

TECHNICAL SPECIFICATION



Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection – Glossary – Part 4-1: Piezoelectric materials – Synthetic quartz crystal

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**Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection – Glossary –
Part 4-1: Piezoelectric materials – Synthetic quartz crystal**

INTERNATIONAL
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COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PIEZOELECTRIC, DIELECTRIC AND ELECTROSTATIC DEVICES AND ASSOCIATED MATERIALS FOR FREQUENCY CONTROL, SELECTION AND DETECTION – GLOSSARY –

Part 4-1: Piezoelectric materials – Synthetic quartz crystal

FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 61944-4-1, which is a technical specification, 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 of IEC 61994-4-1 cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

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

- a) The new terms and definitions given in IEC 60758:2016 have been taken into account;
- b) The general title has been changed according to the change in the title of TC 49 in 2009.

The text of this technical specification is based on the following documents:

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PIEZOELECTRIC, DIELECTRIC AND ELECTROSTATIC DEVICES AND ASSOCIATED MATERIALS FOR FREQUENCY CONTROL, SELECTION AND DETECTION – GLOSSARY –

Part 4-1: Piezoelectric materials – Synthetic quartz crystal

1 Scope

This part of IEC 61994 gives the terms and definition for synthetic quartz ~~single~~ crystals representing the state of the art, which are intended for manufacturing piezoelectric and optical elements ~~for frequency control and selection~~.

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 60050(561):1991, International Electrotechnical Vocabulary (IEV) – Chapter 561: Piezoelectric devices for frequency control and selection~~

~~IEC 60758:2004, Synthetic quartz crystal – Specifications and guide to the use~~

There are no normative references in this document.

3 Terms and definitions

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

3.1

AT-cut plate

rotated Y-cut crystal plate oriented at an angle of about +35° around the X-axis or about –3° from the z (minor rhombohedral)-face

[SOURCE: IEC 60758:2016, ~~3.7.2~~ 3.11, modified – the reference to Figure 3 has been removed.]

3.2

as-grown Y-bar

crystals which are ~~produced using seeds with the largest dimension~~ grown by using long stick seed in the Y-direction

[SOURCE: IEC 60758:2016, ~~3.2.2~~ 3.4]

3.3

as-grown Z-bar

~~as-grown Y-bar crystals in which the Z-grown sector is much larger than the X-growth sector. The relative size of the growth sector is controlled by the X-dimension of the seed~~
crystals which are grown by using Z-cut seed

[SOURCE: IEC 60758:2016, ~~3.2.3 modified~~ 3.5]

3.4

as-grown synthetic quartz crystal

~~single crystal quartz grown hydrothermally. "As-grown" refers to the state of processing and indicates a state prior to mechanical fabrication~~
state of synthetic quartz crystal prior to grinding or cutting

[SOURCE: IEC 60758:2016, ~~3.2.1 modified~~ 3.3]

3.5

autoclave

vessel for the high-pressure and high-temperature condition required for growth of a synthetic quartz crystal

[SOURCE: IEC 60758:2016, ~~3.15~~ 3.26]

3.6

dimensions

dimensions pertaining to growth on Z-cut seed rotated less than 20° from the Y-axis

[SOURCE: IEC 60758:2016, 3.16]

3.7

dislocations

linear defects in the crystal due to misplaced planes of atoms

[SOURCE: IEC 60758:2016, ~~3.18~~ 3.25]

3.8

dopant

~~any~~ additive used in the growth process which may change the crystal habit, chemical composition, physical or electrical properties of the synthetic quartz batch

[SOURCE: IEC 60758:2016, ~~3.10~~ 3.22]

3.9

effective Z-dimension

~~as-grown effective Z-dimension which is defined as the~~ minimum measure in the Z ($\theta = 0^\circ$) or Z' direction in usable Y or Y' area of an as-grown crystals and described by Z_{eff}

[SOURCE: IEC 60758:2016, ~~3.8.1.4~~ 3.17 modified – The definition has been shortened and the reference to Figure 2 has been removed.]

3.9

electrical twins

~~quartz crystal in which regions with a common Z-axis exist, showing a polarity reversal of the electrical X-axis~~

[~~IEC 60758, 3.17~~]

3.10

etch channel

roughly cylindrical void that is present along the dislocation line after etching ~~a test wafer prepared from~~ a quartz crystal

[SOURCE: IEC 60758:2016, ~~3.14~~ 3.21]

~~3.11~~

~~gross dimensions~~

~~maximum dimensions along the X-, Y- or Y'- and Z- or Z'-axes measured along the X-, Y'- and Z'-axes~~

~~[IEC 60758, 3.8.1]~~

3.11

growth band

contrasting density band that can be observed in the Y-cut crystal by Schlieren and similar optical method

[SOURCE: IEC 60758:2016, 3.35, modified – The four notes to entry have been removed.]

