INTERNATIONAL STANDARD

IEC 61019-2

Second edition
2005-05

Surface acoustic wave (SAW) resonators –

Part 2:
Guide to the use

Reference number
IEC 61019-2:2005(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 61019-2

Second edition
2005-05

Surface acoustic wave (SAW) resonators –

Part 2:
Guide to the use

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE U

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SURFACE ACOUSTIC WAVE (SAW) RESONATORS –

Part 2: Guide to the use

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
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 61019-2 has been prepared by IEC technical committee 49: Piezoelectric and dielectric devices for frequency control and selection.

This second edition cancels and replaces the first edition published in 1995. This edition constitutes a technical revision.

The main changes with respect to the previous editon are listed below:

- at the end of 5.1, the edge reflector has been added. Its reference literature has been inserted in the bibliography;
- in Table 1, the propagation properties of $LiNbO_3$ (64° Y) have been added;
- in Table 3, the clause and subclause numbers have been corrected in order to be consistent with IEC 61019-1 (2004) which has replaced IEC 61019-1-1 (1990) and IEC 61019-1-2 (1993).

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

FDIS	Report on voting
49/714/FDIS	49/723/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.

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

Part 1: Generic information

Part 2: Guide to the use

Part 3: Standard outlines and lead connections

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 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.

INTRODUCTION

This part of IEC 61019 gives practical guidance to the use of SAW resonators which are used in telecommunications, radio equipments and consumer products. IEC 61019-1 can be referred to for general information, standard values and test conditions.

The features of these SAW resonators are small size, light weight, adjustment-free and high stability. In addition, the operating frequency of SAW resonators extends to the VHF and UHF ranges.

This part has been compiled in response to a generally expressed desire on the part of both users and manufacturers for a guide to the use of SAW resonators, so that the resonators may be used to their best advantage. To this end, general and fundamental characteristics have been explained in this guide.

SURFACE ACOUSTIC WAVE (SAW) RESONATORS –

Part 2: Guide to the use

1 Scope

SAW resonators are now widely used in a variety of applications: VCR RF-converters, CATV local oscillators, measuring equipment, remote control and so on. While SAW resonators are also applied to narrow bandwidth filters, the scope of this part of IEC 61019 is limited to SAW resonators for oscillator applications

It is not the aim of this guide to explain theory, nor to attempt to cover all the eventualities which may arise in practical circumstances. This guide draws attention to some of the more fundamental questions, which should be considered by the user before he places an order for a SAW resonator for a new application. Such a procedure will be the user's insurance against unsatisfactory performance.

Standard specifications, such as those of the IEC of which this guide forms a part, and national specifications or detail specifications issued by manufacturers, will define the available combinations of resonance frequency, quality factor, motional resistance, parallel capacitance, etc. These specifications are compiled to include a wide range of SAW resonators with standardized performances. It cannot be over-emphasized that the user should, wherever possible, select his SAW resonators from these specifications, when available, even if it may lead to making small modifications to his circuit to enable the use of standard resonators. This applies particularly to the selection of the nominal frequency.

2 Normative references

The following 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 61019-1:2004, *Surface acoustic wave (SAW) resonators – Part 1: Generic specification*

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

3 Technical considerations

It is of prime interest to a user that the resonator characteristics should satisfy particular specifications. The selection of oscillating circuits and SAW resonators to meet such specifications should be a matter of agreement between user and manufacturer.

Resonator characteristics are usually expressed in terms of resonance frequency, motional resistance, quality factor and parallel capacitance (for the one-port type) and centre frequency, insertion attenuation, loaded and unloaded quality factor, input capacitance and output capacitance (for the two-port type). A standard method for measuring resonator characteristics is described in 8.5 and 8.6 of IEC 61019-1. The specifications are to be satisfied between the lowest and highest temperatures of the specified operating temperature range and before and after environmental tests.

4 Fundamentals of SAW resonators

4.1 Basic structure

SAW resonators consist of interdigital transducers (IDT) and of grating reflectors, which are placed on the surface of a piezoelectric substrate. In most cases, the grating reflectors are made of thin metal (such as Al, Au) film while, in some cases, they are constructed with periodic grooves. The die is bonded by an adhesive agent into a sealed enclosure, and the IDT is electrically connected to the terminals with bonding wires. There are two SAW resonator configurations. One is a one-port SAW resonator. The other is a two-port SAW resonator. The former has a single IDT between two reflectors, as shown in Figure 1. The latter has two IDTs between two reflectors, as shown in Figure 2. In the figures, ℓ_{eff} is the resonator cavity length, as described in 5.2 c).

