

INTERNATIONAL STANDARD

Synthetic quartz crystal – Specifications and guidelines for use





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.



IEC 60758

Edition 5.0 2016-05

INTERNATIONAL STANDARD

Synthetic quartz crystal – Specifications and guidelines for use

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.140

ISBN 978-2-8322-3395-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references.....	9
3 Terms and definitions	9
4 Specification for synthetic quartz crystal.....	13
4.1 Standard values	13
4.1.1 Shape of synthetic quartz for optical applications.....	13
4.1.2 Orientation of the seed.....	13
4.1.3 Inclusion density	13
4.1.4 Striae in synthetic quartz for optical applications.....	14
4.1.5 Infrared quality indications of $\alpha_3 500$ and $\alpha_3 585$ for piezoelectric applications	14
4.1.6 Grade classification by α value and Schlieren method for optical applications	15
4.1.7 Frequency-temperature characteristics of synthetic quartz for piezoelectric applications	15
4.1.8 Etch channel density ρ	15
4.1.9 Internal transmittance for optical applications	16
4.2 Requirements and measuring methods	17
4.2.1 Orientation.....	17
4.2.2 Handedness.....	18
4.2.3 Synthetic quartz crystal dimensions	18
4.2.4 Seed dimensions	19
4.2.5 Imperfections	19
4.2.6 Evaluation of infrared quality by α measurement.....	22
4.2.7 Frequency versus temperature characteristics for piezoelectric applications	24
4.2.8 Striae in synthetic quartz for optical applications.....	25
4.2.9 Growth band in synthetic quartz for optical applications	25
4.2.10 Etch channel density.....	26
4.2.11 Internal transmittance for optical applications	27
4.3 Marking.....	27
4.3.1 General	27
4.3.2 Shipping requirements	28
5 Specification for lumbered synthetic quartz crystal	28
5.1 Standard values	28
5.1.1 Tolerance of dimensions	28
5.1.2 Reference surface flatness.....	29
5.1.3 Angular tolerance of reference surface	29
5.1.4 Centrality of the seed	30
5.2 Requirements and measuring methods	31
5.2.1 As-grown quartz bars used for lumbered quartz bars	31
5.2.2 Dimensions of lumbered synthetic quartz crystal.....	31
5.2.3 Identification on reference surface.....	31
5.2.4 Measurement of reference surface flatness.....	31

5.2.5	Measurement of reference surface angle tolerance	31
5.2.6	Centrality of the seed	31
5.3	Delivery conditions	32
5.3.1	General	32
5.3.2	Marking	32
5.3.3	Packing	32
5.3.4	Making batch	32
6	Inspection rule for synthetic quartz crystal and lumbered synthetic quartz crystal	32
6.1	Inspection rule for as-grown synthetic quartz crystal	32
6.1.1	Inspection	32
6.1.2	Lot-by-lot test.....	32
6.2	Inspection rule for lumbered synthetic quartz crystal	33
6.2.1	General	33
6.2.2	Lot-by-lot test.....	34
7	Guidelines for the use of synthetic quartz crystal for piezoelectric applications.....	34
7.1	General.....	34
7.1.1	Overview	34
7.1.2	Synthetic quartz crystal	34
7.2	Shape and size of synthetic quartz crystal	35
7.2.1	Crystal axis and face designation	35
7.2.2	Seed.....	36
7.2.3	Shapes and dimensions	36
7.2.4	Growth zones.....	37
7.3	Standard method for evaluating the quality of synthetic quartz crystal	37
7.4	Other methods for checking the quality of synthetic quartz crystal	38
7.4.1	General	38
7.4.2	Visual inspection.....	38
7.4.3	Infrared radiation absorption method	38
7.4.4	Miscellaneous	39
7.5	α grade for piezoelectric quartz	40
7.6	Optional grading (only as ordered), in inclusions, etch channels, Al content.....	40
7.6.1	Inclusions	40
7.6.2	Etch channels	40
7.6.3	Al content	40
7.6.4	Swept quartz.....	41
7.7	Ordering	42
Annex A (informative)	Frequently used sampling procedures.....	43
A.1	Complete volume counting	43
A.2	Commodity Y-bar sampling – Method 1.....	43
A.3	Commodity Y-bar sampling – Method 2.....	43
A.4	Use of comparative standards for 100 % crystal inspection	44
Annex B (informative)	Numerical example.....	45
Annex C (informative)	Example of reference sample selection.....	46
Annex D (informative)	Explanations of point callipers	47
Annex E (informative)	Infrared absorbance α value compensation	48
E.1	General.....	48
E.2	Sample preparation, equipment set-up and measuring procedure	48
E.2.1	General	48