3.12

growth zones

regions of a synthetic quartz crystal resulting from growth along different crystallographic directions

[SOURCE: IEC 60758:2016, ~~3.5~~ 3.8, modified – The reference to Figure 2 has been removed.]

3.13

hydrothermal crystal growth

~~literally crystal growth in the presence of water, elevated temperatures and pressures by a crystal growth process believed to proceed geologically within the earth's crust. The industrial synthetic quartz growth processes utilize alkaline water solutions confined within autoclaves at supercritical temperatures (330 °C to 400 °C) and pressures (700 to 2000 atmospheres). The autoclave is divided into two chambers: the dissolving chamber, containing raw quartz chips at the higher temperature; the growing chamber, containing cut seeds at the lower temperature~~
crystal growth in the presence of water of elevated temperature and pressure

[SOURCE: IEC 60758:2016, 3.1 modified – The definition has been shortened.]

3.14

impurity concentration

concentration of impurities relative to silicon atoms

[SOURCE: IEC 60758:2016, ~~3.12~~ 3.24]

3.15

inclusions

any foreign material within a synthetic quartz crystal, visible by examination of scattered light from a bright source with the crystal immersed in a refractive index-matching liquid. ~~A particularly common inclusion is the mineral acmite (sodium iron silicate)~~

[SOURCE: IEC 60758:2016, ~~3.9~~ 3.19, modified – Note 1 to entry has been removed.]

3.16

infrared absorption coefficient α value

coefficient (referred to as the α value) established by determining the relationship between absorption of two ~~wavelengths~~ wave numbers

Note 1 to entry: One ~~with~~ wave number is minimal absorption due to OH impurity, the other with high absorption due to the presence of OH impurities in the crystal lattice. The OH impurity creates mechanical loss in resonators and its presence is correlated to the presence of other loss-inducing impurities. The α value is a measure of OH concentration and is correlated with expected mechanical losses due to material impurities.

Note 2 to entry: For the coefficient defined here, the logarithm base 10 is used. The infrared absorption coefficient value α is determined using the following equation:

$$\alpha = \frac{1}{t} \log \frac{T_1}{T_2}$$

where

~~α is the infrared absorption coefficient;~~

~~t is the thickness of Y-cut sample, in centimetres;~~

~~T_1 is the per cent transmission at a wave number of 3 800 cm^{-1} or 3 979 cm^{-1} ;~~

~~T_2 is the per cent transmission at a wave number of 3 410 cm^{-1} , 3 500 cm^{-1} or 3 585 cm^{-1} ;~~

$$\alpha = \frac{1}{t} \log_{10} \left(\frac{T_1}{T_2} \right)$$

where

α is the infrared absorption coefficient;

t is the thickness of Y-cut sample, in cm;

T_1 is the per cent transmission at a wave number of 3 800 cm^{-1} or 3 979 cm^{-1} ;

T_2 is the per cent transmission at a wave number of 3 500 cm^{-1} , or 3 585 cm^{-1} .

[SOURCE: IEC 60758:2016, ~~3.18~~ 3.29]

3.17

internal transmittance

transmittance which does not include loss of surface refraction

[SOURCE: IEC 60758:2016, 3.33, modified – Note 1 to entry has been removed.]

3.18

lumbered synthetic quartz crystal

synthetic quartz crystal whose X- and Z- or Z'- surfaces in the as-grown condition have been processed flat and parallel by sawing, grinding, lapping, etc., to meet specified dimensions and orientation

[SOURCE: IEC 60758:2016, ~~3.19~~ 3.30]

3.18

lumbered Y-bar

~~quartz bars which are lumbered from an as-grown Y-bar~~

~~[IEC 60758, 3.19.1]~~

~~3.19~~

~~lumbered Z-bar~~

~~quartz bars which are lumbered from an as-grown Z-bar~~

~~[IEC 60758, 3.19.2]~~

3.19

minimum Z-dimension

minimum distance from seed surface to Z-surface described by Z_{\min}

[SOURCE: IEC 60758:2016, ~~3.8.1.2~~ 3.18, modified – The reference to Figure 2d has been removed.]

3.20

orientation of a synthetic quartz crystal

orientation expression of ~~its seed~~ a synthetic quartz crystal with respect to the orthogonal ~~axes~~ axial system

[SOURCE: IEC 60758:2016, ~~3.6~~ 3.9 modified – The definition has been made independent of IEC 60758:2016, 3.7.]

