



BSI Standards Publication

Quartz crystal units of assessed quality

Part 2: Guidelines for the use

National foreword

This British Standard is the UK implementation of EN IEC 60122-2:2025. It is identical to IEC 60122-2:2025.

The UK participation in its preparation was entrusted to Technical Committee W/-, Miscellaneous Standards.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Date	Text affected

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Quartz crystal units of assessed quality - Part 2: Guidelines for
the use
(IEC 60122-2:2025)

Résonateurs à quartz sous assurance de la qualité - Partie
2: Lignes directrices pour l'utilisation
(IEC 60122-2:2025)

Schwingquarze mit bewerteter Qualität - Teil 2: Leitlinien
zur Anwendung
(IEC 60122-2:2025)

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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European foreword

The text of document 49/1506/FDIS, future edition 3 of IEC 60122-2, prepared by TC 49 "Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60122-2:2025.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2026-08-31 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2028-08-31 document have to be withdrawn

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In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60068 (series) NOTE Approved as EN 60068 (series)

IEC 60444 (series) NOTE Approved as EN 60444 (series)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cencenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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+ A1	2017		+ A1	2018

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Quartz crystal units of assessed quality -
Part 2: Guidelines for the use**

FOREWORD

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IEC 60122-2 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection. It is an International Standard.

This third edition cancels and replaces the second edition published in 1983. This edition constitutes a technical revision.

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

- a) addition of SC cut type and related requirements;
- b) addition of ageing calculation and low level of drive requirements according to the general specification,
- c) update of the frequency temperature curve according to the common cut requirements;
- d) removal of infrequently used product types.

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

Draft	Report on voting
49/1506/FDIS	49/1513/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60122 series, published under the general title *Quartz crystal units of assessed quality*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

1 Scope

This part of IEC 60122 has been compiled in response to a generally expressed desire on the part of both users and manufacturers for guidelines to the use of quartz crystal units for filters and oscillators so that the crystal units may be used to their best advantage.

It draws attention to some of the more fundamental questions which will be considered by the user before it places its order for a unit for a new application, and in so doing will, it is hoped, help ensure against unsatisfactory performance, unfavourable cost and non-availability. It is not the function of this document to explain theory, nor to attempt to cover all the eventualities that can arise in practical circumstances. Lastly, it is not considered as a substitute for close liaison between manufacturer and user.

Standard specifications, such as those of the IEC of which these guidelines form a part, and national specifications or detail specifications issued by manufacturers, will define the available combinations of the resonant characteristics and the temperature characteristic. These specifications are compiled to include a wide range of quartz crystal units with standardized performances. It cannot be over-emphasized that it is the responsibility of the user, wherever possible, to select the quartz crystal units from these specifications, when available, even if it can lead to making small modifications to the circuit to enable the use of standard resonators. This applies particularly to the selection of the nominal frequency.

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 60122-1:2002, *Quartz crystal units of assessed quality – Part 1: Generic specification*
IEC 60122-1:2002/AMD1:2017

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60122-1 apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 Quartz crystal unit as an electronic component

4.1 General

The quartz crystal element is a vibrating resonant structure whose orientation and dimensions determine its frequency for a given mode of vibration and which relies on the piezoelectric effect to couple it to an electrical circuit. The intrinsic properties of quartz make it a unique device for highly accurate and stable frequency control and selection because of its high "quality factor" Q . Crystal units are not a primary frequency standard, but when precisely defined, can provide stabilization far in excess of most requirements in the electronic industry.

The crystal element is cut from monocrystal quartz with precise orientation to the crystallographic axes as shown in Figure 1, which shows only generalized examples of the most commonly used crystal cuts.

