IEC 63041-1

Edition 1.0 2017-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Piezoelectric sensors –
Part 1: Generic specifications

Capteurs piézoélectriques –
Partie 1: Spécification générique

IEC 63041-1:2017-12(en-fr)

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Piezoelectric sensors – Part 1: Generic specifications

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 31.140

ISBN 978-2-8322-7414-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PIEZOELECTRIC SENSORS –

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FOREWORD

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International Standard IEC 63041-1 has been prepared by IEC technical committee TC 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

This bilingual version (2019-11) corresponds to the monolingual English version, published in 2017-12.

The text of this International Standard is based on the following documents:

CDV	Report on voting
49/1220/CDV	49/1249/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63041 series, published under the general title *Piezoelectric sensors*, can be found on the IEC website.

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PIEZOELECTRIC SENSORS –

Part 1: Generic specifications

1 Scope

This part of IEC 63041 applies to piezoelectric sensors of resonator, delay-line and non-acoustic types, which are used in physical and engineering sciences, chemistry and biochemistry, medical and environmental sciences, etc.

The purpose of this document is to specify the terms and definitions for the piezoelectric sensors, and to make sure from a technological perspective that users understand the state-of-art piezoelectric sensors and how to use them correctly.

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.

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050-561:2014, *International Electrotechnical Vocabulary – Part 561: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection*

IEC 60122-2-1, *Quartz crystal units for frequency control and selection – Part 2: Guide to the use of quartz crystal units for frequency control and selection – Section One: Quartz crystal units for microprocessor clock supply*

IEC 60444-9, *Measurement of quartz crystal unit parameters – Part 9: Measurement of spurious resonances of piezoelectric crystal units*

IEC 60617, *Graphical symbols for diagrams*, available at http://std.iec.ch/iec60617

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 80000-1:2009, *Quantities and units – Part 1: General*

3 Terms and definitions

3.1 General

For the purpose of this document, the following terms and definitions 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

Units, letter symbols and terminology shall, wherever possible, be taken from the following standards: IEC 60027, IEC 60050-561, IEC 60617, and ISO 80000-1.

NOTE Piezoelectric sensors covered herein are those used for the detection and measurement of physical quantities, chemical substances or biological molecules.

3.2 Piezoelectric sensors

3.2.1
piezoelectric sensor element
electronic component which is able to detect physical quantities as a change in its frequency, phase, delay, electrical charge, resistance, Q-value, bandwidth, etc.

Note 1 to entry: For chemical and biochemical sensor applications, the piezoelectric sensor element includes a sensitive or receptive layer (target recognition material).

3.2.2
resonator type sensor element
piezoelectric sensor component using acoustic resonances

3.2.3
delay line type sensor element
piezoelectric sensor component using a surface acoustic wave (SAW) delay-line of transversal type

3.2.4
non-acoustic type sensor element
piezoelectric sensor component using the electrical charge induced by a quasi-static force, torque or the like

Note 1 to entry: Here, the term, "non-acoustic", represents "quasi-static piezoelectric". Accordingly, the (piezoelectric) non-acoustic type sensor element means a sensor element using the quasi-static piezoelectric effect.

3.2.5
piezoelectric sensor cell
sensor element equipped with necessary mechanical accessories and attachments to correctly detect the parameters to be measured

3.2.6
piezoelectric sensor module
sensor element or cell equipped with electronic accessories for interfacing to external data acquisitions

3.2.7
piezoelectric sensor
generic term that includes a sensor element, cell and module

3.2.8
QCM
quartz crystal microbalance
one of the families of chemical and biochemical sensors using crystal resonators

Note 1 to entry: A thickness share mode (TSM) sensor is identical with a QCM.

3.3 Types of chemical sensors

3.3.1
piezoelectric chemical sensor element
piezoelectric sensor component including a sensitive layer (target recognition material), which is necessary for the practical measurement of simple non-biological molecules in quantity, and which works and detects chemical substances mainly in the gas phase

Note 1 to entry: A gas sensor element is one of the chemical sensor elements.