~~3.21~~

~~optical twins~~

~~quartz crystal in which regions with the common Z-axis exhibit handedness reversal of the optical Z-axis~~

~~[IEC 60758, 3.17]~~

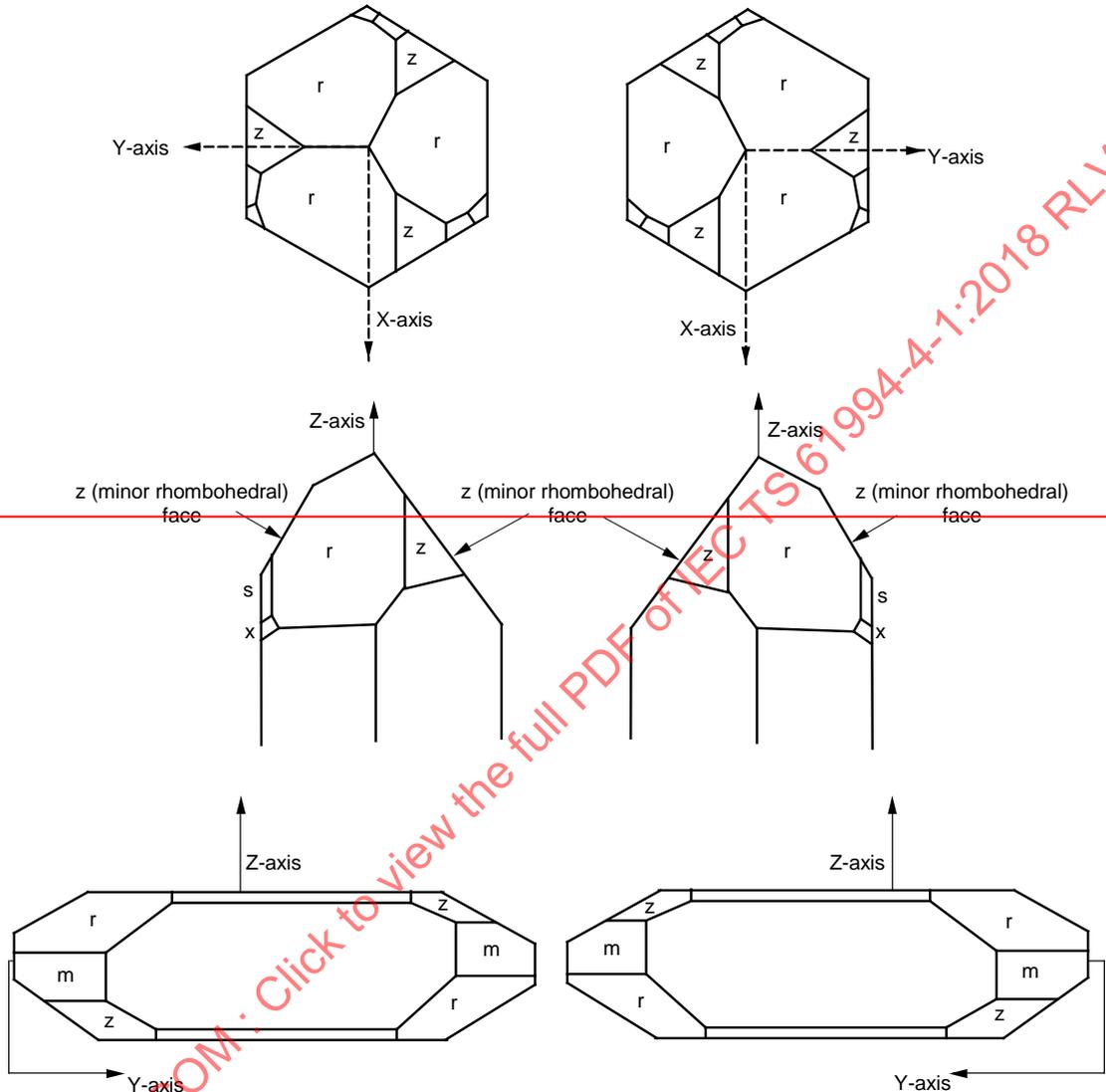
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3.21

orthogonal axial system for of α quartz crystal

~~the orthogonal axial system is illustrated in figure 1~~

orthogonal axis system consisting of three axes with a mutually vertical X axis, Y axis and Z axis



IEC 1704/07

Figure 1 – Orthogonal axial system for quartz

[SOURCE: IEC 60758:2016, ~~3.7.1~~ 3.10, modified – The reference to Figure 1 at the end of the definition and Note 1 to entry have been removed.]