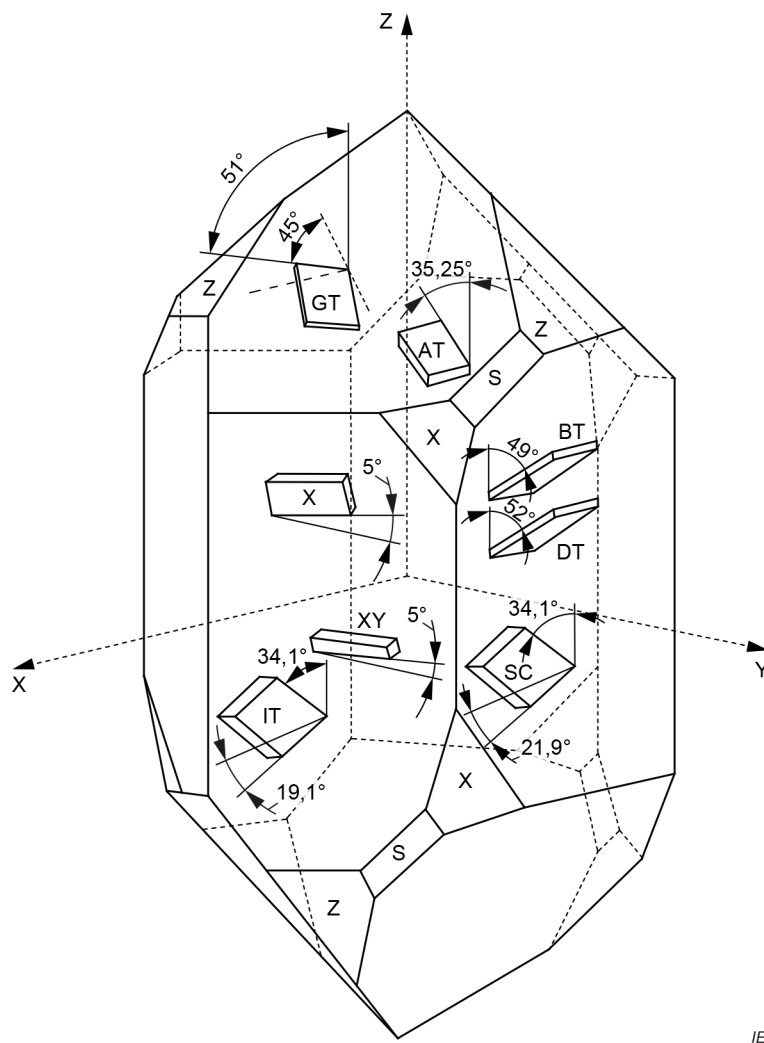


Figure 1 – Designation of the most commonly used crystal cuts

Figure 1 shows a natural quartz crystal. However, most manufacturers now use synthetic material. Techniques have advanced to a point where synthetic quartz is almost indistinguishable from natural material with regard to electrical performance.

There are a number of different cuts and modes of vibration which will produce crystal units of near zero temperature coefficients over a wide frequency range.

4.2 Modes of vibration

The frequency range covered commercially by quartz crystal units can be taken to be a few kHz to 500 MHz. Use is made of many cuts and modes of vibration to cover this range and crystals of the common types are summarized in Table 1.

AT-cut crystal units can also be produced in the range from 400 kHz to 800 kHz, but they usually require larger enclosures.

The choice of mode or cut can be affected by the enclosure size or parameters other than the frequency itself.

