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Interested committees:

Title: BS EN IEC 60122-2 Quartz crystal units of assessed quality

Part 2: Guide to the use

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



49/1419/CD

COMMITTEE DRAFT (CD)

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2023-04-07

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2023-06-30

SUPERSEDES DOCUMENTS:

49/1398/RR

IEC TC 49 : PIEZOELECTRIC, DIELECTRIC AND ELECTROSTATIC DEVICES AND ASSOCIATED MATERIALS FOR FREQUENCY CONTROL, SELECTION AND DETECTION

SECRETARIAT:

Japan

SECRETARY:

Mr Masanobu Okazaki

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☒ QUALITY ASSURANCE

☐ SAFETY

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Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Quartz crystal units of assessed quality - Part 2: Guide to the use

NOTE FROM TC/SC OFFICERS:

The series title of IEC 60122 has been revised in Part 3:2010 and Part 4:2019 to "Quartz crystal units of assessed quality". The project leader is correct with the title in his original CD draft. Previously it was "Quartz crystal units for frequency control and selection - Part 2: Guide to the use of quartz crystal units for frequency control and selection" been revised to "Quartz crystal units of assessed quality - Part 2: Guide to the use".

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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.

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) Add SC cut type and related requirements
- b) According to the general specification, Add aging calculation and Low level of drive requirements have been added
- c) Update the frequency temperature curve according to the common cut requirements
- d) Remove infrequently used product types

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

Draft	Report on voting
49XX/FDIS	49/XX/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.

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,
- replaced by a revised edition, or
- amended.

QUARTZ CRYSTAL UNITS OF ASSESSED QUALITY

Part 2: Guide to use

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 a guide 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 should be considered by the user before he places his 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 standard to explain theory, nor to attempt to cover all the eventualities that may arise in practical circumstances. Lastly, it should not be considered as a substitute for close liaison between manufacturer and user.

Standard specifications, such as those of the IEC of which this guide forms 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 the user should, wherever possible, select his quartz crystal units from these specifications, when available, even if it may lead to making small modifications to his 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

3 Terms and definitions

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

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

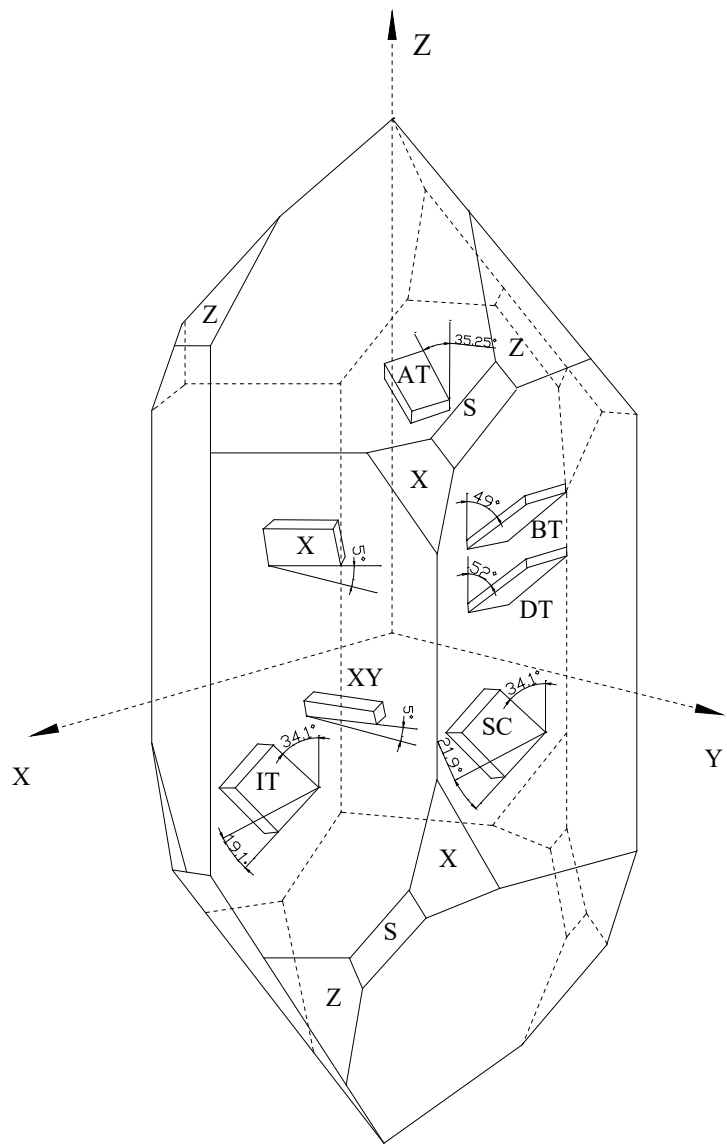
- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 The 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.

185 The crystal element is cut from monocrystalline quartz with precise orientation to the crystallographic
186 axes as shown in Figure 1. This figure only shows only generalized examples of the most commonly
187 used crystal cuts.



