zero for a specific frequency (polar curve (see 13.1.2 a)).

13.1.3 Graphical presentation of results

The graphical presentation of measurement results shall conform to IEC 60268-1:1985, Clause 10.

13.2 Directivity index

13.2.1 Characteristic to be specified

The ratio, expressed in decibels, of the output voltage produced by plane sound waves arriving in the direction of the reference axis, to the output voltage produced by diffuse sound field having the same frequency or frequency band and RMS sound pressure. The frequency or frequency band shall be stated.

13.2.2 Method of measurement

The directivity index D is given by

$$D = 20\lg\frac{M_0}{M_{\text{diff}}}$$

where

M_0 is the free-field sensitivity specified in 11.2.1;

M_{diff} is the diffuse-field sensitivity specified in 11.2.2.

14 Amplitude non-linearity

14.1 General

A general explanation of amplitude non-linearity can be found in IEC 60268-2. The characteristics to be specified and the methods of measurement of various types of amplitude non-linearity which can be of importance for microphones can be found in 14.2 to 14.4. Nonlinearity of the sound field should be negligible. Measurement of highly linear microphones might require special provisions to achieve low distortion at the necessary high sound pressure level. The distortion shall be measured under fixed conditions of bandwidth and level specified for different applications.

14.2 Total harmonic distortion

14.2.1 Characteristic to be specified

The ratio, expressed as a percentage or in decibels, of the RMS sum of the harmonic voltage components in the output voltage to the total RMS output voltage.

Harmonic distortion is one manifestation of amplitude non-linearity. If the sound field distortion cannot be kept small enough compared to the microphone non-linearity, other characteristics, for example difference frequency distortion, (see 14.4) shall be used.

14.2.2 Method of measurement

The relevant conditions specified in Clauses 4 and 5 shall be established.

A selective voltmeter, such as a wave analyzer, preceded if necessary by a high-pass filter which suppresses the fundamental frequency, is connected to the output of the microphone under test. The measuring device shall indicate the true RMS value of the harmonic remainder.

The voltage of each of the separate harmonics U_{nf} is measured.

The total voltage U_{t}, including the fundamental frequency, is measured by a wide band RMS meter connected to the microphone under test.

The total harmonic distortion can be determined by the equations

in percentage:

$$d_{\mathrm{t}} = \frac{\sqrt{U_{2f}^2 + U_{3f}^2 + \ldots + U_{nf}^2}}{U_{\mathrm{t}}} \times 100\ \%$$

in decibels:

$$L_{d\mathrm{t}} = 20\lg\left(\frac{d_{\mathrm{t}}}{100}\right)$$

where

d_{t} is the total harmonic distortion;

U_{nf} is the voltage of the nth harmonics;

U_{t} is the total voltage;

$L_{d\mathrm{t}}$ is the total harmonic distortion in decibels.

The non-linearity distortion of the sound field in which the microphone under test is placed shall be much less than the distortion of the microphone itself (see 14.2.1).

14.3 Harmonic distortion of the n^{th} order (n = 2, 3,...)

14.3.1 Characteristic to be specified

The harmonic distortion of the n^{th} order, expressed in terms of the total voltage.

14.3.2 Method of measurement

The relevant conditions specified in Clauses 4 and 5 shall be established. A selective voltmeter, such as a wave analyzer, preceded, if necessary, by a high-pass filter which suppresses the fundamental frequency, is connected to the output of the microphone under test. The measuring device shall indicate the true RMS value of the harmonic remainder.

The voltage of the separate harmonics U_{nf} is measured.

The total voltage, including the fundamental frequency, U_{t} is measured by a wide band RMS meter connected to the microphone under test.

The harmonic distortion of the n^{th} order can be determined by the equations in percentage:

$$d_n = \frac{U_{nf}}{U_t} \times 100\ \%$$

in decibels:

$$L_{dn} = 20\lg\left(\frac{d_n}{100}\right)$$

The non-linearity distortion of the sound field in which the microphone under test is placed shall be much less than the distortion of the microphone itself (see 14.2.1).

14.4 Difference frequency distortion of second order

14.4.1 Characteristic to be specified

The ratio of the signal of frequency f_d = 80 Hz at the output of the microphone when placed in a sound field consisting of two sinusoidal signals of frequencies f_1 and f_2, such that $f_2 - f_1$ = 80 Hz, selected with an appropriate selective filter, to the signal voltage at the input of the selective filter (see IEC 60268-2:1987, 7.2).

14.4.2 Method of measurement

The measurements are made with two sound sources, one of which radiates the signal of frequency f_1, and the other of frequency $f_1 = f_2 - 80$ Hz. The sound pressure levels produced by each of the sound sources at the reference point of the microphone shall be the same.

The method of measurement shall follow the procedure described in IEC 60268-3:2013, 14.12.8. The result is given by

in percentage

$$d_{fd} = \frac{U_{fd}}{2U_{\text{ref}}} \times 100\ \%$$

in decibels

$$L_{fd} = 20\lg\frac{d_{fd}}{100}$$

with U_{ref} as the geometric mean of U_{f1} and U_{f2}

where

U_{f1} is the voltage of frequency f_1 at the output of the microphone produced by the sound pressure from the first sound source;

U_{f2} as for U_{f1}, but for the voltage of frequency f_2;

U_{fd} is the voltage at the output of the microphone of frequency $f_d = f_2 - f_1$ = 80 Hz.

The distance between the reference points of the sound sources and the microphone under test is chosen so as to produce the required sound pressure levels at the microphone.

15 Limiting characteristics

15.1 Rated maximum permissible peak sound pressure

The maximum instantaneous sound pressure of a plane sound wave, specified by the manufacturer, that the microphone can tolerate without a permanent change of its performance characteristics, for any direction of sound incidence.

NOTE This characteristic includes the word "rated" because it is specified by the manufacturer as a result of a series of tests and cannot be reliably measured in one sample (see IEC 60268-2).

15.2 Overload sound pressure

15.2.1 Characteristic to be specified

The maximum sound pressure of a plane sound wave at which the amplitude non-linearity of the microphone does not exceed a specified limit, for any frequency within the effective frequency range and for any direction of sound incidence. Overload sound pressure shall be measured under rated conditions (see 4.2.2), and also for operation at the minimum permitted load impedance.

NOTE No common limits have yet been defined, however many data sheets refer to values of 0,5 % or 1 % for difference frequency distortion (14.2.2).

15.2.2 Method of measurement

The microphone is brought under rated conditions and the overload sound pressure is then measured for different angles of sound incidence by increasing the sound pressure of a pure sinusoidal sound until the distortion at the output of the microphone reaches a specified value. The sound pressure shall be stated for the angle of incidence for which maximum distortion occurs.

NOTE Non-linearities of the sound sources and of the air can limit the procedure. Difference frequency measurements as specified in 14.4.2 at least minimize the influence of loudspeaker non-linearities.

16 Balance

16.1 Balance of the microphone output

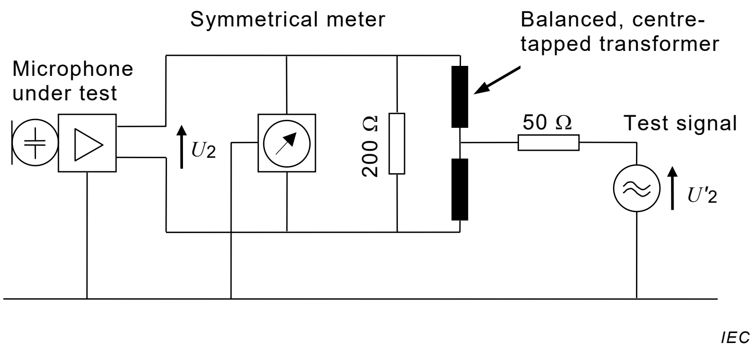


Figure 1 – Balance of the output

Figure 1 shows the measurement set-up shown in IEC 60268-2. Further reference is made to IEC 60268-3:2013, 14.15. All requirements for balance of source and meter are also valid for microphone measurements. The load resistor shall have a value of 200 Ω. The source impedance of the test signal U'_2 shall be 50 Ω. The balance of the measurement device itself shall be tested without the microphone by replacing it by a 200 Ω resistor. The "balance" b in decibels is calculated by

$$b = 20\lg\frac{U_2}{U'_2} \text{ (see Figure 1)}$$

The external sound level should be kept as low as possible in order not to influence the results.