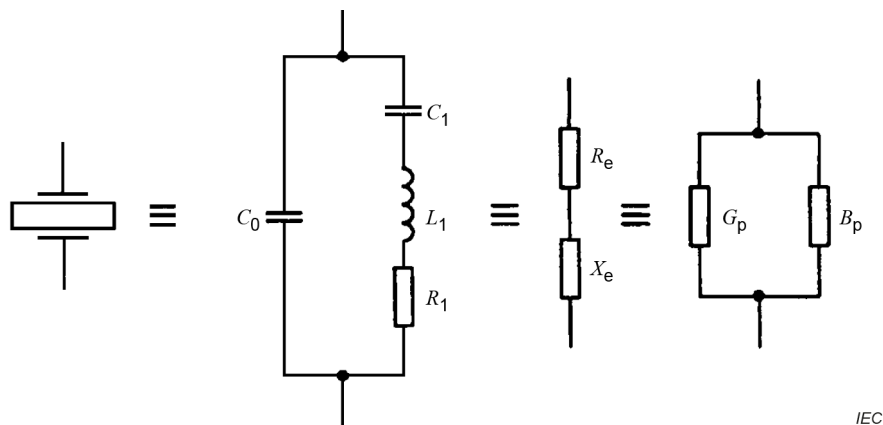
Table 1 – Modes of vibration as a function of frequency

Designation of cut	Mode of vibration	Usual frequency range
XY	Flexural	1 kHz to 80k Hz
5° X bar	Extensional	40 kHz to 200 kHz
AT	Thickness shear (fundamental)	800 kHz to 500 MHz
	3rd overtone	5 MHz to 215 MHz
	5th overtone	5 MHz to 150 MHz
	7th overtone	100 MHz to 200 MHz
BT	Thickness shear (fundamental)	3 MHz to 30 MHz
DT	Face shear	100 kHz to 500 kHz
SC	Thickness shear (fundamental)	8,192 MHz to 30 MHz
	3rd overtone	5 MHz to 100 MHz
	5th overtone	5 MHz to 130 MHz
GT	Coupled mode by two extensional modes	100 kHz to 550 kHz
IT	Fundamental	8,192 MHz to 30 MHz
	3rd overtone	5 MHz to 100 MHz

NOTE The by far most frequently used cuts are XY-cut for “watch crystals” (32.768 kHz), AT-cut for industrial applications in the MHz range, SC-cut and IT cut for high-precision applications.

4.3 The equivalent electrical circuit of a quartz crystal unit

The properties of any mode of a lightly damped mechanical vibrator piezoelectrically excited through electrodes can be represented, in the region of the resonance frequency, by an equivalent electrical circuit which consists of a capacitance (C_1), inductance (L_1) and resistance (R_1) in series, shunted by a second capacitance (C_0). A representation of the quartz crystal unit equivalent circuit is shown in Figure 2.



C_0 is the shunt (parallel) capacitance in the equivalent electric circuit (farad)

C_1 is the motional capacitance in the equivalent electric circuit (farad)

L_1 is the motional inductance in the equivalent electric circuit (henry)

R_1 is the motional resistance in the equivalent electric circuit (ohm)

R_e is the equivalent series resistance of the resonator (ohm)

X_e is the equivalent series reactance of the resonator (ohm)

G_p is the equivalent parallel conductance of resonator (siemens)

B_p is the equivalent parallel susceptance of resonator (siemens)

Figure 2 – Equivalent circuit of a quartz crystal unit

The parameters are independent of frequency for isolated modes of motion. For identification of symbols used in this document, see IEC 60122-1:2002, Table 1.

This representation of a quartz crystal unit is true only if the parameters are constant and independent of frequency and amplitude. The parameters are independent of frequency if the vibrator has no other mode of motion near the particular resonance. Generally, the mode in question is sufficiently isolated from other modes to permit this assumption. When this is not true, the equations and measuring methods normally used do not apply. The validity of the circuit representation can be determined by measuring and plotting the impedance or admittance of the vibrator as a function of frequency.

The inductance represents the vibrating mass, the series capacitance, the compliance of the quartz element and the resistance, the internal friction of the element, mechanical losses in the mounting system and acoustical losses to the surrounding environment. The shunt capacitance is made up of the static capacitance between the electrodes, together with stray capacitances of the mounting system.

There are two zero-phase frequencies associated with this simple circuit, one is resonance frequency, zero reactance (f_r), the other is at anti-resonance frequency, zero susceptance (f_a).