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2004-11

Surface acoustic wave (SAW) resonators –

Part 1: Generic specification

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SURFACE ACOUSTIC WAVE (SAW) RESONATORS –

Part 1: Generic specification

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.
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International Standard IEC 61019-1 has been prepared by IEC technical committee 49: Piezoelectric and dielectric devices for frequency control and selection.

This first edition of IEC 61019-1 cancels and replaces the first edition of IEC 61019-1-1 published in 1990 and the first edition of IEC 61019-1-2 published in 1993. It constitutes a technical revision.

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

FDIS	Report on voting
49/689FDIS	49/698/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.

IEC 61019 consists of the following parts under the general title *Surface acoustic wave (SAW) resonators:*

Part 1: Generic specification

Part 2: Guide to the use (at present under revision)

Part 3: Standard outlines and lead connections

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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.

SURFACE ACOUSTIC WAVE (SAW) RESONATORS –

Part 1: Generic specification

1 Scope

This part of IEC 61019 specifies the methods of test and general requirements for SAW resonators using either capability approval or qualification approval procedures of the IECQ system.

2 Normative references

The following referenced documents are indispensable for the application 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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050-561:1991, *International Electrotechnical Vocabulary (IEC) – Chapter 561: Piezo-electric devices for frequency control and selection*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-7:1983, *Environmental testing – Part 2: Tests – Test Ga and guidance: Acceleration, steady state*

IEC 60068-2-13:1983, *Environmental testing – Part 2: Tests – Test M: Low air pressure*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-17:1994, *Environmental testing – Part 2: Tests – Test Q: Sealing*

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*

IEC 60068-2-21:1999, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-29:1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*

IEC 60068-2-32:1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall*

IEC 60068-2-45:1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-52:1996, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-58:1999, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-64:1993, *Environmental testing – Part 2: Tests – Test Fh: Vibration, broad-band random (digital control) and guidance*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60617 – DB:2001[1] *Graphical symbols for diagrams*

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

IEC 60444 (all parts), *Measurement of quartz crystal unit parameters*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test.* Basic EMC Publication

IEC 61019-2:1995, *Surface acoustic wave (SAW) resonators – Part 2: Guide to the use*

IEC 61019-3:1991, *Surface acoustic wave (SAW) resonators – Part 3: Standard outlines and lead connections*

QC 001001:2002, *IEC Quality Assessment System for Electronic Components (IECQ) – Basic Rules*

QC 001002-2:1998, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure – Part 2: Documentation*

QC 001002-3:1998, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure – Part 3: Approval procedures*

QC 001005:2003, *IEC Quality Assessment System for Electronic Components (IECQ) – Register of Firms, Products and Services approved under the IECQ System, including ISO 9000*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

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1 DB refers to the IEC on-line database.

3 Order of precedence

Where any discrepancies occur for any reason, documents shall rank in the following order of precedence:

– the detail specification;

– the sectional specification;

– the generic specification;

– any other international document (for example, of the IEC) to which reference is made.

The same order of precedence shall apply to equivalent national documents.

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Units, graphical symbols, letter symbols and terminology shall, wherever possible, be taken from the following standards: IEC 60027, IEC 60050-561, IEC 60122-1, IEC 60617, IEC 60642, ISO 1000.

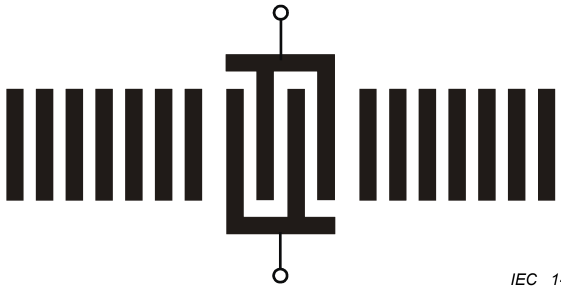
4.1 General terms

4.1.1
surface acoustic wave (SAW)
acoustic wave, propagating along the surface of an elastic substrate, whose amplitude decays exponentially with substrate depth

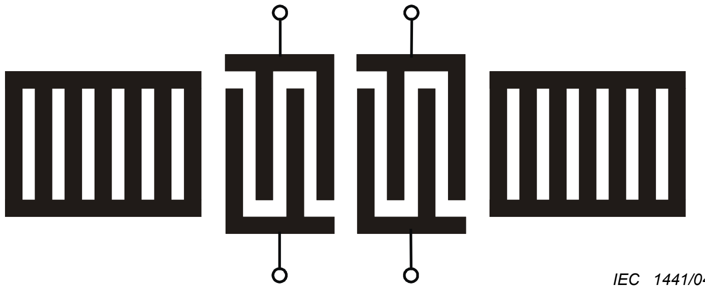
4.1.2
surface acoustic wave resonator (SAW resonator or SAWR)
resonator using multiple reflections of surface acoustic waves

4.1.3
one-port resonator
SAW resonator having a pair of terminals (see 4.2.10 and Figure 1)

4.1.4
two-port resonator
SAW resonator having input and output ports (see 4.2.11 and Figure 1)



a) One-port resonator with opened arrays



b) Two-port resonator with shorted arrays

Figure 1 – Basic configurations of SAW resonators

4.1.5
SAW resonator oscillator
oscillator that uses a SAW resonator as the main frequency controlling element

4.1.6
interdigital transducer (IDT)
SAW transducer made of a comb-like conductive structure deposited on a piezoelectric substrate transforming electrical energy into acoustic energy or vice versa

4.1.7
finger
element of the IDT comb electrode

4.1.8
dummy finger
passive finger which may be included in order to suppress wave-front distortion

4.1.9
bus bar
common electrode which connects individual fingers together and also connects the resonator to an external circuit

4.1.10
shorting bar
common electrode which interconnects individual metal strips (see Figure 1)

4.1.11
apodization (spurious suppression for SAW resonator)
weighting produced by the change in finger overlap over the length of the IDT to suppress the transverse spurious modes

4.1.12
SAW coupling coefficient
k_S^2
SAW electromechanical coupling coefficient is defined as follows:

$$k_S^2 = 2\left|\Delta v / v\right|$$

where $\Delta v/v$ is the relative velocity change produced by short-circuiting the surface potential from the open-circuit condition

4.1.13
grating reflector
SAW reflecting array that normally makes use of the periodic discontinuity provided by metal strips, grooves or ridges

4.1.14
metal strip array
periodic discontinuity realised by electrically short- or open-circuit metal strips providing electrical and mass-loaded perturbations

4.1.15
grooved array
periodic discontinuity realized by topographic perturbation on a surface having shallow grooves

4.1.16
ridge array
periodic discontinuity realized by the mass-loaded perturbation of the surface having thin layer strips

4.1.17
shorted array
metal strip array interconnected with a shorting bar (see Figure 1b))

4.1.18
opened array
metal strip array without a metal strip array interconnection (see Figure 1a))

4.1.19
mass loading
perturbation in the SAW propagation caused by the mass of an overlay on the substrate surface

4.1.20
IDT aperture
maximum IDT finger overlap length which approximately corresponds to the SAW beamwidth, where the aperture may be expressed in length units or normalized term of wavelength

4.2 Operational properties

4.2.1
nominal frequency
frequency given by the manufacturer or the specification to identify the resonator

4.2.2
working frequency
f_W
operational frequency of the resonator together with its associated circuits

4.2.3
frequency tolerance

4.2.3.1
overall tolerance
maximum permissible deviation of the working frequency from the nominal frequency due to a specific cause or a combination of causes

4.2.3.2
adjustment tolerance
permissible deviation of the working frequency from the nominal frequency at the reference temperature under specified conditions

4.2.3.3
ageing tolerance
permissible deviation due to time under specified conditions

4.2.3.4
tolerance over the temperature range
permissible deviation over the temperature range with respect to the frequency at the specified reference temperature

4.2.3.5
tolerance due to level of drive variation
permissible deviation due to the level of drive variation

4.2.4
operating temperature range
range of temperatures as measured on the enclosure over which the resonator must function within the specified tolerances

4.2.4.1
operable temperature range
range of temperatures as measured on the enclosure over which the resonator must function though not necessarily within the specified tolerances

4.2.4.2
storage temperature range
range of temperatures over which the resonator can be stored without causing permanent change in the performance beyond the specified tolerances

4.2.4.3
reference temperature
temperature at which certain resonator measurements are made. For controlled temperature resonators, the reference temperature is the mid-point of the controlled temperature range. For non-controlled temperature resonators, the reference temperature is normally 25 °C ± 2 °C

4.2.5
spurious resonance
state of resonance of a resonator other than that frequency associated with the working frequency

4.2.6
transverse spurious resonance
spurious resonance caused by excitation of higher order transverse modes which appear at slightly higher frequencies. It is desirable to apodize the interdigital transducer to match the desired transverse mode profile

4.2.7
level of drive
measure of the operating conditions imposed upon the resonator expressed in terms of power dissipated

NOTE In special cases the level of drive may be specified in terms of resonator current or voltage.