16.2 Balance under working conditions

The procedure specified in 16.1 does not cover interference picked up via the output cable. With a modification of the setup in accordance with

Figure 1, the corresponding voltage U_2 can be measured (see Figure 2).

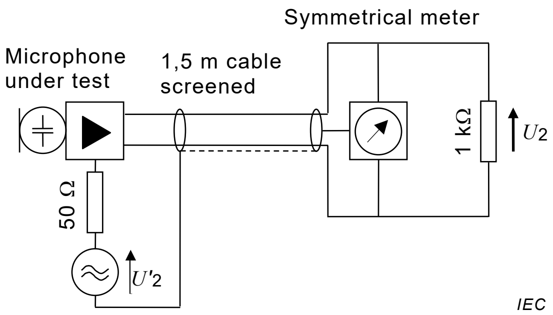


Figure 2 – Balance under working conditions

To get comparable conditions for different mechanical designs of microphones, the test shall be made including 1,5 m of high-quality cable and with an output load of 1 kΩ.

NOTE A separate measurement of the cable verifies that its contribution to the result is negligible.

For the measurement, the cable screen is disconnected at the microphone output and the test voltage inserted. The ratio of the resulting voltage at the balanced meter to the interfering source is calculated in accordance with 16.1.

17 Equivalent sound pressure level due to inherent noise

17.1 Characteristic to be specified

The external sound pressure level that would give the same weighted output voltage as is observed when there is no external field, and the output voltage is only due to the inherent noise of the microphone. The reference frequency of the external sound pressure level shall be the same as for the rated free-field sensitivity.

It shall be specified which value (maximum, average, typical) is given in the specification. The maximum value is preferred.

NOTE Unless otherwise stated, it is understood that reference is made to free-field conditions and zero angle of incidence of sound.

17.2 Method of measurement

For measurements, proceed as follows.

a) When measuring the inherent electric noise, the microphone shall be isolated against sound, wind, shock, vibration and electric or magnetic external fields. However, the microphone shall be in acoustical operating mode (see Note 2).

NOTE 1 An example for an efficient sound insulation device is given in Annex B.

NOTE 2 It has often been the practice to measure the noise level only of the electronics, using an "equivalent" circuit to replace the transducer element. This does not accurately measure the noise level of the complete microphone, due to noise contributed by the transducer element itself.

NOTE 3 Using a modern 40 dB to 60 dB amplifier for this measurement gives enough headroom that the microphone noise is dominant and there is no need to correct the measurement for amplifier noise.

b) The weighted output voltage of the microphone due to inherent noise is measured, using the weighted measurements specified in IEC 60268-1:1985. Psophometric, quasi-peak measurements in accordance with IEC 60268-1:1985, 6.2.2, shall be included. It is strongly recommended that A-weighted RMS noise measurements in accordance with IEC 60268-1:1985, 6.2.1, and one-third octave unweighted RMS noise measurements in accordance with IEC 60268-1:1985, 6.2.3, are also included.

c) With the microphone replaced by a resistor at room temperature, equal in value to the rated impedance of the microphone, the measured output voltage shall be less than one third of the value measured in step b), so that the wanted result is increased by less than 10 % by the internal noise of the measuring equipment and any residual external sound.

d) The equivalent sound pressure due to inherent noise is the ratio of the output voltage to the rated free-field sensitivity.

e) The equivalent sound pressure level is the ratio, expressed in decibels, of the equivalent sound pressure to the reference sound pressure (20 μPa).

18 Ambient conditions

18.1 General

The following characteristics shall be specified independently of each other. In cases where interdependencies exist, conditions and effects shall be specified by the manufacturer.

18.2 Pressure range

The ambient pressure range over which the characteristics of the microphone do not vary by more than ±2 dB. If the manufacturer claims that the microphone is suitable for applications in which a high rate of change of ambient pressure occurs (such as an air-borne sound system) then the maximum tolerable rate of change of the ambient pressure shall also be stated.

18.3 Temperature range

The temperature range over which the characteristics of the microphone do not vary by more than ±2 dB.

18.4 Relative humidity range

The relative humidity range over which the characteristics of the microphone do not vary by more than ±2 dB.

19 External influences

19.1 General

19.1.1 Specification and methods of measurement

Microphones are subject to many forms of external interference, which it can be of vital importance to exclude or limit in particular cases. As, however, external influences by reason of non-linear effects can give rise to very complicated interference, no generally valid method of measurement can be given to evaluate all of them. The special case of external influences known as electromagnetic compatibility is covered in Clause 20. Specifications are subject to discussion between supplier and user and can lead to possibly elaborate laboratory and/or field tests.

The methods of measurement given below (see 19.2 to 19.4) deal only with external influences from:

– mechanical vibrations;
– wind;
– the "pop" effect.

The methods given are neither exhaustive nor final, but are intended to provide useful guidance.

19.1.2 Other external interferences

For all external interferences other than those given in this document, specifications shall be determined by agreement between the supplier and the user.

19.2 Equivalent sound pressure due to mechanical vibration

19.2.1 Characteristic to be specified

For a mechanical vibration, specified by the RMS value of the acceleration, frequency and direction, the equivalent sound pressure due to the vibration, in the absence of a sound field. The equivalent sound pressure shall be stated for the direction of the vibration for which maximum influence occurs. The directions for both maximum and minimum influence shall be stated.

The equivalent sound pressure may be stated for vibrations at specified frequencies, or within a specified frequency band having the reference frequency as the geometric mean frequency. If linear relations exist, the equivalent sound pressure may be specified as a transmission factor, relating the equivalent sound pressure and the acceleration.

19.2.2 Method of measurement

For measurements, proceed as follows.

a) The microphone is connected under rated conditions and in a surrounding with sufficiently low acoustic background signal.
b) A mechanical vibration of a specified RMS acceleration and of a specified frequency or a specified frequency band is applied. The direction of the vibration shall be such that maximum output voltage is obtained.
c) The RMS output voltage U'_2 and the RMS acceleration are measured.
d) The equivalent sound pressure is computed from U'_2 and from the rated sensitivity. The acceleration and the direction of the vibration shall be specified.
e) A test is made to obtain the direction of vibration for minimum influence. This direction is also specified.
f) The measurement is preferably made with a gliding frequency up to 250 Hz.
g) If a linear relation exists between the equivalent sound pressure and the acceleration, the transmission factor may be specified. In cases of strong dependency on frequency, more values or the complete characteristic may be given.

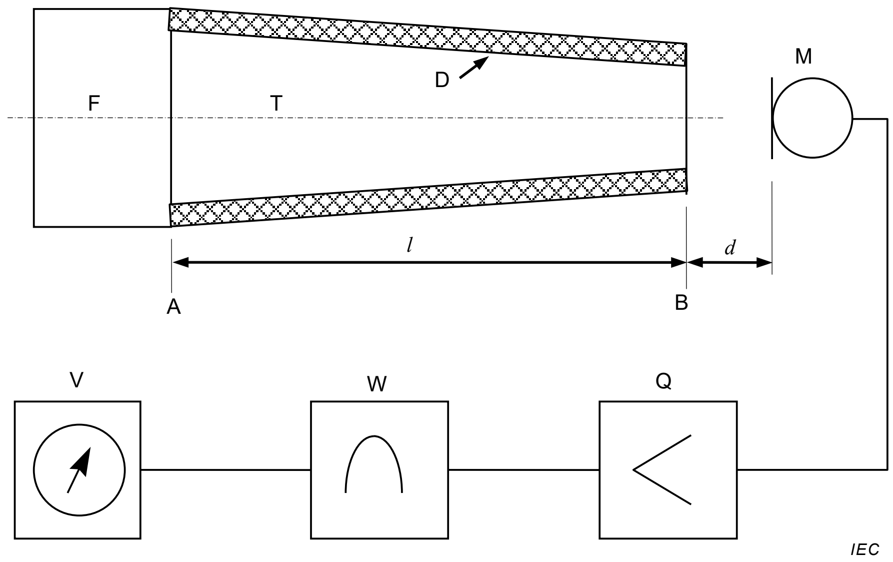
19.3 Equivalent sound pressure due to wind

19.3.1 Characteristic to be specified

For a wind, specified by velocity and direction, the equivalent sound pressure due to the wind in the absence of a sound field. The equivalent sound pressure shall be stated for the direction of the wind for which maximum influence occurs. The directions for both maximum and minimum influence shall be stated. Besides the weighted wide-band level, the equivalent sound pressure level may also be stated for octave or third-octave bands in the effective frequency range of the microphone and for additional wind velocities besides the reference value of 10 m/s.