3.3.2
piezoelectric biochemical sensor element
piezoelectric sensor component including a receptive layer (target recognition material), which is necessary for the practical measurement of complex biological molecules in quantity, and which works mainly in aqueous media and detects biomolecules therein

3.4 Types of physical sensors

3.4.1
piezoelectric force sensor element
piezoelectric sensor component whose resonance frequency, delay or electrical charge/voltage is used for force measurement

3.4.2
piezoelectric pressure sensor element
piezoelectric sensor component whose resonance frequency, delay or electrical charge/voltage is used for pressure measurement

3.4.3
piezoelectric torque sensor element
piezoelectric sensor component whose resonance frequency, delay or electrical charge/voltage is used for torque measurement

3.4.4
piezoelectric viscosity sensor element
piezoelectric sensor component whose resonance frequency, delay or insertion loss/gain is used for viscosity measurement

3.4.5
piezoelectric temperature sensor element
piezoelectric sensor component whose resonance frequency or delay is used for temperature measurement

3.4.6
piezoelectric film-thickness sensor element
piezoelectric sensor component whose resonance frequency is used for film-thickness measurement

4 Symbols of sensor elements

4.1 General

Figures 1 to 6 show the conceptual diagrams and defined symbols for sensor elements of bulk acoustic wave (BAW) resonator, SAW resonator and SAW delay-line types. The symbols are essentially the same as those given in IEC 60122-1, IEC 61019-1 and IEC 60862-1.

Figure 7 and Figure 8 show the conceptual diagram and defined symbol for sensor elements of non-acoustic type.

NOTE 1 The diagonal line in Figure 2, Figure 4, Figure 6 and Figure 8 shows an emblem expressing changes in objects to be measured.

NOTE 2 Letter symbols (see 4.6) showing the types of sensors are put in the circle at the upper right corner in Figure 2, Figure 4, Figure 6 and Figure 8.

4.2 Symbol for sensor elements of BAW resonator type

Figure 1 shows the conceptual diagrams for sensor elements of BAW resonator type from which a mounting portion is omitted. Figure 2 shows the symbol for sensor elements of BAW resonator type.

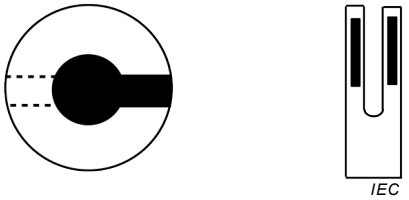

Figure 1 – Conceptual diagrams for sensor elements of BAW resonator type

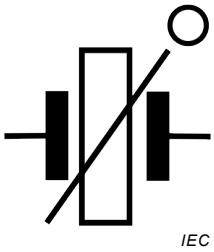

Figure 2 – Symbol for sensor elements of BAW resonator type

4.3 Symbol for sensor elements of SAW resonator type

Figure 3 and Figure 4 show, respectively, the conceptual diagram and symbol for sensor elements of SAW resonator type.

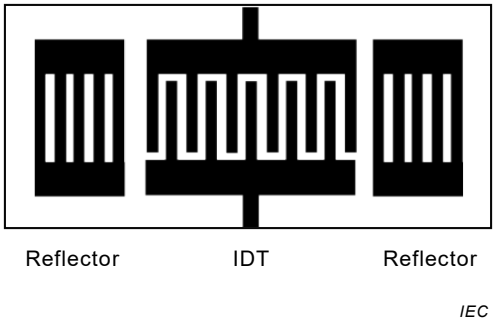

Figure 3 – Conceptual diagram of sensor elements of SAW resonator type

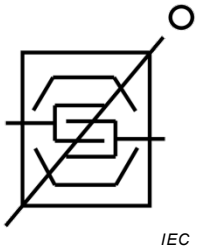

Figure 4 – Symbol for sensor elements of SAW resonator type

4.4 Symbol for sensor elements of SAW delay-line type

Figure 5 and Figure 6 show, respectively, the conceptual diagram and symbol for sensor elements of SAW delay-line type.

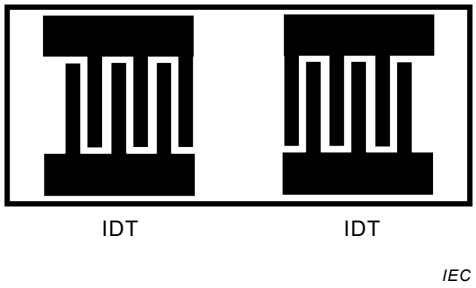

Figure 5 – Conceptual diagram for sensor elements of SAW delay-line type

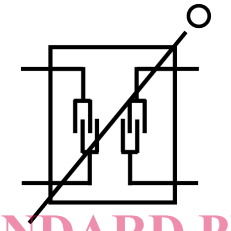

Figure 6 – Symbol for sensor elements of SAW delay-line type

4.5 Symbol for sensor elements of non-acoustic type

Figure 7 shows the conceptual diagrams for sensor elements of non-acoustic type from which a mounting portion is omitted. Figure 8 shows the symbol for sensor elements of non-acoustic type.