4.2.8
d.c. breakdown voltage
lowest d.c. voltage which causes the destruction of the resonator

4.2.9
ageing (long-term parameter variation)
relationship which exists between any parameter (for example, resonance frequency) and time

NOTE Such a parameter variation is due to long-term changes in the resonator and is usually expressed in fractional parts per period of time.

4.2.10
one-port SAW resonator

4.2.10.1
one-port resonator equivalent circuit
electrical circuit which has the same impedance as the resonator in the immediate neighbourhood of resonance. It is usually represented by a parallel capacitance shunted by a motional (series) arm. The motional (series) arm, in its turn, is represented by an inductance, capacitance and resistance in series. The parameters of the motional (series) arm of inductance, capacitance and resistance are usually given by L_1, C_1 and R_1 respectively. The shunt capacitance is given by C_0 (see Figure 2)

NOTE The characteristic frequencies which occur in the resonance neighbourhood can be completely defined by considering the resistance and the reactance of the resonator as a function of frequency and from the impedance and admittance diagrams described in Figure 3, and IEC 60122-1, to which reference should be made.

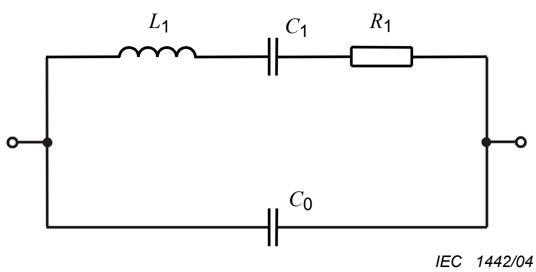


Figure 2 – One-port resonator equivalent circuit

4.2.10.2
resonance frequencies

4.2.10.2.1
frequency of maximum admittance (minimum impedance)
f_m
frequency at which the resonator exhibits a maximum admittance in the immediate neighbourhood of resonance (see Figures 3 and 4)

4.2.10.2.2
motional (series) resonance frequency
f_s
resonance frequency of the motional (series) arm of the equivalent circuit of the resonator (see Figure 3)

4.2.10.2.3
resonance frequency of zero susceptance
f_r
lower of the two frequencies of the resonator alone, under specified conditions at which the electrical impedance of the resonator is resistive (see Figure 3)

4.2.10.3
anti-resonance frequencies

4.2.10.3.1
frequency of minimum admittance (maximum impedance)
f_n
frequency at which the resonator exhibits a minimum admittance in the immediate neighbourhood of resonance (see Figures 3 and 4)

4.2.10.3.2
parallel resonance frequency (lossless)
f_p
frequency of parallel resonance of the motional (series) arm and the shunt capacitance (see Figure 3)

4.2.10.3.3
anti-resonance frequency of zero susceptance
f_a
higher of the two frequencies of a resonator alone, under specified conditions at which the electrical impedance of the resonator is resistive (see Figure 3)

4.2.10.4
motional resistance
R_1
resistance of the motional (series) arm of the equivalent circuit (see Figure 2)

4.2.10.5
motional capacitance
C_1
capacitance of the motional (series) arm of the equivalent circuit (see Figure 2)

4.2.10.6
motional inductance
L_1
inductance of the motional (series) arm of the equivalent circuit (see Figure 2)

4.2.10.7
shunt capacitance
C_0
capacitance which shunts the motional (series) arm of the equivalent circuit of the resonator (see Figure 2)

4.2.10.8
quality factor
Q
quality factor for the resonator which is given by $2\pi f_s L_1/R_1$. The value of Q is limited by the SAW propagation loss, the electrical resistance of the electrodes, the mode conversion loss, etc.

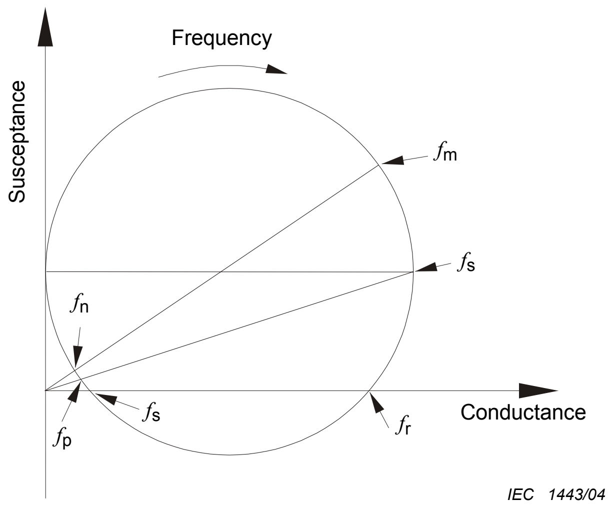


Figure 3 – Vector admittance diagram of a one-port SAW resonator

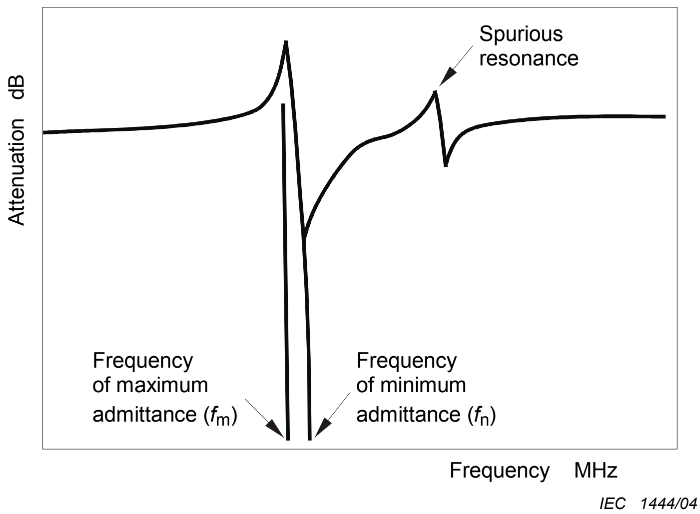


Figure 4 – Typical frequency characteristics of a one-port SAW resonator inserted into a transmission line in series (see 4.2.10.2.1 and 4.2.10.3.1)