188
189 **Figure 1 – Designation of the most commonly used crystal cuts**

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

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

195 **4.2 Modes of vibration**

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

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

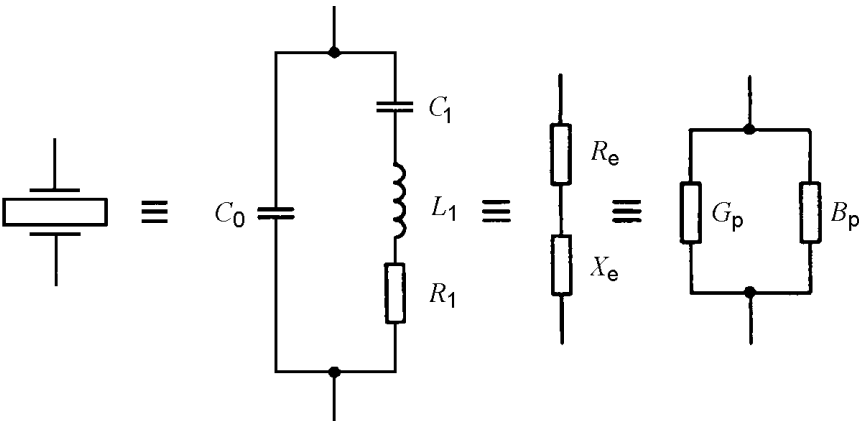
The choice of mode or cut may be affected by the enclosure size or parameters other than the frequency itself.

Table 1 – Modes of vibration as a function of frequency

Designation of cut	Mode of vibration	Usual frequency range
ZYW	Tuning Fork	10kHz~200kHz
XY	Flexural	1kHz~80kHz
5° X bar	Extensional	40kHz~200kHz
AT	Thickness shear (fundamental)	800kHz~500MHz
	3rd overtone	5MHz~215MHz
	5th overtone	5MHz~150MHz
	7th overtone	100MHz~200MHz
BT	Thickness shear (fundamental)	3MHz~30MHz
DT	Face shear	100kHz~500kHz
SC	Thickness shear (fundamental)	8.192Mhz~30MHz
	3rd overtone	5MHz~100MHz
	5th overtone	5MHz~130MHz
IT	fundamental	8.192Mhz~30MHz
	3rd overtone	5MHz~100MHz

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 (C1), inductance (L1) and resistance (R1) in series, shunted by a second capacitance (C0).A representation of the quartz crystal unit equivalent circuit is shown in Figure 2.



- Co is Shunt (parallel) capacitance in the equivalent electric circuit(farad)
- C1 is Motional capacitance in the equivalent electric circuit(farad)
- L1 is Motional inductance in the equivalent electric circuit (henry)

- 215 R1 is Motional resistance in the equivalent electric circuit (ohm)
 216 Re is Equivalent series resistance of resonator (ohm)
 217 Xe is Equivalent series reactance of resonator (ohm)
 218 Gp is Equivalent parallel conductance of resonator
 219 Bp is Equivalent parallel susceptance of resonator.

Figure 2 – Equivalent circuit of a quartz crystal unit

221 The parameters are independent of frequency for isolated modes of motion. Generally, the mode in
 222 question is sufficiently isolated from other modes to permit this assumption. When this is not true, the
 223 equations and measuring methods outlined herein do not apply. For identification of symbols used in
 224 this part, see IEC 60122-1:2002 table 1.

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

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

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

4.4 Crystal resistance

238 The following points on the resistance parameters should be noted:

- 239 a. The lowest values will be found under vacuum.
 240 b. There are certain differences in the resistance parameters of the same lot of crystal elements, and
 241 lot-to-lot variations may be even larger.
 242 c. The smaller the enclosure chosen for a given frequency the higher the average values of R1 and
 243 L1 are likely to be.
 244 d. In general, the resistance of low frequency cuts rises appreciably with temperature. For example,
 245 crystal units employing DT-cuts may have twice the resistance at 85°C that they have at 25 °C.

246 The equivalent circuit of the crystal unit has one other important parameter, this is R1, the motional
 247 resistance. This parameter controls the Q of the crystal unit and will define the level of oscillation in any
 248 maintaining circuit. The load resonance resistance for a given crystal unit depends upon the load
 249 capacitance with which that unit is intended to operate.

250 As was seen earlier, the frequency of oscillation in an appropriate circuit is approximately the same in
 251 either a series or parallel connection of the load capacitance. If the external capacitance is designated,
 252 the load resonance resistance may be calculated as follows:

$$R_L = R_1 \left(1 + \frac{C_0}{C_L}\right)^2$$

254 The equivalent shunt or parallel resistance at the load resonance frequency is approximately:

$$R_p = \frac{1}{R_1} [\omega(C_0 + C_L)]^{-2}$$

It should be remembered that R_1 does not change; thus, the effective parameters of any user network can be readily calculated.

In most cases, the resistance of a particular unit cannot be predicted during manufacture; it is only possible to ensure that it is less than the maximum given in the specification.

Finally, it should always be remembered when specifying that the resistance with a series capacitor is always increased over the value of the crystal itself. Some national specifications give values of resonance resistance with load capacitance as well as without load capacitance.

When used in an oscillator, quartz crystal units will operate at any frequency within the broken lines of Figure 4, as determined by the phase and effective reactance of the maintaining circuit.

By variation of this reactive condition, the crystal frequency may be trimmed to a limited extent. The degree to which this frequency may be varied (frequency pulling) is inversely proportional to the capacitance ratio

$$\gamma = \frac{C_0}{C_1}$$

The C_0/C_1 ratios are typical values. However, various techniques adopted by individual manufacturers in the design of quartz crystal units may lead to quite wide variations; C_0 is the shunt capacitance and C_1 is the motional capacitance.

For AT and BT-cuts, the C_0/C_1 ratio will tend to increase with smaller enclosures, particularly at the lower end of the frequency range.

In filter applications, the bandwidth may be affected by this ratio. In general, the higher the ratio the narrower the bandwidth.

