IEC 63041-2

Edition 1.0 2017-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Piezoelectric sensors –
Part 2: Chemical and biochemical sensors

Capteurs piézoélectriques –
Partie 2: Capteurs chimiques et biochimiques

IEC 63041-2:2017-12(en-fr)

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PIEZOELECTRIC SENSORS –

Part 2: Chemical and biochemical sensors

FOREWORD

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International Standard IEC 63041-2 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
49/1221/CDV	49/1250/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.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
- replaced by a revised edition, or
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PIEZOELECTRIC SENSORS –

Part 2: Chemical and biochemical sensors

1 Scope

This part of IEC 63041 is applicable to piezoelectric chemical sensors mainly used in the field of biological, medical, gas and environmental sciences. It provides users with technical guidelines on biochemical sensors as well as basic knowledge of common chemical sensors.

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

IEC 63041-1, *Piezoelectric sensors – Part 1: Generic specifications*

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, IEC 63041-1, and ISO 80000-1.

NOTE 1 In the market of chemical and biochemical sensors, the terms related in fields such as chemistry, biochemistry, healthcare, etc. are widely used.

NOTE 2 Piezoelectric sensors covered herein are those used for the detection and measurement of either chemical substance in the gas phase or biological molecules in aqueous media.

3.2 Types of chemical and biochemical sensors

3.2.1
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: For example, there are odour sensors, vapour sensors, smoke sensors, etc.

[SOURCE: IEC 63041-1:2017, 3.3.1, modified – Note 1 to entry has been added.]

3.2.2
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

[SOURCE: IEC 63041-1:2017, 3.3.2]

4 Specifications

4.1 General

Chemical and biochemical sensors are used in various applications, for example, in the detection of target molecules/substances, the detection of growth, decrease, differentiation and cohesion in cells, the detection of adsorption or absorption, the confirmation of the competition reaction, etc. Concepts and specifications for chemical and biochemical sensors are shown in detail in 4.2 to 4.5.

4.2 Conceptual diagram of BAW sensor elements and cells

Figure 1 shows the practical conceptual diagram for a bulk acoustic wave (BAW) sensor element. In the figure, mounting stages and enclosures are omitted.

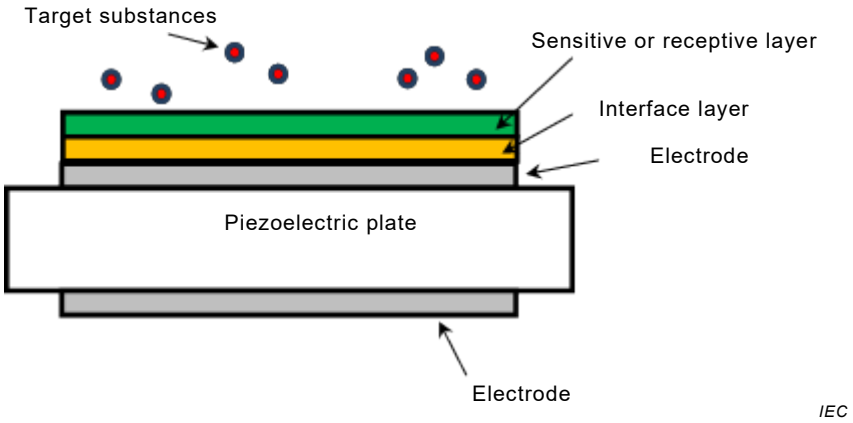

Figure 1 – Conceptual diagram for chemical and biochemical sensor elements and cells of BAW resonator type (side view)

4.3 Conceptual diagram of SAW sensor elements and cells

Figures 2 and 3 show the practical conceptual diagrams for two kinds of sensor elements and cells, respectively, of surface acoustic wave (SAW) resonator and delay-line types. In the figures, mounting stages and enclosures are omitted.

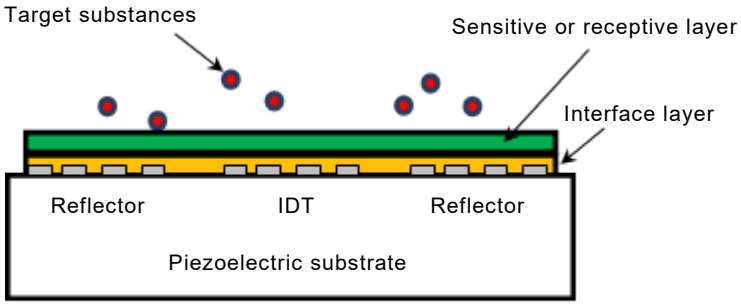

Figure 2 – Conceptual diagram for chemical and biochemical sensor elements and cells of SAW resonator type (side view)

NOTE Reflector and interdigital transducer (IDT) are defined in IEC 61019-1:2004.