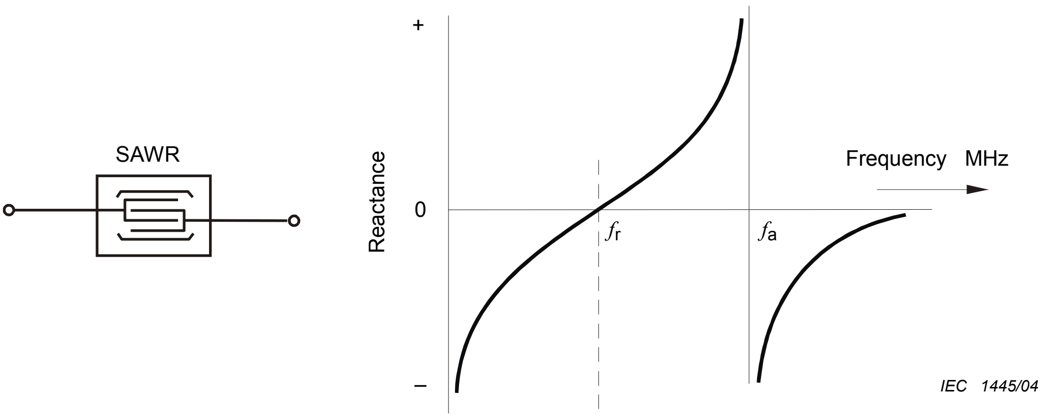


Figure 5a) Reactance curve of one-port SAW resonator

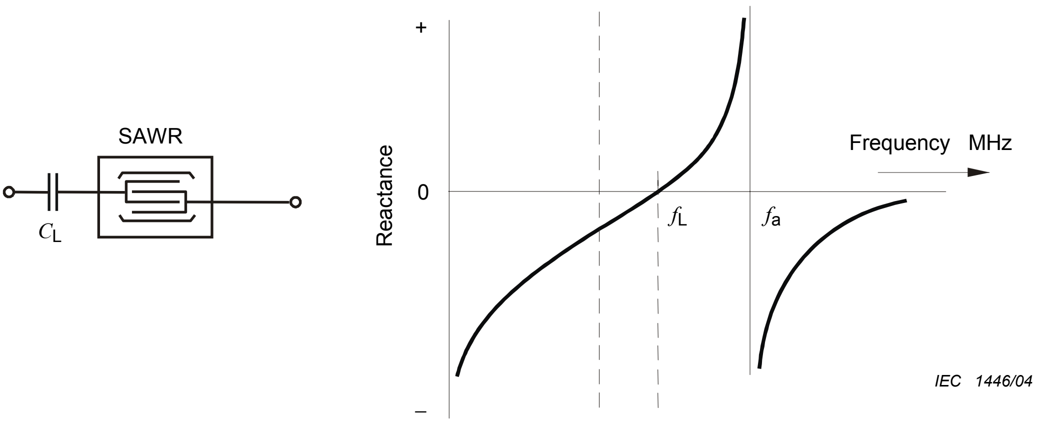


Figure 5b) Reactance curve of one-port SAW resonator with serial load capacitance

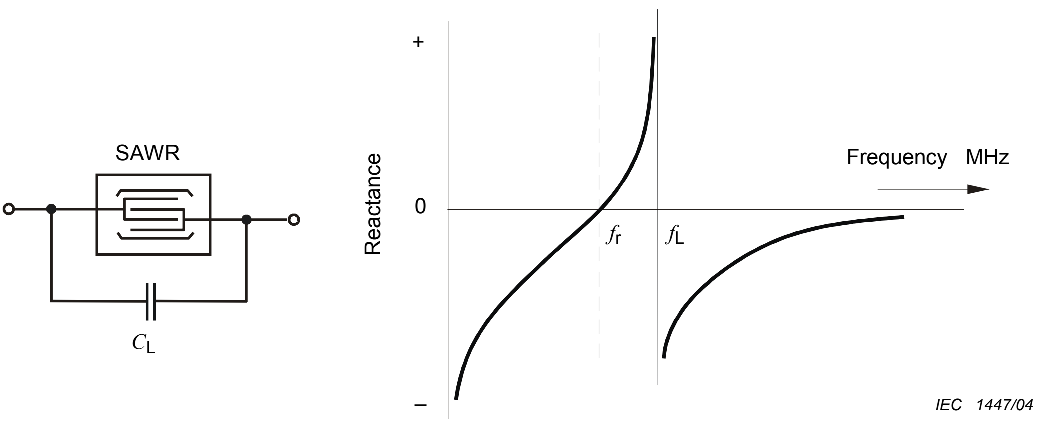


Figure 5c) Reactance curve of one-port SAW resonator with parallel load capacitance

NOTE The values of load capacitances C_L shown in Figures 5b) and 5c) are equal.

Figure 5 – Resonance and anti-resonance frequencies

(see 4.2.10.2.3, 4.2.10.3.3, 4.2.10.11 and 4.2.10.13)

4.2.10.9
capacitance ratio
r
ratio of the shunt capacitance (C_0) to the motional capacitance (C_1)

4.2.10.10
figure of merit
M
value given by Q/r which indicates the activity of the resonator

4.2.10.11
load capacitance
$\boldsymbol{C}_{\mathbf{L}}$
effective external capacitance associated with the resonator which determines the load resonance frequency f_L (see Figure 5)

4.2.10.12
load resonance resistance
$\boldsymbol{R}_{\mathbf{L}}$
resistance of the resonator in series with a stated external capacitance at the load resonance frequency f_L

NOTE The value of R_L is related to the value of R_1 by

$$R_L = R_1 \left(1 + C_0 / C_L\right)^2$$

4.2.10.13
load resonance frequency
$\boldsymbol{f}_{\mathbf{L}}$
one of the two frequencies of a resonator in association with a series or parallel load capacitance, under specified conditions, at which the electrical impedance of the combination is resistive. This frequency is the lower of the two frequencies when the load capacitance is in series and the higher when it is in parallel (see Figure 5)

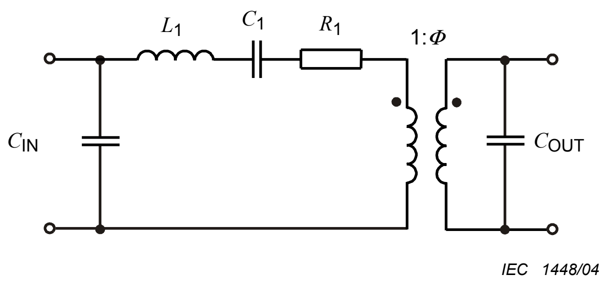
For a given value of load capacitance (C_L), these frequencies are identical for all practical purposes and are given by

$$\frac{1}{f_L} = 2\pi\sqrt{\frac{L_1 C_1 (C_0 + C_L)}{C_1 + C_0 + C_L}}$$

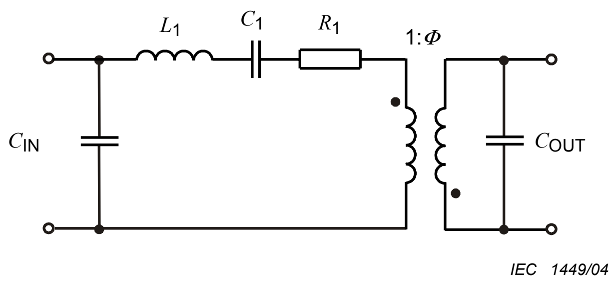
NOTE The frequencies defined in 4.2.10.2 and 4.2.10.3 are listed as being the terms most commonly used. The frequencies associated with a resonator are numerous and, for a full explanation, IEC 60122-1 should be consulted. When higher accuracies are required or secondary data (for example, values of the resonator motional parameters) are to be derived from the frequency measurements, then IEC 60122-1 and IEC 60444 should be consulted.

4.2.11
two-port SAW resonator

4.2.11.1
two-port resonator equivalent circuit
electrical circuit which has the same impedance as the resonator in the immediate neighbourhood of resonance. It is usually represented by a two-port network constructed by the motional (series) arm of inductance, capacitance and resistance in series, parallel capacitances shunting the input and output ports, and an ideal transformer. The parameters of the motional inductance, motional capacitance and motional resistance in the motional (series) arm are also given by L_1, C_1 and R_1 respectively. The parallel (input/output) capacitances are given by C_{IN} and C_{OUT}. The turns ratio of the ideal transformer given by Φ is derived from the input and output transducer structures. When both structures are the same. the value of Φ is unity (see Figure 6).



a) Zero-phase shift type



b) 180° phase-shift type

Figure 6 – Two-port resonator equivalent circuits

4.2.11.2
input capacitance
C_{IN}
capacitance which shunts the input port of the resonator equivalent circuit (see Figure 6)

4.2.11.3
output capacitance
C_{OUT}
capacitance which shunts the output port of the resonator equivalent circuit (see Figure 6)

4.2.11.4
series (motional) resonance frequency for two-port resonator
f_s
resonance frequency of the series (motional) arm of the two-port resonator equivalent circuit

4.2.11.5
unloaded quality factor
Q_U
quality factor for the resonator alone given by $2\pi f_s L_1 / R_1$

4.2.11.6
loaded quality factor
Q_L
quality factor for the resonator connected with the external circuit, defined as the ratio of centre frequency to the 3 dB bandwidth

4.2.11.7
insertion attenuation (for two-port SAW resonator)
logarithmic ratio of the power delivered to the load impedance before and after insertion of the resonator