19.3.2 Method of measurement

All measurements of wind noise are subject to large variations if the stream of air is turbulent at the source or develops turbulence between source and microphone. After evaluating several methods, the wind tunnel method has proven to give the best matching to natural wind conditions. It is, however, still difficult to measure the nature of the generated wind and to describe it with enough accuracy. Therefore, at present it is better to specify the generator by mechanical characteristics.



Key

F fan with low acoustic noise

A inlet cross-section of wind tunnel

T wind tunnel

D damping material

B outlet cross-section of wind tunnel

l length of tunnel

d measuring distance between microphone and tunnel outlet

M microphone under test

Q amplifier

W weighting filter / band filter (optional)

V voltmeter

Figure 3 – Measurement set-up for wind influence

Two different solutions have been investigated, a short device with radial fan and a long device with axial fan (see Figure 4). The first has been installed by several institutions and has proven to give reproducible results everywhere. Similar experience with the second is not yet known. Comparative measurements between the first installation and other generators showed that major differences have to be expected. Therefore, the published wind sensitivity values shall also state whether machine 1 or machine 2 has been used.

A block diagram of the measurement setup is shown in Figure 3. The microphone under test is placed at a distance of 25 cm from the outlet of the tunnel. The tunnel is operated in a room not influencing the measurement results, for example an anechoic chamber. The output voltage of the microphone under wind conditions is measured by the A-weighting filter in accordance with IEC 60268-1 and optionally as octave or third-octave band value. Microphones with detachable windscreens shall be measured with and without the windscreen.

The two different machines to generate the air flow are shown in Figure 4. The tunnel inner surface is constructed to provide a homogeneous air flow. The dimensions chosen are large enough compared with those of the microphones to be tested. The higher velocity at the outlet of machine 1 is achieved by the conical construction reducing the cross-section. To achieve a laminar flow, the inside of machine 2 is covered with glass wool of 55 kg/m^3 density and 2,5 cm thickness, or similar material. At the necessary speed, the fans produce negligible acoustic noise. The measuring distance of 25 cm has been chosen to get an amount of turbulence similar to the natural wind conditions.

The nature of wind noise is such that pressure fluctuations, whose frequencies lie below the effective frequency range (so that they are not directly indicated), can give rise to microphone output signals large enough to overload the first stage of the amplifier. Care shall be taken to avoid such overloading effects.

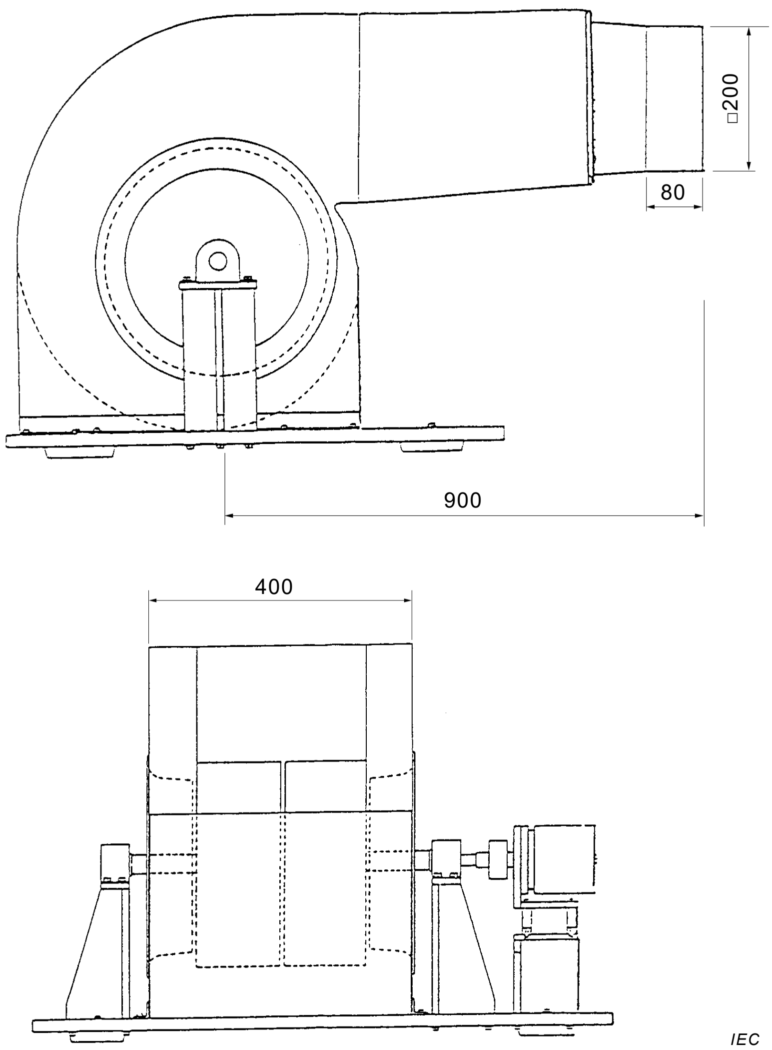


Figure 4a – Wind generator with radial fan (front and side view)

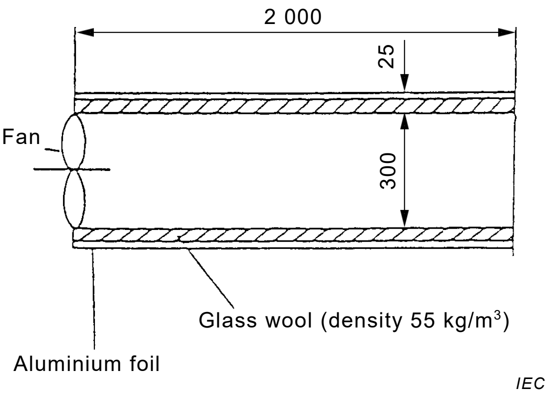


Figure 4b – Wind generator with axial fan

Figure 4 – Wind generators, type 1 (Figure 4a) and type 2 (Figure 4b)

The procedure is given in steps a) to c).

a) The microphone is connected under rated conditions to an amplifier in the absence of a sound field.

b) The microphone under test is submitted to a wind of specified velocity, the reference being 10 m/s, and specified direction. The microphone is orientated with respect to the wind direction so that maximum output is obtained.

c) The equivalent sound pressure level is computed from the output voltage of the microphone (wide band, weighted or additional narrow bands) and from the free-field sensitivity and is given in decibels with respect to the sound pressure level reference of 20 μPa. The direction of wind shall be specified and, in case of the wind speed differing from the reference value of 10 m/s, this value shall also be stated.