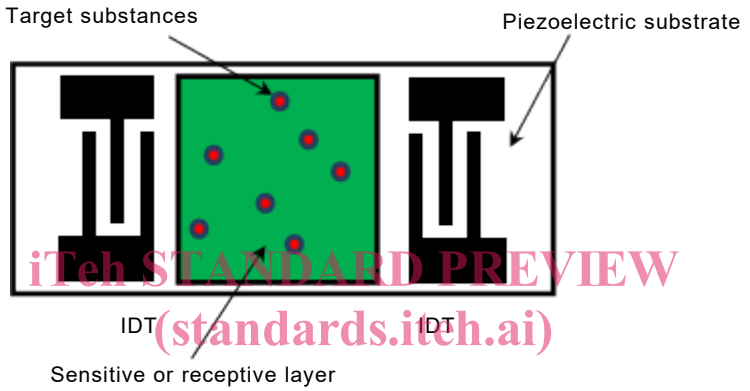

Figure 3 – Conceptual diagram for chemical and biochemical sensor elements and cells of SAW delay-line type (top view)

4.4 Key points of specifications

4.4.1 General

Key points of the specification are identified in Clause 5 of IEC 63041-1:2017. In addition, the items specified in 4.4.2 to 4.4.4 should clearly be defined.

4.4.2 Interface layer

As can be seen in Figures 1 and 2, an interface layer is formed to increase the adhesion of the sensitive or receptive layer to the electrode/substrate.

4.4.3 Sensitive or receptive layer (target recognition material)

A sensitive layer employed in chemical sensor applications or a receptive layer employed in biochemical sensor applications should properly be selected for specific target molecules/substances.

For BAW resonator type sensor elements and cells, the sensitive or receptive layer is formed on the electrode of one surface (see Figure 1), whereas it is formed on the SAW propagation surface of SAW resonator and delay-line type sensor elements and cells (see Figures 2 and 3).

4.4.4 Nonspecific and unselective reactions

For chemical and biochemical sensor elements and cells, sensitive or receptive layers and solvents should be selected so that nonspecific and unselective reactions may be minimized in conjunction with target molecules/substances.

4.5 Improved sensor performance

In some situations, an acoustic waveguide layer is formed to increase the sensitivity of SAW delay-line type chemical and biochemical sensor elements and cells.

Figure 4 shows the conceptual diagram of shear horizontal (SH)-SAW delay-line type chemical and biochemical sensor elements and cells, where the material for the interface layer, acoustic waveguide layer and the like should be defined in the contract.

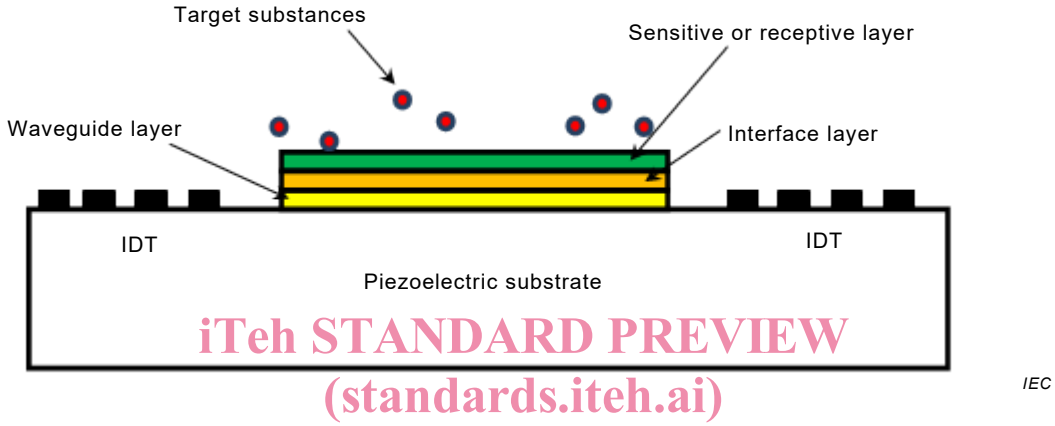

Figure 4 – Conceptual diagram for SAW chemical and biochemical sensor elements and cells with three-layer reaction region on a propagation surface (side view)

4.6 Technical documents

The following 1) and 2) should clearly be defined in the specifications in the contract to be concluded between the manufacturer and customers.

1) When a term other than a) to d) shown below is used.
   a) Limit of detection: the minimum amount or concentration detectable by sensor cells.
   b) Limit of quantitation: the minimum amount or concentration detectable by sensor modules.
   c) Maximum limit of determination: the maximum analyte amount or concentration on which quantitative analysis can be performed, also called the “maximum limit of quantitation”.
   d) Sensitivity: the dependence of the output of sensor elements and cells upon the detected amount or concentration, i.e., the slope of a calibration curve.
2) Setting of reliability interval.

5 Delivery conditions

See Clause 7 of IEC 63041-1:2017.

6 Quality and reliability

See Clause 8 of IEC 63041-1:2017.

7 Test and measurement procedures

See Clause 9, and Annexes A and B of IEC 63041-1:2017.