4.2.11.8
minimum insertion attenuation (for two-port SAW resonator)
minimum insertion attenuation value in the vicinity of the nominal frequency (see Figure 7)

4.2.11.9
centre frequency (for two-port SAW resonator)
f_c
arithmetic mean of two frequencies at which the attenuation relative to the minimum insertion attenuation reaches a specified value

4.2.11.10
spurious resonance rejection
difference between the maximum level of spurious resonances and the minimum insertion attenuation (see Figure 7)

4.2.11.11
operating phase shift
phase shift between input and output terminals at the centre frequency. SAW resonators can be designed to provide a nominal zero or 180° phase shift

4.2.11.12
tuning inductance
inductance which is attached at the input or output terminal for tuning at the desired oscillation frequency

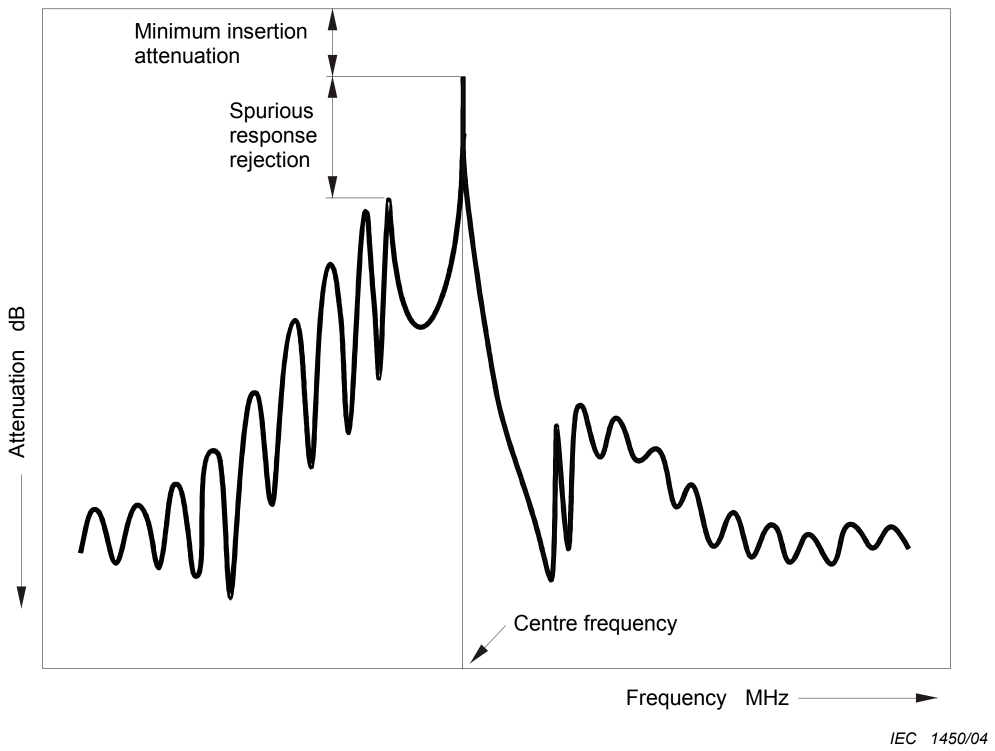


Figure 7 – Typical frequency characteristics of a two-port resonator

5 Preferred values for ratings and characteristics

5.1 Standard nominal frequency values in megahertz (MHz)

5.1.1 Standard nominal frequency values for use in video r.f. converters

46,25	55,25	57,25	61,25
62,25	64,25	67,25	77,25
83,25	86,25	91,25	95,25
97,25	103,25	171,25	175,25
176,25	177,25	183,25	184,25
189,25	199,25	211,25	471,25
559,25	591,25	623,25	

5.1.2 Standard nominal frequency values for use in CATV converters

567	666	668	672
674	678	680	688
690			

5.1.3 Standard nominal frequency values for use in remote keyless entry systems

315	418	433,92	868,30

5.2 Standard operating temperature ranges in degrees Celsius (°C)

–20 to +70	–20 to +50	–10 to +60	0 to +60
–25 to +55	–15 to +45		

5.3 Standard values of load capacitance in picofarads (pF)

1	2	5	7,5	10	15	20

5.4 Standard levels of drive in milliwatts (mW)

0,001	0,01	0,05	0,1	0,2	0,5
1	2	5	10	20	30

5.5 Standard values of minimum insertion attenuation in decibels (dB)

3	6	10	15

5.6 Standard climatic category

For metal, glass and ceramic enclosures, the standard climatic category is 40/085/56.

For requirements where the operating temperature range of the SAW resonator is greater than –40 °C to +85 °C, a climatic category consistent with the operating temperature range shall be specified.

For plastic enclosures, the standard climatic category is 20/085/21.

5.7 Bump severity

4 000 ± 10 bumps at 400 m/s^2 peak acceleration in each direction along three mutually perpendicular axes (see 8.7.6)

Pulse duration 6 ms.

5.8 Vibration severity

Sinusoidal	
10 Hz to 55 Hz 0,75 mm displacement amplitude (peak value) 55 Hz to 500 Hz or 55 Hz to 2 000 Hz 100 m/s^2 acceleration amplitude (peak value)	30 min in each of 3 mutually perpendicular axes (see 8.7.7)
or	
10 Hz to 55 Hz 1,5 mm displacement amplitude (peak value) 55 Hz to 2 000 Hz 200 m/s^2 acceleration amplitude (peak value)	30 min in each of 3 mutually perpendicular axes (see 8.7.7)

Random	
19,2 $(m/s^2)^2$/Hz between 20 Hz and 2 000 Hz 196 m/s^2 acceleration	30 min in each of 3 mutually perpendicular axes (see 8.7.7)
or	
48 $(m/s^2)^2$/Hz between 20 Hz and 2 000 Hz 314 m/s^2 acceleration	30 min in each of 3 mutually perpendicular axes (see 8.7.7)
or	
19,2 $(m/s^2)^2$/Hz between 20 Hz and 2 000 Hz 62 m/s^2 acceleration	30 min in each of 3 mutually perpendicular axes (see 8.7.7)

5.9 Shock severity

1 000 m/s^2 peak acceleration for 6 ms duration; three shocks in each direction along three mutually perpendicular axes (see 8.7.8) half-sine pulse, unless otherwise stated in the detail specification.

5.10 Fine leak rate

10^{-4} Pa × cm^3/s (10^{-9} bar cm^3/s)

10^{-3} Pa × cm^3/s (10^{-8} bar cm^3/s)

10^{-2} Pa × cm^3/s (10^{-7} bar cm^3/s)

10^{-1} Pa × cm^3/s (10^{-6} bar cm^3/s)

6 Marking

6.1 Resonator marking

Surface acoustic wave resonators shall be clearly and durably marked (see 8.7.18) with items a) to c) in the order given below and with as many possible of the remaining items as considered necessary.

a) Type designation as defined in the detail specification.
b) Year and week (or month) of manufacture (or production lot number).
c) Manufacturer's name or trade mark.
d) Terminal identification (if applicable).
e) Mark of conformity (unless a certificate of conformity used).
f) Designation of electrical connections (if applicable).
g) Serial number (if applicable).
h) Surface mounted device classification (if applicable).
i) Nominal frequency in kilohertz or megahertz (if applicable).
j) Factory identification code (if applicable).

Where the available surface area of miniature SAW resonators imposes practical limits on the amount of marking, instructions on the marking to be applied shall be given in the detail specification

6.2 Package marking

The primary packaging containing the SAW resonators(s) shall be clearly marked with the information listed in 6.1 except item g) and electrostatic sensitive device (ESD) identification where necessary.

7 Quality assessment procedures

7.1 Primary stage of manufacture

The primary stage of manufacture for a SAW resonator, in accordance with 4.2.1.2 of QC 001002-3 is the final surface cleaning of the substrates.

7.2 Structurally similar components

The grouping of structurally similar SAW resonators for the purpose of qualification approval, capability approval and quality conformance inspection shall be prescribed in the relevant sectional specification.

7.3 Subcontracting

These procedures shall be in accordance with 3.1.2 of QC 001002-3.

However, the final surface cleaning of the substrate and all subsequent processes shall be carried out by the manufacturer to whom approval has been granted.