3.22

pre-dimensioned bar

~~any bar of as-grown quartz with dimensions~~ bar whose as-grown dimensions have been altered by sawing, grinding, lapping, etc, to meet a particular dimensional ~~and orientation~~ requirement

[SOURCE: IEC 60758:2016, ~~3.11 modified~~ 3.23]

3.23

reference surface

surface of the lumbered bar prepared to specific flatness and orientation with respect to a crystallographic direction (typically the X-direction)

[SOURCE: IEC 60758:2016, ~~3.20~~ 3.31]

3.24

right-handed quartz or left-handed quartz

handedness of quartz crystal as determined by observing the sense of handedness of the optical rotation in the polarized light. ~~Right handed quartz is the crystal of dextrorotatory and left handed quartz is the crystal of levorotary.~~

[SOURCE: IEC 60758:2016, ~~3.16~~ 3.27, modified – Note 1 to entry has been removed.]

3.25

seed

rectangular parallelepiped quartz plate or bar to be used as a nucleus for crystal growth

[SOURCE: IEC 60758:2016, ~~3.4~~ 3.7]

3.26

seed veil

array of inclusions or voids at the ~~interface~~ surface of the seed ~~and the grown crystal~~ upon which a crystal has been grown

[SOURCE: IEC 60758:2016, ~~3.9.1~~ 3.20]

3.27

striae

short range deviations of refractive index in quartz, growing defects in which the refractive index fluctuates with a typical period of fractions of one millimetre to several millimetres

[SOURCE: IEC 60758:2016, 3.34, modified – Note 1 to entry has been removed.]

3.28

synthetic quartz crystal

single crystal of α quartz grown by the hydrothermal method. ~~The crystal is of either handedness and in the "as grown" condition~~

[SOURCE: IEC 60758:2016, 3.2, modified – Note 1 to entry has been removed.]

3.29

synthetic quartz crystal batch

synthetic quartz crystals grown at the same time in one autoclave

[SOURCE: IEC 60758:2016, ~~3.3~~ 3.6]

3.30

synthetic quartz for optical applications

synthetic quartz which satisfies the requirements for the use of optical pickups, optical lowpass filters (OLPF) and wave plates for digital single-lens reflex camera, monitoring camera, digital video camera and optical communication module operating in the 300 nm – 1 700 nm wave length ($5\ 882\ \text{cm}^{-1}$ - $33\ 333\ \text{cm}^{-1}$)

[SOURCE: IEC 60758:2016, 3.32]

3.31

twins

~~twins follow laws of crystallography relating symmetrically to specific faces or axes. Common twins observed in synthetic quartz are optical and electrical twins~~

two or more same single crystals which are combined together by the law of symmetrical plane or axis

[SOURCE: IEC 60758:2016, ~~3.17~~ 3.28, modified – The term has been expressed in the singular and Note 1 to entry has been removed.]

3.32

X-cut plate

crystal plate perpendicular to the X-axis

[SOURCE: IEC 60758:2016, ~~3.7.4~~ 3.12, modified – The reference to Figure 3b has been removed.]

3.33

Y-cut plate

crystal plate perpendicular to the Y-axis

[SOURCE: IEC 60758:2016, ~~3.7.5~~ 3.13, modified – The reference to Figure 3b has been removed.]

3.34

Z-cut plate

crystal plate perpendicular to the Z-axis

[SOURCE: IEC 60758:2016, ~~3.7.6~~ 3.14, modified – The reference to Figure 3b has been removed.]

3.35

z (minor rhombohedral)-cut plate

crystal plate parallel to the z (minor rhombohedral)-face

[SOURCE: IEC 60758:2016, ~~3.7.3~~ 3.15, modified – The reference to Figure 3a has been removed.]

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Bibliography

IEC 60758:2016, *Synthetic quartz crystal – Specifications and guidelines for use*

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[SOURCE: IEC 60758:2016, 3.11, modified – the reference to Figure 3 has been removed.]