19.4 Transient equivalent sound pressure due to "pop" effect

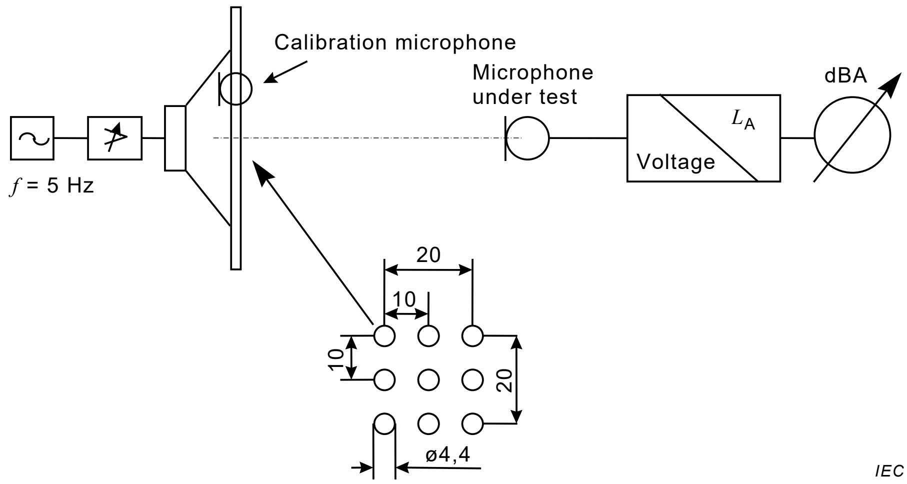
19.4.1 General

The procedure is meant to supply reproducible and comparable measurement results for the "pop" effect of microphones. It provides a ranking of microphones according to "pop" noise and especially allows the definition of the "pop" attenuation of "pop" screens or other means applied to the microphone.

NOTE The test equipment is the same as described in Annex C of IEC 60268-4:2014. However, the measurement procedure has been simplified for a differently specified characteristic instead of the earlier "pop sensitivity".

19.4.2 Characteristic to be specified

The equivalent sound pressure level due to a defined "pop" excitation, measured in the absence of a sound field, with a measurement installation shown in Figure 5 that can simulate the air flow produced by human stop consonants (P, T, etc.).



Dimensions in millimetres

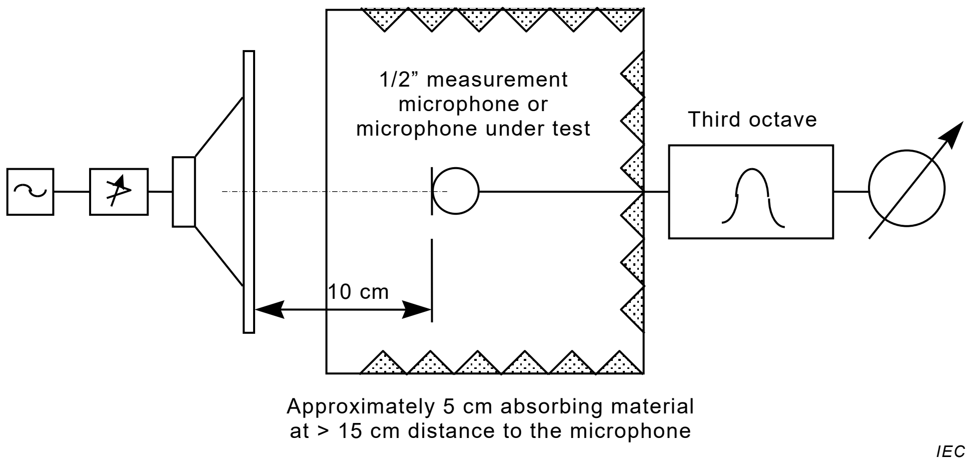


Figure 5 – Electrical and mechanical setup for the measuring of the "pop" effect

NOTE Comparing microphones with different frequency response can result in different psychoacoustic sensation of the "pop" even if the calculated equivalent SPL is the same. Earlier proposals for adjustment/corection are still under consideration.

19.4.3 Method of measurement

The measurement setup is shown in Figure 5. A woofer is covered with a 5-mm thick metal baffle to enclose a volume between the diaphragm and the baffle. In the middle of the baffle, nine holes are arranged in a square pattern, each having a diameter of 4,4 mm and at a distance to the neighbour of 10 mm. The holes shall have no sharp edges, for example a 45° polished chamfer. For calibration purposes of the sound pressure within the chamber, a measurement microphone M_c is tightly mounted into an extra hole in the baffle. The distance between the measurement microphone and the nine holes shall be at least 30 mm.

NOTE The smoothness of the holes in the baffle influences the measurement results. Careful polishing leads to a better suppression of artefacts.

The loudspeaker is fed with a sinusoidal signal of 5 Hz from an amplifier with adjustable gain. The gain is adjusted to a peak sound pressure level of 140 dB in the chamber between the baffle and the diaphragm of the loudspeaker.

The microphone under test is positioned 10 cm on axis from the central hole.

The mounting equipment shall have negligible influence on the sound field and produce only negligible acoustic artefacts. With an adequate filter, frequencies below 5 Hz are cut off. The output is then measured as an RMS value using an A-weighting filter.

For validation that the signal at the microphone output is generated by the airflow, the microphone is mounted 50 mm off-axis. In this case, the signal shall be at least 10 dB lower than on axis.

The equivalent sound pressure level is computed from the output voltage of the microphone (wide band, weighted or additional narrow bands) and from the free-field sensitivity and is given in decibels with respect to the sound pressure level reference of 20 µPa.

20 Electromagnetic compatibility (EMC)

20.1 Regulatory requirements

Regulatory requirements are not within the scope of this document and vary in different parts of the world. Table 2 gives examples of relevant regulations and standards.

Table 2 – Examples of EMC regulations and standards

Type of microphone	Emission USA	Immunity USA	Emission Europe	Immunity Europe
Microphone with analogue or digital audio output	FCC 47CFR15	–	EN 55032	EN 55035
Radio microphone	FCC 47CFR2, 47CFR15, 47CFR74, 47CFR90	–	EN 300 422-2	EN 300 422-2

NOTE In the USA, analogue microphones containing oscillators at frequencies below 1,705 MHz are exempt. The requirements of 47 CFR 15.109(a) apply to digital microphones and those with internal circuits operating above 1,705 MHz, when tested in accordance with 15,33 and verified in accordance with 2,902 et seq. of that regulation. Internally documented compliance with CISPR 22 is also an acceptable form of verification for microphones having any digital capability, including internal DSP.

20.2 Requirements for preserving programme quality

In many applications of microphones, additional immunity to electromagnetic disturbances is required in order to preserve programme quality.

Table 3 gives a list of the electromagnetic disturbances likely to affect microphones and the relevant IEC EMC Basic standards, with methods of test and notes on their application to microphones.

Table 3 – Basic EMC standards and their application to microphones

Basic standard	Description	Application	Methods of test
IEC 61000-4-2	Immunity to electrostatic discharge (ESD)	See CISPR 35	Contact discharge 4 kV, air discharge 8 kV
IEC 61000-4-3	Immunity to radiated radio-frequency electromagnetic fields	See CISPR 35	Enclosure port 80 MHz to 1 000 MHz, 3 V/m and spot frequencies
IEC 61000-4-4	Immunity to fast transients or bursts	See CISPR 35	Analogue/digital data and DC power ports
IEC 61000-4-6	Immunity to conducted disturbances induced by radio-frequency fields	See CISPR 35	Current injected in cable screen simulates exposure to RF. 3 V from 0,15 MHz to 10 MHz, decreasing linearly with the logarithm of frequency to 1 V at 30 MHz, then maintained at 1 V to 80 MHz.
IEC 61000-4-8	Immunity to power frequency magnetic field	See CISPR 35 and IEC 60268-1:1985, Clause 12	50/60 Hz, 1 A/m and statement of equivalent SPL
IEC 61000-4-16	Immunity to conducted common-mode disturbances, 0 Hz to 150 kHz	See IEC 61000-4-16	Current injected in cable screen simulates mains fault currents
IEC 61000-4-17	Immunity to ripple on DC input power port	See IEC 61000-4-17	Performance degradation with ripple on DC power
NOTE If the microphone has a mains power supply, additional requirements apply to it, such as IEC 61000-3-2 and IEC 61000-3-3.			

Apart from electrostatic discharge, for which performance criterion B applies, all of the disturbances can be continuous or at least repetitive, so that performance criterion A applies.

20.3 Performance criteria

NOTE For other performance criteria, see CISPR 35.

