



SLOVENSKI STANDARD

oSIST prEN IEC 60122-2:2024

01-oktober-2024

Kvarčna kristalna enota določene kakovosti - 2. del: Smernice za uporabo

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

Résonateurs à quartz sous assurance de la qualité - Partie 2: Lignes directrices pour l'utilisation

Ta slovenski standard je istoveten z: prEN IEC 60122-2:2024

ICS:

31.140

Piezoelektrične naprave

Piezoelectric devices

oSIST prEN IEC 60122-2:2024

en



49/1461/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER:

IEC 60122-2 ED3

DATE OF CIRCULATION:

2024-08-16

CLOSING DATE FOR VOTING:

2024-11-08

SUPERSEDES DOCUMENTS:

49/1451/CD, 49/1456/CC

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 CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC☐ ENVIRONMENT☒ QUALITY ASSURANCE☐ SAFETY☒ SUBMITTED FOR CENELEC PARALLEL VOTING☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

Attention IEC-CENELEC parallel voting

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.

The CENELEC members are invited to vote through the CENELEC online voting system.

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant "In Some Countries" clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

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

PROPOSED STABILITY DATE: 2027

NOTE FROM TC/SC OFFICERS:

Copyright © 2024 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
Part 2: Guidelines for the use	7
1 Scope	7
2 Normative references	7
3 Terms and definitions	7
4 The quartz crystal unit as an electronic component	7
4.1 General	7
4.2 Modes of vibration	8
4.3 The equivalent electrical circuit of a quartz crystal unit	9
4.4 Crystal resistance	10
4.5 Frequency versus temperature characteristics	11
4.6 Q Factor	14
4.7 level of drive and drive level dependency	15
4.7.1 level of drive	15
4.7.2 High level of drive	15
4.7.3 Low level of drive	15
4.7.4 drive level dependency	15
4.8 Specifying frequency tolerance and operating temperature range	16
4.9 Load capacitance and frequency pulling	17
4.10 Unwanted responses	20
4.11 Effects of ageing	22
Figure 11 –Typical aging curves	23
4.12 Crystal unit enclosures	24
4.13 Start-up time	24
4.14 Mechanical reliability	25
5 Application guide	25
5.1 Oscillator circuits and oscillation condition	25
5.1.1 Factors affecting the frequency	25
5.1.2 Types of oscillators	25
5.1.3 Series resonance oscillators	26
5.2 Oscillators, practical considerations	28
5.2.1 Crystal unit resistance	28
5.2.2 Unwanted responses	28
5.2.3 Drive level	28
5.2.4 Frequency stability.....	28
5.3 Use in filter applications	28
6 Factors affecting cost and availability of quartz crystal units	29
6.1 Introduction	29
6.2 Crystal unit frequency.....	29
6.3 Crystal unit enclosures	30
6.4 Frequency tolerances	30
6.5 AT-cut. Temperature coefficient cost aspects	30
6.6 Ageing.....	31
6.7 Environmental	31
6.8 General testing considerations	31

7 Technical data to accompany order form	31
7.1 Check list of crystal unit parameters to be specified in article sheet	31
7.2 Mandatory requirements	32
Table 3 – Checklist	32
Bibliography	34
Figure 1 – Designation of the most commonly used crystal cuts	8
Figure 2 – Equivalent circuit of a quartz crystal unit	9
Figure 3 – Reactance/frequency variation characteristic in the vicinity of resonance	11
Figure 4 – Theoretical frequency/temperature curves of some common crystal cuts	12
Figure 5 – Frequency/temperature curves generalized(AT-cut)	13
Figure 6 – Frequency/temperature curves generalized(SC-cut)	14
Figure 7 – Theoretical reactance/frequency of quartz crystal resonators	17
Figure 8 – Fractional load resonance frequency offset (D_L), fractional pulling range ($D_{L1, L2}$) and pulling sensitivity of a quartz crystal unit.	19
Figure 9 – Pulling sensitivity (S) versus C_0/C_1 for various values of load capacitance C_L	19
Figure 10 – Five example unwanted crystal responses measured over the spectrum adjacent to the main response	21
Figure 11 – Typical aging curves	23
Figure 12 – Series resonance oscillator	26
Figure 13 – Positive reactance oscillator	26
Figure 14 – The crystal unit operates as an inductance in the phase shifting network	27
Figure 15 – Crystal unit with a series connected load capacitance	27
Figure 16 – AT cut crystal units-frequency tolerance/temperature range difficulty aspect	31
Table 1 – Modes of vibration as a function of frequency	9
Table 2 – Tine acceleration factors for $E_a=0.38\text{eV}$	23
Table 3 – Checklist	32

INTERNATIONAL ELECTROTECHNICAL COMMISSION

QUARTZ CRYSTAL UNITS OF ASSESSED QUALITY

Part 2: Guidelines for the use

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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, 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

56

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

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

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

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

- 67 • reconfirmed,
- 68 • withdrawn,
- 69 • replaced by a revised edition, or
- 70 • amended.

71

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[oSIST prEN IEC 60122-2:2024](https://standards.iteh.ai/catalog/standards/sist/df2a5a1f-3e01-4f21-a802-a8eb8e07560c/osist-pren-iec-60122-2-2024)

<https://standards.iteh.ai/catalog/standards/sist/df2a5a1f-3e01-4f21-a802-a8eb8e07560c/osist-pren-iec-60122-2-2024>

72

INTRODUCTION

73 The International Electrotechnical Commission (IEC) draws attention to the fact that it is
74 claimed that compliance with this document may involve the use of a patent. IEC takes no
75 position concerning the evidence, validity, and scope of this patent right.