E.2.2	Sample preparation.....	48
E.2.3	Equipment set-up.....	48
E.2.4	Measurement procedure.....	49
E.3	Procedure to establish correction terms.....	49
E.4	Calculation of compensated (corrected) absorbance values.....	51
Annex F (informative)	Differences of the orthogonal axial system for quartz between IEC standard and IEEE standard.....	52
Annex G (informative)	α value measurement consistency between dispersive infrared spectrometer and fourier transform infrared spectrometer.....	54
G.1	General.....	54
G.2	Experiment.....	54
G.3	Experimental result.....	55
Bibliography	58
Figure 1	– Quartz crystal axis and cut direction.....	17
Figure 2	– Idealized sections of a synthetic quartz crystal grown on a Z-cut seed.....	19
Figure 3	– Typical example of cutting wafers of AT-cut plate, minor rhombohedral-cut plate, X-cut plate, Y-cut plate and Z-cut plate.....	21
Figure 4	– Frequency-temperature characteristics deviation rate of the test specimen.....	25
Figure 5	– Typical schlieren system setup.....	25
Figure 6	– Lumbered synthetic quartz crystal outline and dimensions along X-, Y- and Z-axes.....	29
Figure 7	– Angular deviation for reference surface.....	30
Figure 8	– Centrality of the seed with respect to the dimension along the Z- or Z'-axis.....	31
Figure 9	– Quartz crystal axis and face designation.....	36
Figure 10	– Synthetic quartz crystal grown on a Z-cut seed of small X-dimensions.....	37
Figure 11	– Example of a relation between the α value and the Q value at wave number $3\,500\text{ cm}^{-1}$	39
Figure D.1	– Point callipers.....	47
Figure D.2	– Digital point callipers.....	47
Figure E.1	– Schematic of measurement set-up.....	49
Figure E.2	– Graph relationship between averaged α and measured α at two wave numbers of $\alpha_{3\,500}$ and $\alpha_{3\,585}$	50
Figure F.1	– Left- and right-handed quartz crystals.....	53
Figure G.1	– Relationship of α between measuring value and reference value.....	57
Table 1	– Inclusion density grades for piezoelectric applications.....	14
Table 2	– Inclusion density grades for optical applications.....	14
Table 3	– Infrared absorbance coefficient grades for piezoelectric applications.....	14
Table 4	– Infrared absorbance coefficient grades and Schlieren method for optical applications.....	15
Table 5	– Etch channel density grades for piezoelectric applications.....	16
Table 6	– Test conditions and requirements for the lot-by-lot test for group A.....	33
Table 7	– Test conditions and requirements for the lot-by-lot test for group B.....	33
Table 8	– Test conditions and requirements for the lot-by-lot test.....	34
Table B.1	– Commodity bar sampling, method 1.....	45

Table B.2 – Commodity bar sampling45

Table E.1 – Example of calibration data at α_3 58550

Table E.2 – Example of calibration data at α_3 50050

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SYNTHETIC QUARTZ CRYSTAL –
SPECIFICATIONS AND GUIDELINES FOR 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.

International Standard IEC 60758 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

This fifth edition cancels and replaces the fourth edition, published in 2008. This edition constitutes a technical revision.

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

- order rearrangement and review of terms and definitions;
- abolition as a standard of the infrared absorbance coefficient α_3 410;
- addition of the α value measurement explanation by FT-IR equipment in annex;
- addition of the synthetic quartz crystal standards for optical applications.

The text of this standard is based on the following documents:

FDIS	Report on voting
49/1185/FDIS	49/1190/RVD

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

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

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

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

A bilingual version of this publication may be issued at a later date.