20.3.1 Criterion A

The equipment shall continue to operate as intended without operator intervention. No degradation of performance, loss of function or change of operating state is allowed below a performance level specified by the manufacturer when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user can reasonably expect from the equipment if used as intended.

20.3.2 Criterion B

After the test, the equipment shall continue to operate as intended without operator intervention. No degradation of performance or loss of function is allowed, after the application of the electromagnetic disturbance below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is allowed. However, no unintended change of operating state or stored data is allowed to persist after the test. If the minimum performance level (or the permissible performance loss) is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and by what the user can reasonably expect from the equipment if used as intended.

20.4 Testing for immunity to disturbances in the presence of acoustical noise

Degradation of performance in microphones due to electromagnetic disturbance, when present, generally occurs in the form of additional noise added to the output signal. The output can be near the inherent noise level of the microphone as measured in 17.2, and it can be difficult to measure in a test environment capable of producing the disturbances required in Table 3 owing to acoustic noise in the test environment.

It is recommended to test for immunity using a modified microphone with the sound-sensing element disabled, while maintaining its electrical properties and its effect on an electromagnetic field. Details of this procedure, if used, shall be included in the test report. Examples of suitable procedures are:

- dynamic microphones: replace the magnet(s) by non-magnetized parts;
- capacitor microphones: disconnect the polarizing voltage supply at a remote point;
- electret microphones: replace the charged element by an uncharged element;
- immobilize the sensing element.

20.5 Immunity to frequency-modulated radiated disturbances

Radiated immunity testing required for compliance with the European EMC Directive (see Bibliography) covers frequencies above 80 MHz, with amplitude modulation (AM). Additional testing might be required to evaluate performance degradation in the presence of frequency-modulated (FM) transmissions.

The tests in CISPR 35:2016, Table 1, table clause 1.2, shall be repeated with a frequency-modulated test signal, 1 000 Hz modulation at 22,5 kHz peak deviation, with a field strength of 10 V/m. The AM and FM tests may be conducted together if the test generator can generate AM and FM simultaneously.

20.6 Immunity to magnetic fields

Power frequency magnetic field immunity testing required for compliance with the EMC Directive covers degradation of performance when the microphone is placed in a 50 Hz or 60 Hz magnetic field of 1 A/m. Additional testing might be required to evaluate the amount of performance degradation at higher frequencies.

An external uniform magnetic field with sinusoidal waveform is applied. The direction of the field shall be such that the maximum output voltage of the microphone is measured. The measurement frequencies shall be 50 Hz or 60 Hz, 1 kHz and 16 kHz. The output of the microphone is measured in accordance with one of the weightings and meters specified in IEC 60268-1. The type of meter and weighting shall be specified. The measurements shall be referred to the free-field sensitivity and stated as equivalent sound pressure levels for magnetic induction. For the method of producing a uniform alternating magnetic field, see 6.3 of IEC 61000-4-8:2009. The measurement shall be repeated to obtain the responses at the harmonics of the mains frequency up to and including the fifth.

20.7 Immunity to ripple on DC power supply

Microphones using phantom or A-B powering in accordance with IEC 61938 can be susceptible to hum due to ripple on the DC power supply.

IEC 61000-4-17 may be used as a reference. Test results shall be stated in terms of maximum DC power supply ripple in the frequency range 50 Hz to 180 Hz, as a percentage of the DC power supply voltage, for which the output voltage level due to noise increases by less than 1 dB. The wide band measurement in IEC 60268-1:1985, 6.1 shall be used.

20.8 Permanent magnetic field

Microphones incorporating permanent magnets can create an unavoidably large magnetic field. This field can affect other equipment, and this fact should be noted in the instruction manual. The user should allow for this and take precautions in placement.

When operating in rated conditions, the magnetic field strength shall be measured by means of a suitable flux meter, such as one incorporating a Hall effect detector, and shall be stated if it exceeds 0,5 mT at 1 cm from any surface of the microphone. If the microphone has an AC power port, the AC magnetic field shall be measured with a suitable search coil as described in IEC 60268-1:1985, 12.2 and shall be stated if it exceeds 1 μT at 1 cm from any surface.

20.9 Evaluation and reporting of the test results

In addition to any other tests that are performed, the microphone output shall be evaluated in the presence of each of the disturbances specified in Table 3 in turn. Except for the electrostatic discharge test, the output of the microphone with the disturbance applied shall be reported as the equivalent input sound pressure level due to electromagnetic disturbance, if it exceeds the output with no disturbance by more than 1 dB. The wide band measurement in IEC 60268-1:1985, 6.1 shall be used in each case, and the output referred to free-field sensitivity of the microphone. If the procedure in 20.4 is used, the output in the absence of the disturbance shall be measured with a typical production sound-sensitive element, in accordance with Clause 17. A graphical presentation of results, stated as the equivalent input sound pressure level versus frequency over the frequency range given for the disturbance, shall be provided where appropriate.

In order for the provisions of Clause 20 to be effective, the manufacturer has an obligation to make the information specified above available on request by a prospective purchaser of the product. This document cannot specify how that obligation can be discharged.

21 Physical characteristics

21.1 Dimensions

The main dimensions of the microphone shall be specified by the manufacturer.

21.2 Weight

The net mass of the microphone shall be specified by the manufacturer.

21.3 Cables and connectors

The connector or cable connections shall be specified by the manufacturer as, for example, connector contact numbers or conductor insulation colours. Polarity information shall be included (see 7.1).

Reference is made to IEC 60268-11 and IEC 60268-12.

22 Classification of the characteristics to be specified

It is essential that markings bearing on safety appear on the label and are clearly visible. Other markings are recommended but these might not, in some cases, be practicable, either for reasons of size or construction, or because variable facilities are provided which make the marking confusing. Accordingly, such markings are indicated by the letter R.

For stereo or multi-channel microphones, the data shall be given for each channel.

Table 4 shows the characteristics originally collected for analogue microphones. Most of them are also valid for microphones with built-in analogue-digital conversion. Changes and extensions for some characteristics are described in Annex C.

For compatibility reasons, the user needs accurate information of data with high influence on the performance. Therefore, the manufacturer shall publish limits ex-factory for at least one characteristic of Clauses 10, 11, 12 and 14. It is highly recommended to provide more on request as some national or international regulations demand such information.

Table 4 – Classification of characteristics

Clause	Subclause		A[a]	B[b]
6	Type description			
	6.1	Principle of the transducer		X
	6.2	Type of microphone		X
	6.3	Type of directional response characteristics		X
	6.4	Application	R	X
7	Terminals and controls			
	7.1	Marking		X
	7.2	Connectors and electrical interface values	R	X
8	Reference point and axis			
	8.1	Reference point	R	X
	8.2	Reference axis	R	X
9	Rated power supply			
	–	type of power supply	X	X
	–	power supply voltage	X	X
	–	upper and lower limits		X
	–	current drawn from power supply		X
10	Electrical impedance			
	10.1	Internal impedance		R
	10.2	Rated impedance		X
	10.3	Minimum permitted load impedance	R	X
11	Sensitivity			
	11.2.1	Free-field sensitivity		X
	11.2.2	Diffuse-field sensitivity		R
	11.2.3	Close-talking or near-field sensitivity		R
	11.2.4	Pressure sensitivity		
	11.3	Rated sensitivity		
12	Response			
	12.1	Frequency response		X
	12.2	Effective frequency range		X
13	Directional characteristics			
	13.1	Directional pattern		X
	13.2	Directivity index		R
14	Amplitude non-linearity (all characteristics)			R

Clause	Subclause		A[a]	B[b]
15	Limiting characteristics			
	15.1	Maximum permissible peak sound pressure		R
	15.2	Overload sound pressure		X
16	Balance			
	16.1	Balance of the microphone output		X
	16.2	Balance under working conditions		R
17	Equivalent sound pressure level due to inherent noise			X
18	Ambient conditions			
	18.2	Pressure range		R
	18.3	Temperature range		R
	18.4	Relative humidity range		R
19	External influences			
	19.2	Equivalent sound pressure due to mechanical vibration	–	R
	19.3	Equivalent sound pressure due to wind	–	R
	19.4	Transient equivalent sound pressure due to "pop" effect	–	R
20	Table 3: EMC (for preserving programme quality) See 20.2			
	Equivalent SPL due to radiated radio-frequency electromagnetic fields		–	X
	Equivalent SPL due to fast transients or bursts		–	X
	Equivalent SPL due to conducted disturbances induced by radio-frequency fields		–	X
	Equivalent SPL due to power frequency magnetic field		–	X
	Equivalent SPL due to conducted common-mode disturbances, 0 Hz to 150 kHz		–	X
	Equivalent SPL due to ripple on DC input power port		–	X
21	Physical characteristics			
	21.1	Dimensions	–	X
	21.2	Weight	–	X
	21.3	Cables and connectors	–	X
Annex A	Additional characteristics			
	A.2	Front-to-rear sensitivity index (0° to 180°)		
	A.3	Noise-cancelling index		

NOTE 1 IEC 61938:2013, 9.1 to 9.6 specify matching and marking of microphones and power supplies with preferred values.