7.4 Incorporated components

Where the final component contains components of a type covered by an IEC generic specification , these shall be produced using the normal IEC procedures.

7.5 Manufacturer's approval

To obtain the manufacturer's approval, the manufacturer shall meet the requirements of Clause 2 of QC 001002-3.

7.6 Approval procedures

7.6.1 General

To qualify a SAW resonator, either capability approval or qualification approval procedures may be used. These procedures conform to those stated in QC 001001 and QC 001002-3.

7.6.2 Capability approval

Capability approval is appropriate when structurally similar SAW resonators based on common design rules are fabricated by a group of common processes.

Under capability approval detail specifications fall into the following three categories.

a) Capability qualifying components (CQCs)

   A detail specification shall be prepared for each CQC as agreed with the National Supervising Inspectorate (NSI). It shall identify the purpose of the CQC and include all relevant stress levels and test limits.

b) Standard catalogue items

   When a component covered by the capability approval procedure is intended to be offered as a standard catalogue item, a detail specification complying with the blank detail specification shall be prepared. Such specifications shall be registered by IECQ and the component may be listed in QC 001005.

c) Custom-built SAW resonators

   The content of the detail specification shall be by agreement between the manufacturer and the customer in accordance with 4.3 of QC 001002-3.

Further information on the detail specification is contained in the sectional specification (under consideration).

The product and capability qualifying components (CQCs) are tested in combination and approval given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures. Further information is given in 7.7 and in the sectional specification (under consideration).

7.6.3 Qualification approval

Qualification approval is appropriate for components manufactured to a standard design and established production process and conforming to a published detail specification.

The programme of tests defined in the detail specification for the appropriate assessment and severity level applies directly to the SAW resonator to be qualified, as prescribed in 7.8 and the sectional specification (under consideration).

7.7 Procedures for capability approval

7.7.1 General

The procedures for capability approval shall be in accordance with QC 001002-3.

7.7.2 Eligibility for capability approval

The manufacturer shall comply with the requirements of 4.2.1 of QC 001002-3 and the primary stage of manufacture as defined in 7.1 of this generic specification.

7.7.3 Application for capability approval

In order to obtain capability approval the manufacturer shall apply the rules of procedure given in Clause 4 of QC 001002-2.

7.7.4 Granting of capability approval

Capability approval shall be granted when the procedures in accordance with Clause 4 of QC 001002-3 have been successfully completed.

7.7.5 Capability manual

Capability manual shall be in accordance with the requirements of the sectional specification.

The NSI shall treat the description of capability as a confidential document. The manufacturer may, if he so wishes, disclose part or all of it to a third party.

7.8 Procedures for qualification approval

7.8.1 General

The procedures for qualification approval shall be in accordance with Clause 3 of QC 001002-3.

7.8.2 Eligibility for qualification approval

The manufacturer shall comply with the requirements of 3.1.1 of QC 001002-3 and the primary stage of manufacture as defined in 7.1 of this generic specification.

7.8.3 Application for qualification approval

In order to obtain qualification approval the manufacturer shall apply the rules of procedure given in 3.1.3 of QC 001002-3.

7.8.4 Granting of qualification approval

Qualification approval shall be granted when the procedures in accordance with 3.1.5 of QC 001002-3 have been successfully completed.

7.8.5 Quality conformance inspection

The blank detail specification associated with the sectional specification shall prescribe the test schedule for quality conformance inspection.

7.9 Test procedures

The test procedures to be used shall be selected from this generic specification. If any required test is not included then it shall be defined in the detail specification.

7.10 Screening requirements

Where screening is required by the customer for SAW resonators this shall be specified in the detail specification.

7.11 Rework and repair work

7.11.1 Rework

Rework is the rectification of processing errors and shall not be carried out.

7.11.2 Repair work

Repair work is the correction of defects in a component after release to the customer. Components that have been repaired can no longer be considered as representative of the manufacturer’s production and may not be released under the IECQ System.

7.12 Certified records of released lots

When certified records of released lots (CRRL) are prescribed in the sectional specification for qualification approval and are requested by the customer, the results of the specified tests shall be summarized (see 1.5 of QC 001002-2).

7.13 Validity of release

SAW resonators held for a period exceeding two years following acceptance inspection shall be re-inspected for the electrical tests detailed in 8.5.2 with a sample tested as described in 8.6.3 prior to release.

7.14 Release for delivery

SAW resonators shall be released in accordance with 3.2.6 and 4.3.2 of QC 001002-3.

7.15 Unchecked parameters

Only those parameters of a component which have been specified in a detail specification and which were subject to testing can be assumed to be within the specified limits. It should not be assumed that any parameter not specified will remain unchanged from one component to another. Should it be necessary for further parameters to be controlled, then a new, more extensive, detail specification should be used. The additional test method(s) shall be fully described and appropriate limits, AQLs or defects per million (dpm) and inspection levels specified.

8 Test and measurement procedures

8.1 General

The test and measurement procedures shall be carried out in accordance with the relevant detail specification.

8.2 Test and measurement conditions

8.2.1 Standard conditions for testing

Unless otherwise specified, all tests shall be carried out under the standard atmospheric conditions for testing as specified in 5.3 of IEC 60068-1:

Temperature	15 °C	to	35 °C
Relative humidity	45 %	to	75 %
Air pressure	86 kPa	to	106 kPa
	(860 mbar	to	1 060 mbar)

In case of dispute, the referee conditions are:

Temperature	25 °C ± 1 °C		
Relative humidity	48 %	to	52 %
Air pressure	86 kPa	to	106 kPa
	(860 mbar	to	1 060 mbar)

Before measurements are made, the SAW resonator shall be stored at the measuring temperature for a time sufficient to allow the SAW resonator to reach thermal equilibrium. Controlled recovery conditions and standard conditions for assisted drying are given in 5.4 of IEC 60068-1.

The ambient temperature during the measurements shall be recorded and stated in the test report.

8.2.2 Precision of measurement

The limits given in detail specifications are true values. Measurement inaccuracies shall be taken into account when evaluating the results. Precaution should be taken to reduce measurement errors to a minimum.

8.2.3 Precautions

8.2.3.1 Measurements

The measurement circuits shown for specified electrical tests are the preferred circuits. Due allowance shall be made for any loading effects in cases where the measuring apparatus modifies the characteristics being examined.

8.2.3.2 Electrostatic sensitive devices

Where the component is identified as electrostatic sensitive, precautions shall be taken to prevent damage from static charge both before, during and after test (see IEC 61000-4-2).

8.2.4 Alternative test methods

Measurements shall preferably be carried out using the methods specified. Any other method giving equivalent results may be used except in case of dispute.

NOTE By ‘equivalent’ is meant that the value of the characteristic established by such other method falls within the specified limits when measured by the specified method.

8.3 Visual inspection

Unless otherwise specified, external visual examination shall be performed under normal factory lighting and visual conditions.

8.3.1 Visual test A

The SAW resonator shall be visually examined to ensure that the condition, workmanship and finish are satisfactory. The marking shall be legible.

8.3.2 Visual test B

The SAW resonator shall be visually examined under 10× magnification. There shall be no cracks in the glass or damage to the terminations. Minute flaking around the further edge of a meniscus shall not be considered a crack.

8.3.3 Visual test C

The SAW resonator shall be visually examined. There shall be no corrosion or other deterioration likely to impair satisfactory operation. The marking shall be legible.

8.4 Dimensions and gauging procedures

8.4.1 Dimensions test A

The dimension spacing and alignment of the terminations shall be checked and shall comply with the specified values.

8.4.2 Dimensions test B

The dimensions shall be measured and they shall comply with the specified values.

8.5 Measurement method of one-port resonator

8.5.1 General

In principle, a SAW one-port resonator can be tested with conventional standard measurement methods for quartz resonators, such as those described in IEC 60122-1 and IEC 60444.

For today's SAW one-port resonators in higher frequency use, a reflection measurement method using a network analyser is becoming very common, which makes it possible to determine the exact electrical parameters in the high-frequency region (above 300 MHz).

Here, a fundamental measurement method based on a reflection measurement is described for the SAW one-port resonators.