Annex A
(informative)

Chemical reaction in sensor cells

A.1 Reference values before and after reaction

As shown in Figures A.1 and A.2, resonance frequency, oscillation frequency, phase, insertion loss/gain, motional resistance, etc. of sensor cell outputs should be defined at time t_1 as the initial values before chemical and/or biochemical reactions occur. In a similar way, they should be also defined at time t_2 as final values after the reaction has completed.

For these specifications, the manufacturer and customer shall have detailed discussions, the discrepancies shall be eliminated, and the results shall clearly be described in the contract clause, the requirements specifications of the customer, the delivery specifications thereof or the like, and shall be settled as one of the contracts with the customer.

The reaction shall be quantified using formulae and recorded.

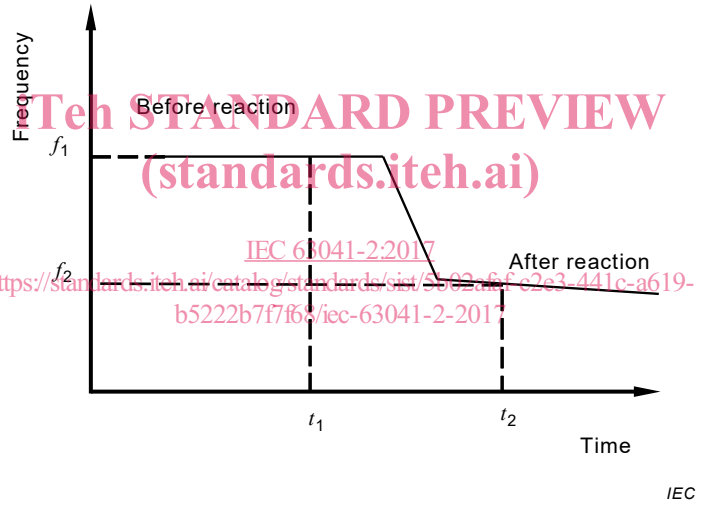

Figure A.1 – Frequency-time characteristics

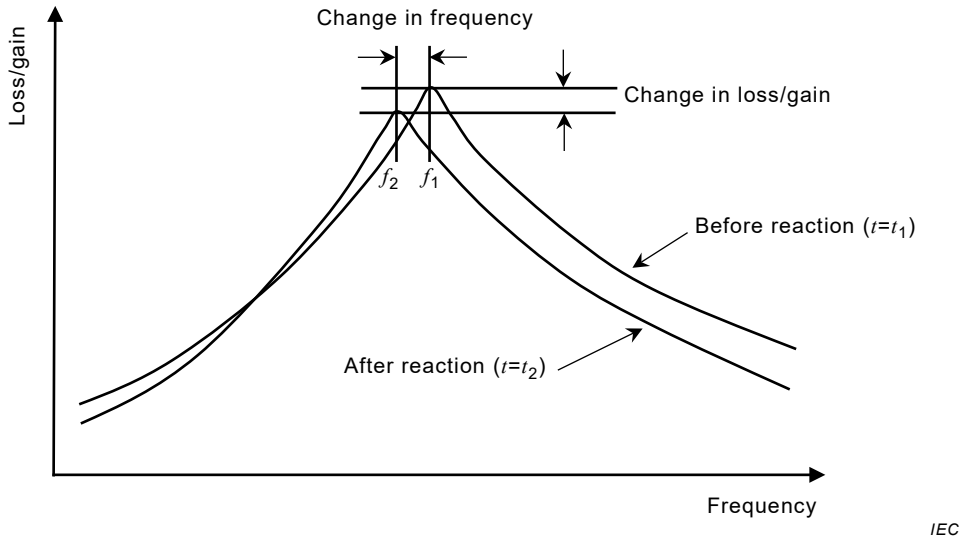

Figure A.2 – Conceptual resonance response of an SAW sensor cell

A.2 Typical formulae

A.2.1 General

The formulae presented in A.2.2 and A.2.3 are typical examples used for chemical and biochemical sensor cells. For these formulae, the manufacturer and customer shall have detailed discussions, the discrepancies shall be eliminated, and the results shall be described clearly in the contract clause.

A.2.2 BAW (AT-cut QCM)

a) Mass-loading

$$\Delta f = -2{,}26 \times 10^{-7} \Delta m f^2 \tag{A.1}$$

and

$$\Delta m = \rho' d \tag{A.2}$$

where

f is the frequency;

Δm is the change in the surface mass density;

ρ' is the density of a sensitive or receptive layer;

d is the thickness of a sensitive or receptive layer.

$\Delta f = f_1 - f_2$

b) Viscosity

Relationship between viscosity and frequency deviation,

$$\Delta f = -4{,}17 \times 10^{-8} f^{\frac{3}{2}} \left\{ \left(\rho'_{\mathrm{e}} \eta'_{\mathrm{e}}\right)^{\frac{1}{2}} - \left(\rho_{\mathrm{e}} \eta_{\mathrm{e}}\right)^{\frac{1}{2}} \right\} \tag{A.3}$$

where