NOTE 2 The data relating to Clause 20 are not the data required for regulatory purposes.

[a] A is the data that shall be marked by the manufacturer on the microphone. R means 'Recommended'.

[b] B is the data that shall be specified by the manufacturer in the manual and technical specification.

Annex A
(normative)

Additional characteristics

A.1 Characteristic sensitivity for speech

A.1.1 Characteristic to be specified

The modulus of the relevant sensitivity of the microphone (see 11.2) averaged over the effective frequency range using a weighting that corresponds to a specified speech power spectrum.

NOTE The characteristic sensitivity for speech is intended to provide the information necessary for matching the microphone to the amplifier, taking into account both the frequency response of the microphone and an approximated speech power spectrum. This definition takes account of the fact that the major part of speech power is concentrated in the low-frequency range and also that, generally, microphones for speech transmission have a low-frequency roll-off. The characteristic sensitivity for speech bears no relation to an intelligibility rating.

A.1.2 Method of measurement

Average values of the relevant sensitivity selected from 11.2 are calculated for the octave frequency bands (in accordance with IEC 61260-1) with centre-frequencies 250 Hz, 500 Hz, 1 000 Hz and 2 000 Hz.

These four average values $(M_f)_k$ can be calculated from the value at one frequency (e.g. 1 000 Hz) and from the frequency response measured under the relevant conditions, averaged on a decibel scale within each of the octave bands.

The characteristic sensitivity for speech power shall be calculated from the expression

$$M_{\text{es}} = \left[\sum_{k=1}^{4} \alpha_k \left(M_f \right)_k^2 \right]^{1/2}$$

where

k is the index of the octave-band considered (k = 1....4);

α_k is the speech-power weighting factor for the octave-band with index k given in Table A.1.

Table A.1 – Speech power weighting factor at octave-band centre frequencies

Index k	1	2	3	4
Centre-frequency of octave-band, Hz	250	500	1 000	2 000
Speech-power weighting factor, α_k	0,15	0,55	0,20	0,10

The characteristic sensitivity level for speech power $L_{M\text{cs}}$ is the ratio, expressed in decibels, of the characteristic sensitivity for speech power M_{cs} and the reference sensitivity M_{r} (= 1 V/Pa) expressed as follows:

$$L_{M_{\text{cs}}} = 20 \lg \frac{M_{\text{cs}}}{M_{\text{r}}}$$

NOTE The procedure given above involves several simplifications but gives sufficient accuracy for normal practice. A more accurate method of weighting can be obtained by using a more extended frequency range, true power-averaging in narrower frequency-bands (e.g. third-octave bands) and the appropriate speech-power weighting factors for each of the narrower frequency-bands. However, any set of speech-power weighting factors to be used as a basis for calculation are averages for different languages and different male and female voices, and the deviations for individual persons often exceed the limits of accuracy of the simplified procedure given above.

A.2 Front-to-rear sensitivity index (0° to 180°)

A.2.1 Characteristic to be specified

The ratio, expressed in decibels, of the free-field plane wave sensitivities for incidence of identical sound waves in the direction of the reference axis and in the opposite direction. The frequency or frequency band shall be stated.

A.2.2 Method of measurement

The front-to-rear sensitivity index is not directly measured but derived from the measured free-field plane wave sensitivities (see 11.2.1) for incidence of identical sound waves in the direction of the reference axis and in the opposite direction.

Care should be taken when measuring the front-to-rear sensitivity index of a highly directional microphone in an anechoic room because of the influence of sound reflections from the boundaries (see 13.1.2).

A.3 Noise-cancelling index

A.3.1 Characteristic to be specified

The noise-cancelling index is measured as the ratio of the output voltage produced by sound waves emanating from a specified source (artificial mouth) to the output voltage produced by a diffuse sound field having the same frequency or frequency band and the same RMS sound pressure. The sound source is placed at a stated distance from the microphone, with a stated orientation with respect to the reference axis of the microphone. The index is expressed in decibels. The frequency or frequency band shall be stated.

The noise-cancelling index shall be understood to be equal to the ratio, expressed in decibels, of the close-talking sensitivity (see 11.2.3) and the diffuse-field sensitivity (see 11.2.2) at the same frequency or within the same frequency band. In all cases the sound source used shall be stated.

The noise-cancelling index shall refer to the same source and to the same geometrical configuration of source and microphone as those for the specification of the close-talking sensitivity (see 11.2.3). The noise-cancelling index may be presented as frequency response curves for both the specified source and the diffuse sound field. Instead of an artificial mouth, an artificial head can be used.

A.3.2 Method of measurement

The noise-cancelling index is computed as the ratio, expressed in decibels, of the measured close-talking sensitivity (see 11.2.3) and the measured or calculated diffuse-field sensitivity (see 11.2.2).

It is presented either as a function of frequency within the effective frequency range, or as the frequency response curves for both the specified source (artificial mouth) and the diffuse sound field at the same sound pressure.

A.4 Special characteristics for stereo microphones

A.4.1 General

For stereophonic recording, special microphone units with fixed transducer arrangements for both audio channels are in use, as well as a multitude of well-defined arrangements (arrays) of monophonic microphones. The following characteristics apply to these microphones and arrays.

A.4.2 Included angle of an XY (left-right) microphone

A.4.2.1 Characteristic to be specified

The angle between the reference axis of the left-channel microphone and that of the right channel microphone.

A.4.2.2 Method of measurement

Usually both microphones have the same directional properties and the reference and mechanical axes are the same, so that the angle cannot be directly measured but derived from the mechanical design. In case of doubt, directivity measurements for both channels should be made, following the procedure for monophonic microphones.

A.4.3 Acceptance angle

A.4.3.1 Characteristic to be specified

The angle between the directions of maximum ratio between right and left channel (X/Y and Y/X).