Figure 7 – Conceptual diagrams for sensor elements of non-acoustic type

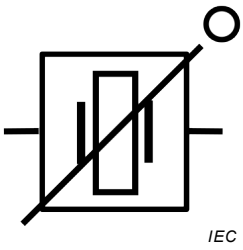

Figure 8 – Symbol for sensor elements of non-acoustic type

4.6 Symbols

The symbols put in the circle at the upper right corner in Figure 2, Figure 4, Figure 6 and Figure 8 are defined below (see ISO 80000 all parts):

a) film-thickness: d;

b) force: F;

c) mass: m;

d) density: ρ;

e) pressure: P;

f) temperature: T;

g) torque: τ;

h) viscosity: υ.

In chemical, biochemical and gas sensor applications, antigen-antibody or chemical reaction occurs between the sensitive or receptive layer and target substances, which is detected as a change in mass density, viscosity or shear modulus of the sensitive or receptive layer. Accordingly, the following specific symbols are defined for biochemical, chemical and gas sensor elements:

i) biochemical: Bi;

j) chemical: Ch;

k) gas: Ga.

5 Specifications

5.1 Sensor elements

5.1.1 General

In consideration of the target sensitivity, dynamic range or the like, the specifications of sensor elements and cells shall be determined. They should be defined clearly in the contract to be concluded between the manufacturer and customers.

Subclauses 5.1.2 and 5.1.3 present key points to be described in the specifications. These elements should be specified numerically unless confidential technological information is concerned.

5.1.2 Sensor elements of resonator and delay-line types

Sensor elements of resonator and delay-line types include the following:

a) range of measurand;

b) sensitivity of output signal with respect to measurand;

c) nominal frequency;

d) frequency tolerance;

e) parameters of equivalent circuit;

f) operating temperature range;

g) unwanted response;

h) level of drive or input power;

i) insertion loss/gain;

j) delay time (for sensor elements of SAW delay-line type);

k) phase response;

l) piezoelectric material, cut angle, or the like;

m) electrode material, dimension, shape, structure or the like;

n) mounting material, dimension, shape, structure or the like;

o) dimensions of enclosure, or name, model number or the like corresponding thereto;

p) category of environmental test;

q) others.

5.1.3 Sensor elements of non-acoustic type

Sensor elements of non-acoustic type include the following:

a) operating temperature range;

b) piezoelectric material, cut angle, dimension, shape, structure or the like;

c) electrode material, dimension, shape, structure or the like;

d) mounting material, dimension, shape, structure or the like;

e) dimensions of enclosure, or name, model number or the like corresponding thereto;

f) category of environmental test;

g) others.

5.2 Frequency ranges

The frequency range applied herein should be 10 kHz to 10 GHz.

When one of the higher-order overtones is used or the frequency deviates from the specified range, the manufacturer and customer shall consult, and the results shall clearly be defined in the contract.

NOTE The frequency ranges for sensor elements of non-acoustic type are not defined.

5.3 Level of drive or input power

For sensor elements and cells, the level of drive or input power shall be limited so that an influence of “heat generation” or a “non-linear effect” does not deteriorate their performance.

NOTE The level of drive or input power for non-acoustic type sensor elements is not defined.

5.4 Unwanted response

Unwanted responses shall be measured based on IEC 60444-9. This rule shall be applied only to sensor elements of BAW resonator type.

According to IEC 60122-2-1, the ratio of the motional resistance R_N for the unwanted response to R_1 for the main response ($N=R_N/R_1$) shall be two and a half times or more.

NOTE Conceptually, the sensitivity increases with an increase in the electrode area, which reduces the ratio of R_N / R_1. Under this situation, unwanted responses affect the main response, and sensor elements of BAW resonator type occasionally oscillate, caused by the unwanted response.

5.5 Analysis of measurements

Electronic circuits and measuring instruments are generally used in sensor systems. The output signals such as frequency, phase, insertion loss/gain, electrical charge / voltage, etc., and their response functions and graphs are obtained as system data.

The rule on how to apply this system data to data analyses shall clearly be defined in the contract to be concluded between the manufacturer and customer, or in individual specifications.

NOTE The response function based on the linear response theory is effective in the analysis of acoustic wave sensor elements and cells of resonator and delay-line types. For example, it is possible for the frequency response to predict the resonant response levels of the acoustic wave sensor.