76 The holder of this patent right has assured IEC that s/he is willing to negotiate licences under
77 reasonable and non-discriminatory terms and conditions with applicants throughout the world.
78 In this respect, the statement of the holder of this patent right is registered with IEC.
79 Information may be obtained from the patent database available at patents.iec.ch/.

80 Attention is drawn to the possibility that some of the elements of this document may be the
81 subject of patent rights other than those in the patent database. IEC shall not be held
82 responsible for identifying any or all such patent rights.

83

84

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[oSIST prEN IEC 60122-2:2024](https://standards.iteh.ai/catalog/standards/sist/df2a5a1f-3e01-4f21-a802-a8eb8e07560c/osist-pren-iec-60122-2-2024)

<https://standards.iteh.ai/catalog/standards/sist/df2a5a1f-3e01-4f21-a802-a8eb8e07560c/osist-pren-iec-60122-2-2024>

QUARTZ CRYSTAL UNITS OF ASSESSED QUALITY

Part 2: Guidelines for the 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 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 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 the quartz crystal units from these specifications, when available, even if it may 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

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.

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

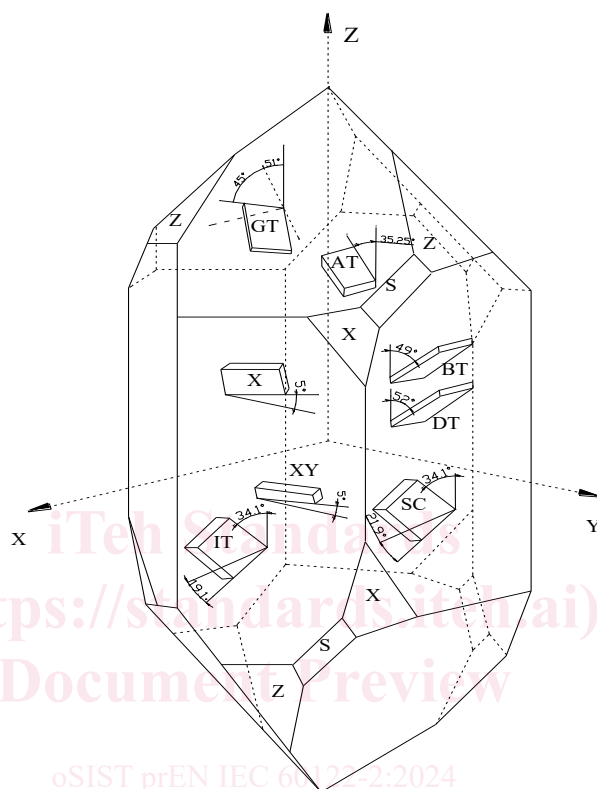


Figure 1 – Designation of the most commonly used crystal cuts

This figure 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 may be taken as 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 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.

151

Table 1 – Modes of vibration as a function of frequency

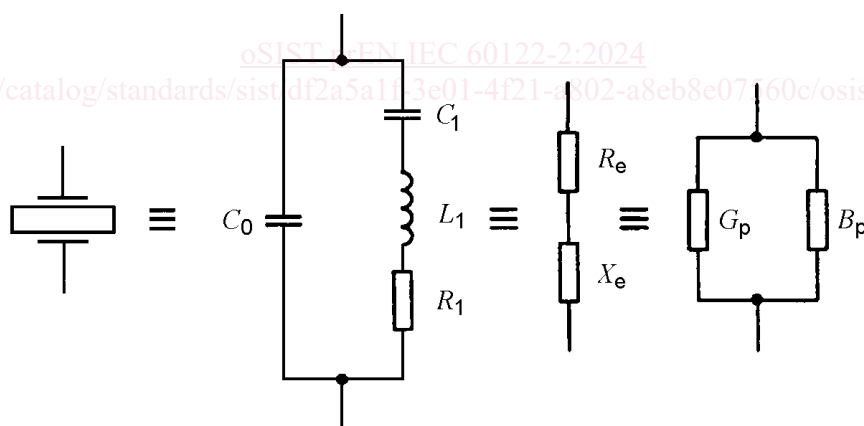
Designation of cut	Mode of vibration	Usual frequency range
XY	Flexural	1kHz~80kHz
5° X bar	Extensional	40kHz~200kHz
AT	Thickness shear (fundamental)	800kHz~500MHz
	3rd overtone	5MHz~215MHz
	5th overtone	5MHz~150MHz
	7th overtone	100MHz~200MHz
BT	Thickness shear (fundamental)	3MHz~30MHz
DT	Face shear	100kHz~500kHz
SC	Thickness shear (fundamental)	8.192MHz~30MHz
	3rd overtone	5MHz~100MHz
	5th overtone	5MHz~130MHz
GT	Coupled mode by two extensional modes	100kHz~550kHz
IT	fundamental	8.192MHz~30MHz
	3rd overtone	5MHz~100MHz

152

4.3 The equivalent electrical circuit of a quartz crystal unit

153

154 The properties of any mode of a lightly damped mechanical vibrator piezoelectrically excited
 155 through electrodes can be represented, in the region of the resonance frequency, by an
 156 equivalent electrical circuit which consists of a capacitance (C_1), inductance (L_1) and
 157 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.



158

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

160 C_1 is Motional capacitance in the equivalent electric circuit(farad)

161 L_1 is Motional inductance in the equivalent electric circuit (henry)

162 R_1 is Motional resistance in the equivalent electric circuit (ohm)

163 R_e is Equivalent series resistance of resonator (ohm)

164 X_e is Equivalent series reactance of resonator (ohm)

165 G_p is Equivalent parallel conductance of resonator(s)

166 B_p is Equivalent parallel susceptance of resonator(s)

167

Figure 2 – Equivalent circuit of a quartz crystal unit