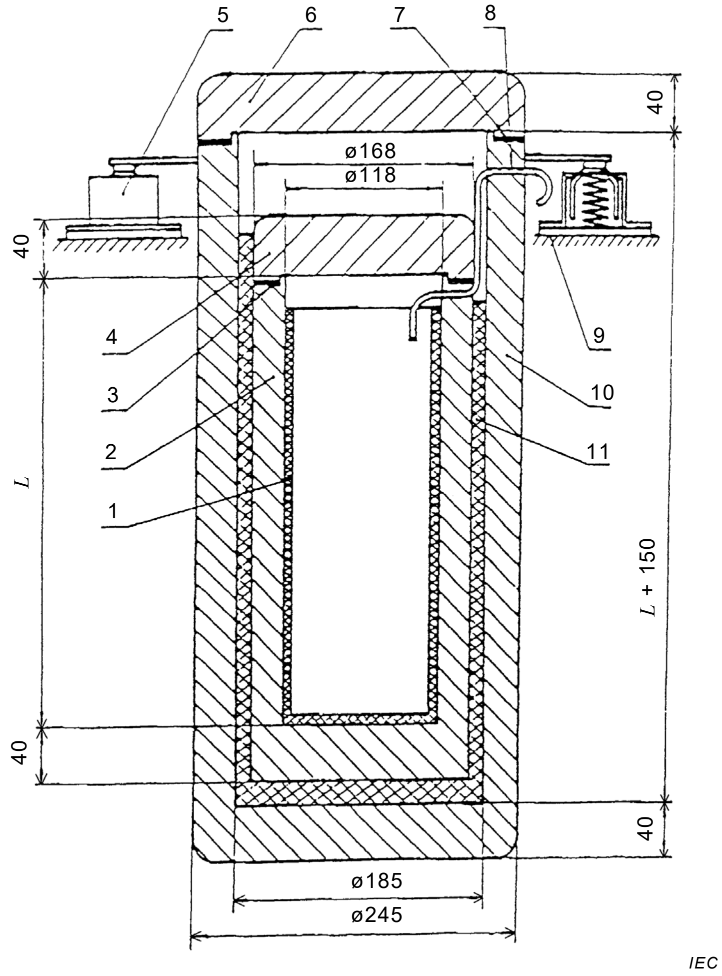
A.4.3.2 Method of measurement

The angle can be derived from directional response plots for left and right output, using the same zero reference direction. This can require the use of an MS to XY converter. The angle varies with frequency, so should be stated for several preferred frequencies.

Annex B
(informative)

Sound insulation device

The sound insulation device is made of normal carbon steel. It has double encapsulation and is filled with damping materials between the inside and outside cans. At the base, the damper has axial symmetry and is uniformly distributed, see Figure B.1.



Dimensions in millimetres

According to the requirements, define L as desired.

Key

1 sound absorbent lining
2 inside can
3 rubber spacer inside can
4 cover of inside can
5 vibration damper (four pieces)
6 cover of outside can
7 rubber spacer outside
8 measuring cable: the outlet for the measuring cable is sealed.
9 base plate
10 outside can
11 damping material

The resonance frequency of the system constituted by the total stiffness of the vibration damper and the total mass of the can should be less than 10 Hz.

Figure B.1 – Sound insulation device

Annex C
(informative)

Recommendations for professional digital microphones

C.1 General

This annex provides guidance resulting from discussions primarily regarding professional microphones using e.g. the AES42 standard output, and should be considered as recommendations for companies publishing specifications of such microphones, only. It includes definitions and further explanations of characteristics introduced with digital microphones. The definitions in this annex are limited to microphones having an interface using linear pulse code modulation (LPCM) coding similar to that specified in IEC 60958-4. Clauses from the main part are recommended for application where stated in Table C.1. New clauses are introduced in Table C.2. Further information can be found in the literature (see Bibliography).

C.2 Data sheets for digital microphones

Signal levels shall be measured digitally relative to full-scale. If the gain can be changed in the microphone, the influence on sensitivity and signal to noise ratio should be stated. Mechanical, electrical and protocol characteristics of a digital microphone are defined in the corresponding standards.

Table C.1 – Classification of the characteristics recommended to be specified

Clause	Subclause	Classification
6	Type description 6.1 Principle of the transducer 6.2 Type of microphone 6.3 Type of directional response characteristics	Same as for analogue microphones.
7	Terminals and controls 7.1 Marking 7.2 Connectors and electrical interface values	Connectors and electrical interfaces are defined in the relevant digital interface standards. The applicable standard shall be stated.
8	Reference point and axis 8.1 Reference point 8.2 Reference axis	Same as for analogue microphones.
9	Rated power supply – type of power supply – power supply voltage – upper and lower limits – current drawn from power supply	The powering is defined in the relevant digital interface standard. The applicable standard shall be stated.

Clause	Subclause	Classification
10	Electrical impedance 10.1 Internal impedance 10.2 Rated impedance 10.3 Minimum permitted load impedance	The interface impedance is defined in the relevant digital interface standard. The applicable standard shall be stated.
11	Sensitivity 11.2.1 Free-field sensitivity 11.2.2 Diffuse-field sensitivity 11.2.3 Close-talking or near-field sensitivity 11.2.4 Pressure sensitivity 11.3 Rated sensitivity	The sensitivity shall be expressed as output level relative to digital full-scale (0 dB FS) generated by a sound pressure of 1Pa (94 dB SPL). In case of variable gain the sensitivity should be stated at least for maximum and minimum gain.
12	Response 12.1 Frequency response 12.2 Effective frequency range	Same as for analogue microphones.
13	Directional characteristics 13.1 Directional pattern 13.2 Directivity index	Same as for analogue microphones.
14	Amplitude non-linearity (all characteristics)	Same as for analogue microphones.
15	Limiting characteristics 15.1 Maximum permissible peak sound pressure 15.2 Overload sound pressure	Same as for analogue microphones.
16	Balance 16.1 Balance of the microphone output	Not applicable or defined in relevant digital interface standards.
17	Equivalent sound pressure level due to inherent noise	Signal levels are measured in the digital domain. The equivalent sound pressure is calculated with the digital sensitivity. If gain is not fixed sensitivity should be stated at least for maximum and minimum gain.
18	Ambient conditions 18.1 General 18.2 Pressure range 18.3 Temperature range 18.4 Relative humidity range	Same as for analogue microphones
19	External influences 19.1 General 19.2 Equivalent sound pressure due to mechanical vibration 19.3 Equivalent sound pressure due to wind 19.4 Transient equivalent sound pressure due to "pop" effect	See Clause 17.

Clause	Subclause	Classification
20	Electromagnetic compatibility (EMC)	Same as for analogue microphones.
21	Physical characteristics 21.1 Dimensions 21.2 Weight 21.3 Cables and connectors	Mechanical parameters same as for analogue microphones. Cables and connectors are defined in relevant digital interface standards. The applicable standard shall be stated.

Table C.2 – Additional digital characteristics to be specified

	Digital characteristics: 1 Word length 2 Sampling frequencies 3 Latency time 4 Internal signal processing 5 Output interface jitter 6 Audio data dc offset 7 Method of synchronization 8 Type of codec	Latency is expressed as the number of samples or latency time at each stated sampling frequency. Internal DSP functions which can affect the described characteristics should be stated.

Annex D
(informative)

Recommended method for measuring noise levels according to ITU-R BS.468-4 in the digital domain

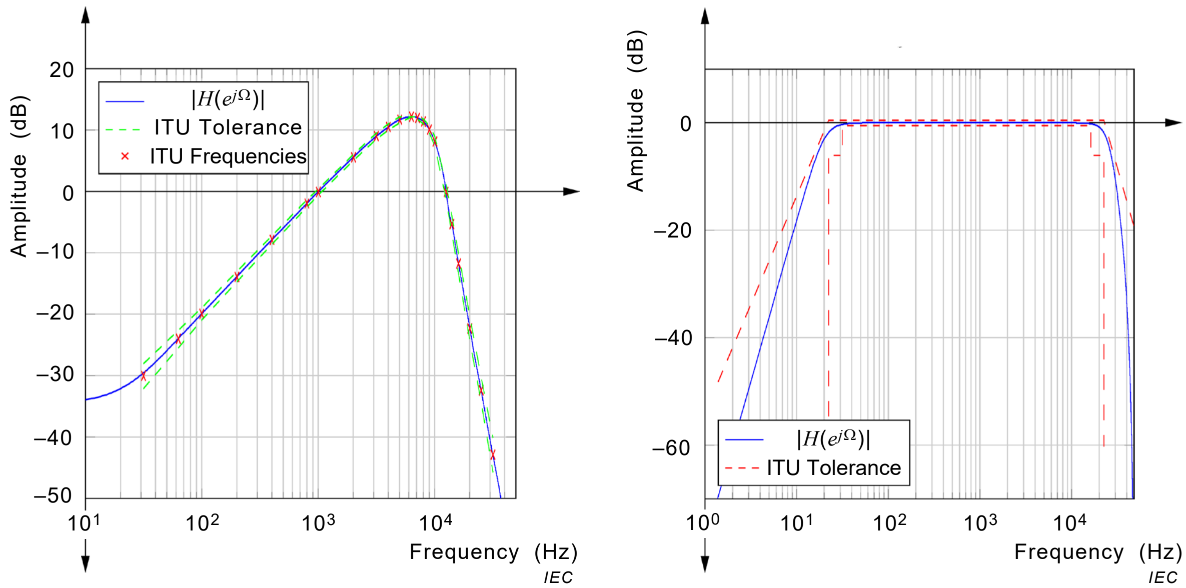
D.1 General

This annex describes a method to measure quasi-peak noise in accordance with ITU-R BS.468-4 in the digital domain.