3.2

as-grown Y-bar

crystals which are grown by using long stick seed in the Y-direction

[SOURCE: IEC 60758:2016, 3.4]

3.3

as-grown Z-bar

crystals which are grown by using Z-cut seed

[SOURCE: IEC 60758:2016, 3.5]

3.4

as-grown synthetic quartz crystal

state of synthetic quartz crystal prior to grinding or cutting

[SOURCE: IEC 60758:2016, 3.3]

3.5

autoclave

vessel for the high-pressure and high-temperature condition required for growth of a synthetic quartz crystal

[SOURCE: IEC 60758:2016, 3.26]

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[SOURCE: IEC 60758:2016, 3.22]

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3.10

etch channel

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[SOURCE: IEC 60758:2016, 3.21]

3.11

growth band

contrasting density band that can be observed in the Y-cut crystal by Schlieren and similar optical method

[SOURCE: IEC 60758:2016, 3.35, modified – The four notes to entry have been removed.]

3.12

growth zones

regions of a synthetic quartz crystal resulting from growth along different crystallographic directions

[SOURCE: IEC 60758:2016, 3.8, modified – The reference to Figure 2 has been removed.]

3.13**hydrothermal crystal growth**

crystal growth in the presence of water of elevated temperature and pressure

[SOURCE: IEC 60758:2016, 3.1 modified – The definition has been shortened.]

3.14**impurity concentration**

concentration of impurities relative to silicon atoms

[SOURCE: IEC 60758:2016, 3.24]

3.15**inclusions**

any foreign material within a synthetic quartz crystal, visible by examination of scattered light from a bright source with the crystal immersed in a refractive index-matching liquid

[SOURCE: IEC 60758:2016, 3.19, modified – Note 1 to entry has been removed.]

3.16**infrared absorption coefficient α value**

coefficient (referred to as the α value) established by determining the relationship between absorption of two wave numbers

Note 1 to entry: One wave number is minimal absorption due to OH impurity, the other with high absorption due to the presence of OH impurities in the crystal lattice. The OH impurity creates mechanical loss in resonators and its presence is correlated to the presence of other loss-inducing impurities. The α value is a measure of OH concentration and is correlated with expected mechanical losses due to material impurities.

Note 2 to entry: For the coefficient defined here, the logarithm base 10 is used. The infrared absorption coefficient value α is determined using the following equation:

$$\alpha = \frac{1}{t} \log_{10} \left(\frac{T_1}{T_2} \right)$$

where

α is the infrared absorption coefficient;

t is the thickness of Y-cut sample, in cm;

T_1 is the per cent transmission at a wave number of 3 800 cm^{-1} or 3 979 cm^{-1} ;

T_2 is the per cent transmission at a wave number of 3 500 cm^{-1} , or 3 585 cm^{-1} .

[SOURCE: IEC 60758:2016, 3.29]

3.17**internal transmittance**

transmittance which does not include loss of surface refraction

[SOURCE: IEC 60758:2016, 3.33, modified – Note 1 to entry has been removed.]

3.18**lumbered synthetic quartz crystal**

synthetic quartz crystal whose X- and Z- or Z'- surfaces in the as-grown condition have been processed flat and parallel by sawing, grinding, lapping, etc., to meet specified dimensions and orientation

[SOURCE: IEC 60758:2016, 3.30]

3.19**minimum Z-dimension**

minimum distance from seed surface to Z-surface described by Z_{\min}

[SOURCE: IEC 60758:2016, 3.18, modified – The reference to Figure 2d has been removed.]

3.20**orientation of a synthetic quartz crystal**

orientation expression of a synthetic quartz crystal with respect to the orthogonal axial system

[SOURCE: IEC 60758:2016, 3.9 modified – The definition has been made independent of IEC 60758:2016, 3.7.]

3.21**orthogonal axial system of α quartz crystal**

orthogonal axis system consisting of three axes with a mutually vertical X axis, Y axis and Z axis

[SOURCE: IEC 60758:2016, 3.10, modified – The reference to Figure 1 at the end of the definition and Note 1 to entry have been removed.]

3.22**pre-dimensioned bar**

bar whose as-grown dimensions have been altered by sawing, grinding, lapping, etc., to meet a particular dimensional requirement

[SOURCE: IEC 60758:2016, 3.23]

3.23**reference surface**

surface of the lumbered bar prepared to specific flatness and orientation with respect to a crystallographic direction (typically the X-direction)

[SOURCE: IEC 60758:2016, 3.31]

3.24**right-handed quartz or left-handed quartz**

handedness of quartz crystal as determined by observing the sense of handedness of the optical rotation in the polarized light

[SOURCE: IEC 60758:2016, 3.27, modified – Note 1 to entry has been removed.]

3.25**seed**

rectangular parallelepiped quartz plate or bar to be used as a nucleus for crystal growth

[SOURCE: IEC 60758:2016, 3.7]

3.26**seed veil**

array of inclusions or voids at the surface of the seed upon which a crystal has been grown

[SOURCE: IEC 60758:2016, 3.20]