8.5.2 Admittance measurement

8.5.2.1 Principle of measurement

SAW one-port resonators are characterized with the equivalent circuit shown in Figure 2. The resonator measurement is made to determine parameters L_1, C_1, R_1 and C_0 and the series resonance frequency f_s. C_0 is measured directly with a capacitance meter. The other parameters can be calculated from the vector admittance diagram, shown in Figure 3, which are obtained by impedance measurement with a vector impedance analyser or network analyser.

8.5.2.2 Measurement circuit

The measurement set-up is shown in Figure 8. An r.f. signal coming from the r.f. output port 1 of a network analyser is fed direct to the test fixture, and a vector ratio of A/R is measured for return attenuation. All of those connections have to be made with r.f. coaxial cables, the nominal impedance of which shall be equal to the system impedance.

NOTE 1 In Figure 8, the *R* channel should detect source power for the reference. The *A* channel should detect port 1 power reflected from the input of resonator.

NOTE 2 A vector voltmeter or other resonator test equipment can be used instead of the network analyser.

NOTE 3 In order to avoid inaccurate measurements due to noise, it is advisable to work at a reasonably high power level or insert amplifiers at the ends of the test fixture to compensate for the resonator attenuation.

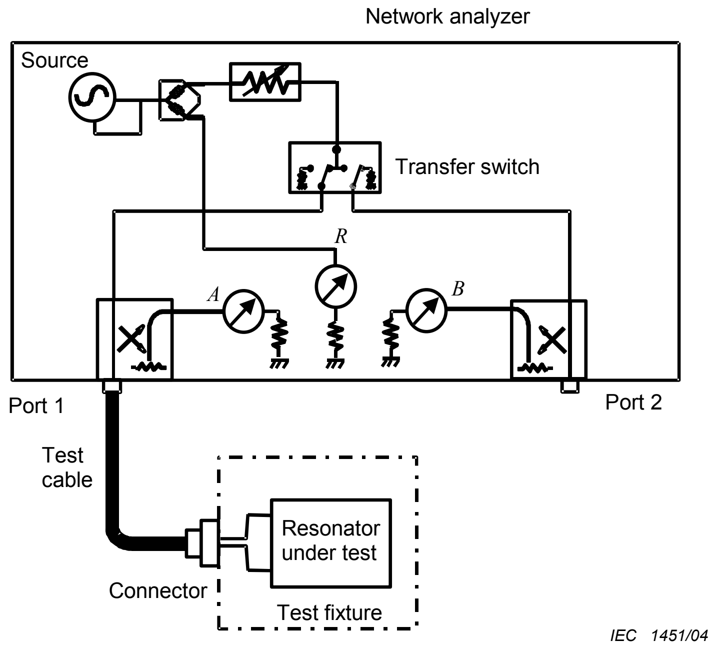


Figure 8 – Reflection measurement

8.5.2.3 Resonator test fixture

The test fixture shall be connected to either port of a network analyser. A suitable socket shall be provided to connect the resonator. The socket is provided to replace the resonator by calibration terminations. The distance between the test fixture connector and the resonator should be as short as possible.

8.5.2.4 Measurement method

Disconnect the test fixture from the connector of test cable, then one-port calibration shall be performed at the end of the connector. The readings of the magnitude and phase of the network analyser are normalized to be the reference level and phase. When the calibration is performed properly, the reading of the phase can be kept at 0° independent of the frequency. The relative attenuation and phase shift to the reference level and phase are the return attenuation for the system impedance of the network analyser.

NOTE Generally, return attenuation is used in the dB scale and its linear coefficient is called reflectivity.

8.5.2.5 Relation between reflectivity and resonator admittance

Resonator reflectivity is represented by the following equation:

$$\gamma = |\gamma| \exp(j\varphi)$$

where

γ is reflectivity;

$|\gamma|$ is its absolute value, i.e. reflection coefficient;

φ is the reflective phase shift in radians.

Resonator admittance can be calculated from the following equation:

$$Y = Y_0 \frac{1-\gamma}{1+\gamma}$$

where

Y is the resonator admittance;

Y_0 is the system admittance of the test equipment.

8.5.2.6 Calculating parameters from the admittance diagram

SAW resonator parameters can be calculated with the admittance data obtained above. Resonance frequency f_r is the lower frequency, where the imaginary part of the admittance goes to zero.

Motional resistance R_1 is an inverse of the maximum value of the conductance, which is the real part of the admittance at the motional resonance frequency f_s.

Motional inductance L_1 is derived from the following equation:

$$L_1 = \frac{1}{4\pi} \frac{\Delta X}{\Delta f}$$

where $\Delta X/\Delta f$ is the frequency derivative of the resonator reactance (imaginary part of the inverse value of the admittance) around the f_m.

Motional capacitance C_1 is calculated as follows:

$$C_1 = \frac{1}{(2\pi f_s)^2} \times \frac{1}{L_1}$$

Shunt capacitance C_0 is measured direct with a capacitance meter.

NOTE The admittance data can be read direct on the admittance chart of the recent network analyser.

8.6 Measurement method of two-port resonator

8.6.1 General

Today the most popular and simplest method to test resonators is by using network analysers. The system impedance of such equipment is usually 50 Ω. Therefore, the termination condition between the resonator and the test equipment has to be considered.

8.6.2 Transmission characteristics measurement

8.6.2.1 Principle of measurement

Parameters for the SAW two-port resonator equivalent circuit are shown in Figure 6. The resonator measurement is made to determine the parameters. However, in general, SAW two-port resonators are specified by C_{IN}, C_{OUT}, centre frequency f_C, minimum insertion attenuation IA_{min} (dB), loaded quality factor Q_L and operating phase shift with transmission measurement.

C_{IN} and C_{OUT} can be measured direct with a capacitance meter.

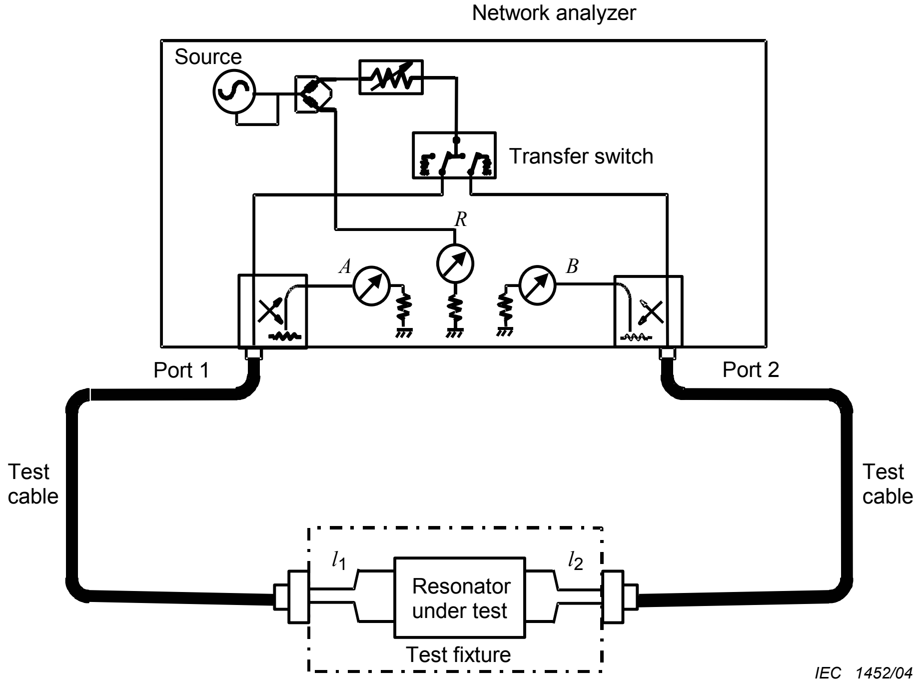


Figure 9 – Transmission measurement

The insertion attenuation is obtained as a ratio of the signal level measured when the signal is fed through a through connection, to that when it is fed through the resonator with a resonator test fixture (see Figure 9).

Similarly, relative phase shift is obtained as a phase shift relative to the reference phase. But the resonator phase shift should be reduced by calculated phase shift due to the effective electrical length of the resonator test fixture as described in 8.6.2.3.