D.2 Recommended method

The recommended method works in the time domain. The filters for the weighted and unweighted measurements are shown in Figure D.1. The frequency response for the weighted measurements is implemented with an FIR filter, using the frequency sampling method. The frequency points are defined in ITU-R BS.468.

The filter for the unweighted measurements is implemented with two 3rd order IIR Butterworth filters.



a) Filter for weighted measurements **b) Filter for unweighted measurements**

The left graph shows the CCIR-1k curve.

Figure D.1 – ITU weighting filter for weighted and unweighted measurements

To achieve a quasi-peak measurement, a series of two peak value rectifiers (PVR) with specific time constants have to be used. The PVR system is shown in Figure D.2. The PVR system can be split in two states with the difference equations given in the two following equations.

$$x_p(n) = (1 - AT) \cdot x_p(n-1) + AT \cdot |x(n)|$$

$$x_p(n) = (1 - RT) \cdot x_p(n-1)$$

The time constants AT and RT can be calculated using

$$AT = 1 - \exp\left(-\frac{2{,}2 \cdot T_A}{t_A}\right)$$

$$RT = 1 - \exp\left(-\frac{2{,}2 \cdot T_A}{t_R}\right)$$

where

T_A is the sampling interval;

t is the desired attack or release time in seconds.

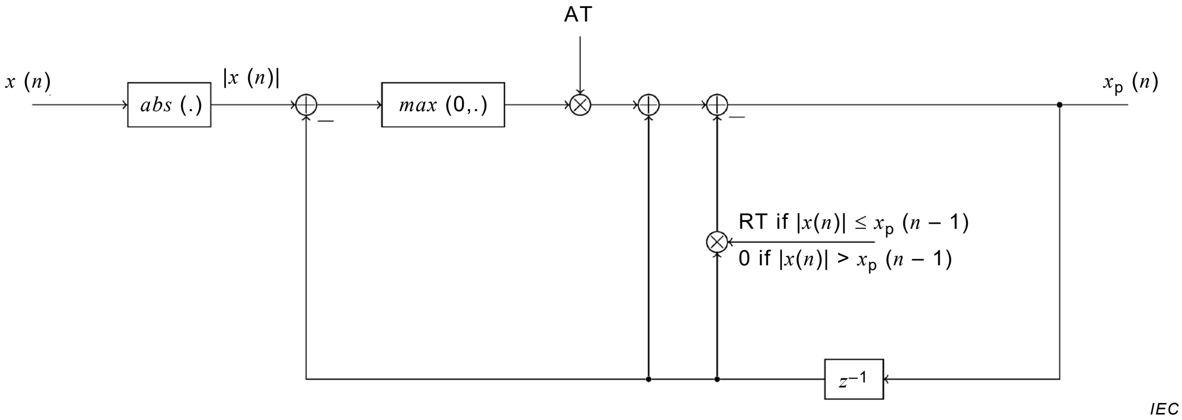


Figure D.2 – Peak value rectifier scheme

The time constants for the two PVRs are given in Table D.1.

Table D.1 – Time constants for the two PVRs

	PVR1	PVR2
t_A	3,4 ms	375 ms
t_R	872 ms	1 000 ms

PVR1 has to be calculated first. The output of PVR1 is then applied to PVR2. The output of PVR2 is the desired quasi-peak value.

D.3 Matlab[1] code

The following Matlab code shows a reference implementation of the recommended method.

1 MATLAB ® is a trademark of the MathWorks, INC. The detail is available at http://www.mathworks.com. This information is given for the convenience of users of this document and does not constitute an endorsement by [ISO or IEC] of the product named. Equivalent products may be used if they can be shown to lead to the same results.

```
function res = qpeak(x,fs,varargin)
% Calculates quasi peak response with ccir-1k filtering
%
%   The function takes an audio signal x with the sampling rate fs and
%    returns the quasi peak response of this signal with a ccir-1k
weighting
%   filter or the unweighted filter according ITU-R BS.468-4.
%   The minimum fs for this function is 88.2kHz because of the
%   CCIR-1k filter specifications.
%   If fs < 88.2kHz x is resampled to double fs
%
%       x: Input Signal
%       fs: Sampling frequency of x
%       ftype (opt): Choose the weighting filter. 'uw' for unweighted
%                    measurement. Defaults to weighted measurment.
%       res: Returns a vector with quasi peak values
%
% H. Riekehof 28.11.2016, SCHOEPS Mikrofone

if fs < 88200
    x = resample(x,2,1);
    fs = 2*fs;
end

ftype = 'w'; % Default setting is set to weighted measurement

if nargin > 3
    error('Too many input arguments');
elseif nargin > 2
    ftype = varargin{1};
end

%% CCIR-1k weighting filter design for "weighted" measurements

fny = fs/2;

% FIR-Design
ccir_freq = [0 31.5 63 100 200 400 800 1000 2000 3150 4000 5000 6300
7100 8000 9000 10000 12500 14000 16000 20000 25000 31500 fny];
ccir_ampl = 10.^([-29.9 -23.9 -19.8 -13.8 -7.8 -1.9 0 5.6 9 10.5 11.7
12.2 12 11.4 10.1 8.1 0 -5.3 -11.7 -22.2 -32.2 -42.7]./20);
ccir_ampl = [0 ccir_ampl 0];

n = 0:length(ccir_ampl)-1;
nq = 0:0.01:length(ccir_ampl)-1;
ccir_ampli = interp1(n,ccir_ampl,nq,'spline');
fq = 0:0.01:length(ccir_freq)-1;
ccir_freqi = interp1(n,ccir_freq,fq,'spline');

n = 3000;
ccir_freqi = ccir_freqi / fny;
h = fir2(n,ccir_freqi,ccir_ampli,2^16);

%% 3rd order butterworth filter for "unweighted" measurements

Wn = 20 / fny;
[b_high,a_high]  =  butter(3,Wn,'high');  %  3rd  order  butterworth
highpass

Wn = 24000 / fny;
[b_low,a_low] = butter(3,Wn,'low'); % 3rd order butterworth lowpass

%% Calculate quasi peak level
```

```
% Optimized time constants by Mr. Ritter from Sennheiser
ta1= 3.4e-3;
tr1= 872e-3;
ta2= 375e-3;
tr2= 1;

% Apply weighting filter
if strcmp(ftype, 'uw')
    xx = filter(b_high,a_high,x);
    x_flt = filter(b_low,a_low,xx);
else
    x_flt = fftfilt(h,x);
end

% Two PVRs in series to obtain quasi peak values
p1 = pvr(x_flt,ta1,tr1,fs);
res = pvr(p1,ta2,tr2,fs);

end

function [ y ] = pvr(x,ta,tr,fs)
% #######################################################
% Linear peak value rectifier.
%
% Input variabels
%   x: Inputsignal
%   ta: Attacktime
%   tr: Releasetime
%   fs: Samplingfrequency
%
%   SCHOEPS Mikrofone
%   H. Riekehof 15.6.2014
%
% ########################################################

AT = 1 - exp(-2.2/(ta*fs));
RT = 1 - exp(-2.2/(tr*fs));

% State memory
s1=0;
y=zeros(length(x),1);

for k=1:length(x),
   xR = abs(x(k));
   flag=(xR>s1);
   if (flag)        % Attack-Phase
      y(k)=AT*xR+(1-AT)*s1;
   else             % Release-Phase
       y(k)=(1-RT)*s1;
   end;
   s1=y(k);
end

end
```

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