

Measurement microphones —

Part 6: Electrostatic actuators for determination of frequency response

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electro-acoustics, which has the responsibility to:

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Measurement microphones**Part 6: Electrostatic actuators for determination of frequency response
(IEC 61094-6:2004)**

Microphones de mesure
Partie 6: Grilles d'entraînement
pour la détermination
de la réponse en fréquence
(CEI 61094-6:2004)

Messmikrofone
Teil 6: Elektrostatische Anregeelektroden
zur Ermittlung des Frequenzgangs
(IEC 61094-6:2004)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

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The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2005-09-01 |
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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61094-6:2004 was approved by CENELEC as a European Standard without any modification.

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MEASUREMENT MICROPHONES –

Part 6: Electrostatic actuators for determination of frequency response

1 Scope

This part of IEC 61094

- gives guidelines for the design of actuators for microphones equipped with electrically conductive diaphragms;
- gives methods for the validation of electrostatic actuators;
- gives a method for determining the electrostatic actuator response of a microphone.

The applications of electrostatic actuators are not fully described within this standard but may include

- a technique for detecting changes in the frequency response of a microphone,
- a technique for determining the environmental influence on the response of a microphone,
- a technique for determining the free-field or pressure response of a microphone without specific acoustical test facilities, by the application of predetermined correction values specific to the microphone model and actuator used,
- a technique applicable at high frequencies not typically covered by calibration methods using sound excitation.

2 Normative references

The following referenced documents are indispensable for the application 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.

IEC 61094-1, *Measurement microphones – Part 1: Specifications for laboratory standard microphones*

IEC 61094-2, *Measurement microphones – Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique*

IEC 61094-3, *Measurement microphones – Part 3: Primary method for free-field calibration of laboratory standard microphones by the reciprocity technique*

IEC 61094-5, *Measurement microphones – Part 5: Methods for pressure calibration of working standard microphones by comparison*

ISO/IEC GUIDE EXPRESS: 1995, *Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61094-1 as well as the following apply.

3.1

electrostatic actuator

device for determination of microphone frequency response comprising an electrically conductive stiff plate placed near the microphone diaphragm such that a time-varying voltage, applied between the plate and the diaphragm, produces an electrostatic force that simulates a sound pressure uniformly distributed over the surface of the diaphragm

3.2

electrostatic actuator response of a microphone

microphone output as a function of frequency measured using a specified design of electrostatic actuator driven by a voltage that is of uniform amplitude with frequency, relative to the output at a specified frequency

NOTE Electrostatic actuator response is expressed in decibels (dB).

3.3

acoustic radiation impedance

acoustic impedance loading the microphone diaphragm on its outer surface

NOTE 1 Acoustic radiation impedance is expressed in pascal-second per cubic meter ($\text{Pa}\cdot\text{s}\cdot\text{m}^{-3}$).

NOTE 2 The radiation impedance depends on the presence and design of the actuator.

4 Reference environmental conditions

The reference environmental conditions are:

temperature	23,0 °C
static pressure	101,325 kPa
relative humidity	50 %

5 Principle of electrostatic actuator operation

5.1 General

In practice, measurements of sound are made in many different environments where different types of sound fields exist. The sensitivity and frequency response of measurement microphones depend on the type of sound field, so ideally the microphone should be calibrated using a similar type of field to that which exists on the measurement site. The various types of sound fields are generally approximated by three idealized fields: free field, diffuse-field and pressure-field.

However, the establishment of such idealized sound fields, which are suitable for calibration of measurement microphones over the frequency ranges of interest is technically difficult and requires costly acoustical laboratory facilities. Therefore, the electrostatic actuator method is used for determining a relative frequency response of measurement microphones. This method, which accounts for the type of sound field by using specific predetermined corrections, requires no such facilities.

At higher frequencies, the free-field sensitivity of a microphone is determined by the behaviour of its diaphragm and the sound diffraction and reflection caused by the microphone.

The effect of the diaphragm behaviour, which may cause significant differences in the relative frequency responses between individual microphones of the same model, requires specific determination. This frequency response determination is performed using the electrostatic actuator method.

The effect of the diffraction and reflection depends on the type of sound field and on the shape and dimensions of the microphone. As these parameters are essentially the same for all microphones of the same model, the influence of diffraction and reflection does not differ significantly between individual microphones of the same model.

Therefore, corrections for specific types of sound field may be determined once for a model of microphone and subsequently applied to the electrostatic actuator response of any microphones of that model.

Free-field and pressure-field corrections are calculated by determining the respective frequency responses of one or more microphones of the same model by using acoustical calibration methods, for example, those in IEC 61094-2 and IEC 61094-3, and by subtracting the respective electrostatic actuator responses.

In principle, the electrostatic actuator calibration method may be used from very low to very high frequencies. However, the actuator excites the microphone diaphragm only and not the static pressure equalisation vent, which is generally exposed to sound when measurements are made in a free-field. The actuator excitation corresponds to that of a pressure-field and thus cannot be used for determination of the lower limiting frequency under free-field conditions. Free-field response determinations by electrostatic actuator should only be made at frequencies which are at least 10 times greater than the lower limiting frequency derived from the time constant of the venting system of the microphone. At low frequencies, a small perforation in the microphone diaphragm will exhibit different effects in the actuator response and in the acoustic responses in a pressure field or a free field. At high frequencies, the degree to which the actuator excitation approximates that of a pressure field depends on the relation between the acoustic impedance of the microphone diaphragm and the acoustic radiation impedance of the microphone diaphragm with the actuator in place. This relation is described in 5.3, while 9.3 describes some practical consequences for the determination of the environmental characteristics of a microphone.

5.2 Electrostatic pressure

The rigid and electrically conductive plate of the actuator is placed close to and parallel to the microphone diaphragm, see Figure 1. It forms an electrical capacitor together with the microphone diaphragm, which shall also be electrically conductive. When a voltage is applied between the capacitor plates, the actuator produces a force F distributed over the diaphragm surface; see Equation (1) below.

The corresponding electrostatically produced pressure p_{act} is defined by Equation (2). Edge effects are neglected. The ratio between the effective actuator area and the active diaphragm area gives a constant, which is generally less than unity because the actuator is perforated for acoustic reasons.