NOTE 1 In Figure 9, the R channel should detect source power for the reference. The A channel should detect port 1 power reflected from the input of resonator and the B channel should detect port 2 power transmitted through resonator.

NOTE 2 A vector voltmeter or other resonator test equipment can be used instead of the network analyser.

NOTE 3 In order to avoid inaccurate measurements due to noise, it is advisable to work at a reasonably high power level or insert amplifiers at the ends of the test fixture to compensate for the resonator attenuation.

8.6.2.2 Measurement circuit

The measurement set-up is shown in Figure 9. An r.f. signal coming from the r.f. output port 1 of a network analyser is fed direct to port 2 through a test fixture, and a vector ratio of B/R is measured for insertion attenuation. All of those connections have to be made with r.f. coaxial cables, the nominal impedance of which shall be equal to the system impedance.

8.6.2.3 Resonator test fixture

The test fixture shall have standard input and output connectors and sockets for the resonator. In order to minimize test fixture attenuation, the distance between the test fixture connectors and the sockets should be kept as short as possible and the test fixture should use a high conductivity material. If these requirements are met, the contribution of the test fixture to the insertion attenuation can be made negligible.

The test fixture is considered to consist effectively of lossless transmission lines, connecting the input and output connectors of the test fixtures and the corresponding resonator sockets. The electrical length of these transmission lines can be obtained from reflection measurements at the input and output ports of the test fixture.

In order to determine the effective electrical length l_1 between the input connector and the resonator socket, place the measurement reference plane in the reflection mode at the input cable connector, attach the test fixture without a resonator to the input cable and adjust the electrical length of the network analyser so that the reflection phase is constant and independent of the frequency. Use the same procedure to determine the effective electrical length l_2 between the output connector and the resonator socket. The effective electrical length l of the test fixture is the sum of l_1 and l_2, i.e.

$$l = l_1 + l_2$$

8.6.2.4 Measurement method

Before connecting the resonator test fixture, the calibration of network analysers shall be made in order to eliminate systematic error among network analyser, cable and connectors.

The full two-port calibration technique is appropriate to compensate the systematic errors (i.e. presenting open, short, reference impedance, normally 50 Ω, and through standards at the ends of test cable connectors and storing the measured values).

After performing calibration, insert the test fixture with the resonator. Use effective electrical length (l) to be stored in the network analyser for minimizing the phase shift of the test fixture.

8.6.2.5 Resonator electrical characteristics

The minimum insertion attenuation is the minimum value of the insertion attenuation in the vicinity of the nominal frequency.

The centre frequency f_c is the arithmetic mean of two frequencies at which the attenuation relative to the minimum insertion attenuation reaches a specified value (for example, 3 dB).

The loaded quality factor Q_L can be calculated from the following equation:

$$Q_L = f_c / \Delta f$$

where Δf is the difference between the two frequencies at which the attenuation relative to the minimum insertion attenuation reaches 3 dB.

The operating phase shift is the relative phase shift, measured at the centre frequency.

The input and the output capacitances are measured direct with a capacitance meter.

8.6.2.6 Calculation of parameters from transmission characteristics

Parameters for the SAW two-port resonator equivalent circuit, shown in Figure 6, can be derived from the preceding measured values, which are input and output capacitances, C_{IN} and C_{OUT}, centre frequency f_c, minimum insertion attenuation, IA_{min} (dB) and loaded quality factor, Q_L.

The unloaded quality factor Q_U can be calculated from the following equation:

$$Q_U = \frac{Q_L}{1 - 10^{-(IA_{min}/20)}}$$

where IA_{min} (dB) is the minimum insertion attenuation.

A source impedance R_s (for example, 50 Ω) of the network analyser, shunted by the C_{IN}, is equivalent to a series impedance Z_g which is R_g connected by C_g in series, as follows:

$$|Z_g| = \frac{R_s}{\sqrt{1 + (2\pi f_c C_{IN} R_s)^2}}$$

$$R_g = \frac{R_s}{1 + (2\pi f_c C_{IN}\ R_s)^2}$$

$$C_g = \left[1 + (2\pi f_c C_{IN}\ R_s)^{-2}\right] C_{IN}$$

Also, load impedance R_L of the network analyser test port shunted by the C_{OUT} is re-written to a series impedance Z_t which is R_t connected by C_t in series, as follows:

$$|Z_t| = \frac{R_L}{\sqrt{1 + (2\pi f_c C_{OUT} R_L)^2}}$$

$$R_t = \frac{R_L}{1 + (2\pi f_c C_{OUT}\ R_L)^2}$$

$$C_t = \left[1 + (2\pi f_c C_{OUT}\ R_L)^{-2}\right] C_{OUT}$$

A motional resistance R_1 is derived from the minimum insertion attenuation IA_{min} (dB) by the following equation:

$$R_1 = \frac{(R_s + R_L) \times |Z_g| \times |Z_t|}{R_s \times R_L} \times 10^{IA_{min}/20} - R_g - R_t$$

A motional inductance L_1 is obtained from the loaded quality factor Q_L by the following equation:

$$L_1 = \frac{Q_L \times (R_g + R_t + R_1)}{2\pi f_c}$$

A motional capacitance C_1 is calculated as follows:

$$C_1 = \frac{1}{(2\pi f_c)^2 L_1 - 1/C_g - 1/C_t}$$

8.6.3 Insulation resistance

Insulation resistance shall be measured by means of direct voltage as specified in the detail specification. This voltage is applied between

a) the terminations;

b) the terminations connected together and the metal parts of the case.

Insulation resistance shall be not less than the value specified in the relevant detail specification.

8.6.4 Voltage proof

The resonator shall pass the following tests without evidence of arcing, flashover, insulation breakdown or damage.

An alternating voltage of a specified value shall be applied for a period of 5 s between

a) the terminations;

b) the terminations connected together and the metal parts of the case.

8.7 Mechanical and environmental test procedures

8.7.1 Robustness of terminations (destructive)

8.7.1.1 Tensile and thrust tests on terminations

The tests shall be performed in accordance with test Ua_1 (tensile) and test Ua_2 (thrust) of IEC 60068-2-21.

Unless otherwise stated in the detail specification, the loading shall be

– for pin (solder) terminations: 1 N thrust;
– for pin (solder) terminations: 5 N tensile;
– for wire (solder) terminations: 10 N tensile.

8.7.1.2 Flexibility of wire terminations

The test shall be performed in accordance with test Ub (bending) of IEC 60068-2-21.

The detail specification shall define the loading force to be applied and the position at which the bend shall start.

8.7.1.3 Torque test on mounting studs

The test shall be performed in accordance with test Ud (torque) of IEC 60068-2-21.

Unless otherwise stated in the detail specification, severity 2 shall be used.

8.7.2 Sealing tests (non-destructive)

8.7.2.1 Gross leak test

This test shall be performed in accordance with the procedure specified in test method 1 or 2 of test Qc of IEC 60068-2-17.

Method 1

The liquid shall be degassed water and the pressure of air above the water shall be reduced to 8,5 kPa (85 mbar) or less. It shall not be necessary to drain or remove the specimen from the water before breaking the vacuum.

Method 2

The detail specification shall define the temperature at which the liquid shall be maintained. The immersion time shall be 30 s, unless otherwise specified in the relevant detail specification.

During the test there shall be no evidence of leakage of gas or air from the inside of the SAW resonator. The continuous formation of bubbles shall be evidence of leakage.

After the test, there shall be no visible damage to the resonator.

8.7.2.2 Fine leak test

The test shall be performed in accordance with method 1 of test Qk of IEC 60068-2-17.

Unless otherwise stated in the detail specification, the pressure in the pressure vessel shall be 200 kPa (2 bar). However, care should be taken to ensure that the pressure chosen does not cause mechanical damage to the device under test.

The maximum leak rate shall not exceed the value given in 6.6 of IEC 60068-2-17, unless otherwise stated in the detail specification.

8.7.3 Soldering (solderability and resistance to soldering heat) (destructive)

8.7.3.1 Solderability

Test A (Lead terminations)

This test shall be performed in accordance with method 1 of test Ta of IEC 60068-2-20. The terminations shall be examined for good tinning, as evidenced by free flowing of the solder with wetting of the terminations.

Test B (Lead terminations)

This test shall be performed in accordance with method 2 of test Ta of IEC 60068-2-20 with the size of soldering iron stated in the detail specification. The terminations shall be examined for good tinning, as evidenced by free flowing of the solder with wetting of the terminations.

Test C (Surface-mounted devices)

This test shall be performed in accordance with test Td of IEC 60068-2-58. The immersion time shall be 2 s ± 0,2 s at a temperature of 235 °C ± 5 °C unless otherwise specified in the detail specification. The terminations shall be examined for good wetting of the terminations.

8.7.3.2 Resistance to soldering heat

Test A (Lead terminations)

This test shall be performed in accordance with method 1A of test Tb of IEC 60068-2-20. The immersion time shall be 5 s ± 1 s unless otherwise specified in the detail specification. A screen of thermally insulating material shall be used to prevent the component being heated by direct radiation from the solder bath. It shall also allow the immersion of the terminations up to a point 2 mm from the emergence of the terminations from the body unless otherwise specified in the detail specification.

Test B (Lead terminations)

This test shall be performed in accordance with method 2 of test Tb of IEC 60068-2-20 with the size of the soldering iron specified in the detail specification. The soldering iron shall be applied for a duration of 5 s ± 1 s unless otherwise specified in the detail specification.

Test C (Surface-mounted devices)

This test shall be performed in accordance with test Td of IEC 60068-2-58. The immersion time shall be 10 s ± 1 s, unless otherwise specified in the detail specification, at a temperature of 260 °C ± 5 °C.

8.7.4 Rapid change of temperature: severe shock by liquid immersion (non-destructive)

The test shall be performed in accordance with test Nc of IEC 60068-2-14. The units shall be subjected to one cycle in a downward direction from 98 °C ± 3 °C for 15 s to 1 °C ± 1 °C for 5 s.

8.7.5 Rapid change of temperature with prescribed time of transition (non-destructive)

The test shall be performed in accordance with test Na of IEC 60068-2-14.

The low and high test-chamber temperatures shall be the extreme temperatures of the operating range stated in the detail specification.

The SAW resonator shall be maintained at each extreme of temperature for 30 min unless otherwise specified in the detail specification.

The SAW resonator shall be subjected to five complete thermal cycles and then exposed to standard atmospheric conditions for recovery for not less than 2 h.

8.7.6 Bump (destructive)

The test shall be performed in accordance with test Eb of IEC 60068-2-29.

The SAW resonator shall be mounted or clamped as required by the detail specification. The three mutually perpendicular axes in which the bump is to be applied shall include

– an axis parallel to the terminations;
– an axis parallel to the base of the SAW resonator.

The degree of severity shall be as prescribed in the detail specification.

8.7.7 Vibration (destructive)

8.7.7.1 Vibration (sinusoidal) (SAW resonator not operating)

The test shall be performed in accordance with IEC 60068-2-6.

The SAW resonator shall be mounted or clamped as required by the detail specification. The three mutually perpendicular axes in which the acceleration is to be applied shall include

– an axis parallel with the terminations;
– an axis parallel to the base of the SAW resonator.

The degree of severity shall be stated in the detail specification.

8.7.7.2 Vibration (sinusoidal) (SAW resonator operating)

The test shall be as described in 8.7.7.1, except that during the test the resonator shall be energized and electrical tests, as defined in the detail specification, shall be performed.

The degree of severity shall be stated in the detail specification.

8.7.7.3 Random vibration (SAW resonator not operating)

The test shall be performed in accordance with test Fh of IEC 60068-2-64.

The SAW resonator shall be mounted or clamped as required by the detail specification. The three mutually perpendicular axes in which the acceleration is to be applied shall include

– an axis parallel to the terminations;
– an axis parallel to the base of the SAW resonator.

The detail specification shall state the acceleration spectral density (ASD), the frequency range and the duration.

8.7.7.4 Random vibration (SAW resonator operating)

The test shall be as described in 8.7.7.3 except that during the test the resonator shall be energized and electrical tests, as defined in the detail specification, shall be performed.

8.7.8 Shock (destructive)

The test shall be performed in accordance with test Ea of IEC 60068-2-27.

The SAW resonator shall be mounted or clamped as required by the detail specification. The three mutually perpendicular axes in which the shock is to be applied shall include

– an axis parallel to the terminations;
– an axis parallel to the base of the SAW resonator.

The degree of severity shall be as stated in 5.9, unless otherwise stated in the detail specification.

8.7.9 Free fall (destructive)

The test shall be performed in accordance with procedure 1 of test Ed of IEC 60068-2-32.

The SAW resonator shall be suspended by its terminations at a height of 1 000 mm ± 5 mm and dropped on to a base, the material of which shall be defined in the detail specification. The number of falls shall be two unless otherwise stated in the detail specification.

8.7.10 Acceleration, steady state (non-destructive)

8.7.10.1 Acceleration, steady state (resonator not operating)

The test shall be performed in accordance with test Ga of IEC 60068-2-7.

The SAW resonator shall be mounted or clamped as required by the detail specification. The procedure and severity shall be as stated in the detail specification.

8.7.10.2 Acceleration, steady state (resonator operating)

The test shall be as described in 8.7.10.1 except that during the test the resonator shall be energized and electrical tests, as defined in the detail specification, shall be performed.

The procedure and severity shall be as stated in the detail specification.

8.7.11 Low air pressure (non-destructive)

This test shall be performed in accordance with test M of IEC 60068-2-13. The pressure in the chamber shall be reduced to 30 kPa for a duration of 2 h unless otherwise stated in the detail specification.

8.7.12 Dry heat (non-destructive)

The test shall be performed in accordance with test Ba of IEC 60068-2-2. The conditioning shall be carried out at the upper temperature indicated by the climatic category for a duration of 16 h unless otherwise stated in the detail specification.

8.7.13 Damp heat, cyclic (destructive)

This test shall be performed in accordance with test Db variant 1 of IEC 60068-2-30 at severity b), 55 °C for six cycles.

8.7.14 Cold (non-destructive)

This test shall be performed in accordance with test Aa of IEC 60068-2-1 at the lower temperature indicated by the climatic category for a duration of 2 h unless otherwise stated in the detail specification.

8.7.15 Climatic sequence (destructive)

The test and measurements shall be performed in the following order:

dry heat:	see 8.7.12;
damp heat cyclic:	see 8.7.13 (first cycle only);
cold:	see 8.7.14;
low air pressure:	see 8.7.11 (when applicable);
damp heat cyclic:	see 8.7.13 (remaining five cycles).

In the climatic sequence, an interval of not more than three days is permitted between any of these tests, except between the damp-heat cyclic (first cycle) and dry-cold.

In such a case, the cold test shall follow immediately after the recovery period specified for the damp-heat test.

8.7.16 Damp heat, steady state (destructive)

This test shall be performed in accordance with test Cab of IEC 60068-2-78, for the appropriate climatic category stated in 5.6.

8.7.17 Salt mist cyclic (destructive)

This test shall be performed in accordance with test Kb of IEC 60068-2-52. Severity 1 shall be used unless otherwise stated in the detail specification.

8.7.18 Immersion in cleaning solvents (non-destructive)

This test is applicable to superficial markings only. To establish the permanence of marking, this test shall be performed in accordance with method 1 of test XA of IEC 60068-2-45. The detail specification shall prescribe the solvent, the temperature of the solvent, the rubbing material and its dimensions, and the force to be used.

The marking shall be legible.

8.7.19 Radiation hardness

Under consideration.

8.7.20 Flammability test (destructive)

This test shall be performed in accordance with the needle-flame test of IEC 60695-2-2. The detail specification shall state the duration of application of the test flame selected from 5 s, 10 s, 20 s, 30 s, 60 s, or 120 s as appropriate to the design and materials of the test specimen.

The duration and extent of burning shall be stated in the detail specification.

8.8 Endurance test procedure

8.8.1 Ageing (non-destructive)

The SAW resonator shall be maintained at a temperature of 85 °C ± 2 °C for a continuous period of 30 days unless otherwise specified in the detail specification.

After the test period the resonator shall be kept at standard atmospheric conditions for testing until thermal equilibrium has been reached.

The specified tests shall be carried out and the final measurements shall be within the limits specified in the detail specification.

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