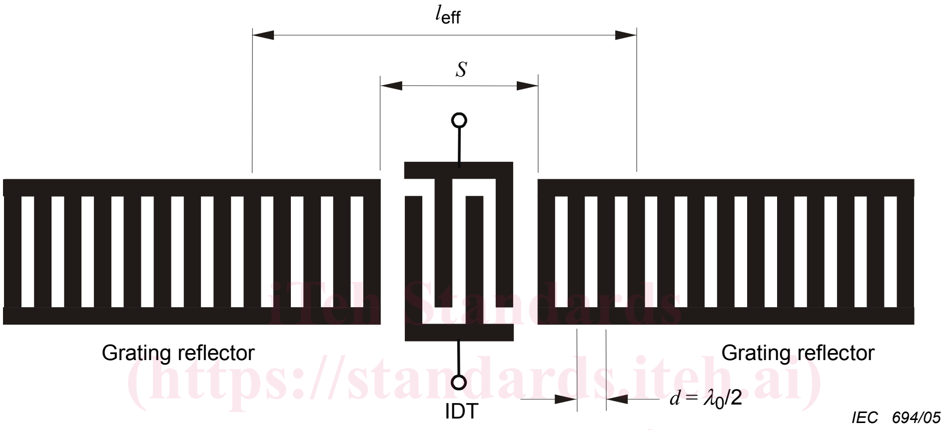


Figure 1 – One-port SAW resonator configuration

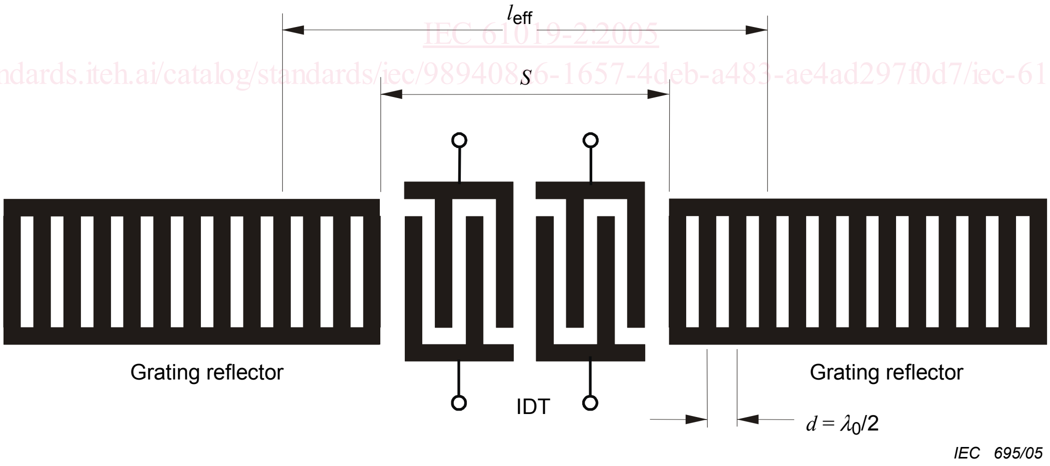


Figure 2 – Two-port SAW resonator configuration

4.2 Principle of operation

The resonance phenomenon for SAW resonators is achieved by confining the SAW vibration energy within grating reflectors. The SAW, excited by an alternating electrical field between IDT electrode fingers, propagates outside the IDT to be reflected by grating reflectors.

The grating reflectors feed the perturbation to the SAW, owing to the discontinuity in electrical or mechanical impedance. When the SAW is incident on such grating reflectors, the incident wave is gradually converted into a reflected wave. Although the amount of perturbation per unit reflective element may be very small, a large number of such elements, arranged periodically, reflect the SAW in phase, and maximize coherent reflection.

These grating configurations can form effective reflecting boundary, creating a standing wave between the reflectors and make resonance with a very high Q. Figure 3 shows the displacement distribution for this standing wave for a one-port SAW resonator. As shown in the figure, the SAW energy is maximum near the centre of the IDT, and gradually decays towards the edges of the grating reflectors. The resonance frequency, f_r, is approximately determined by

$$f_r \approx v_s/(2d) = v_s/\lambda_0$$

where

v_s is the SAW propagation velocity;

d is the distance between electrode centres;

λ_0 is the SAW wavelength at the stop band centre frequency.

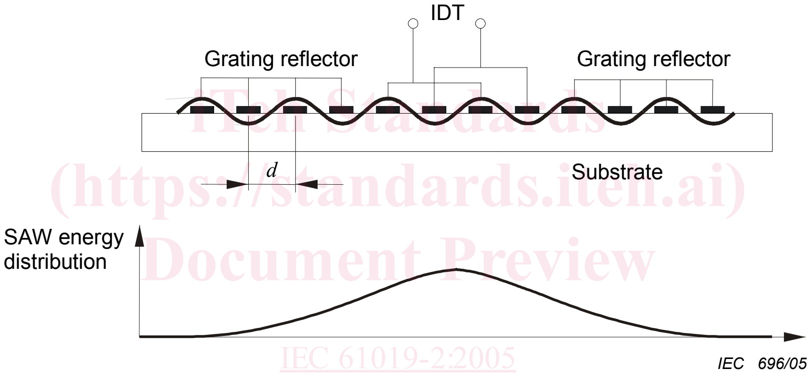


Figure 3 – Standing wave pattern and SAW energy distribution

5 SAW resonator characteristics

5.1 Reflector characteristics

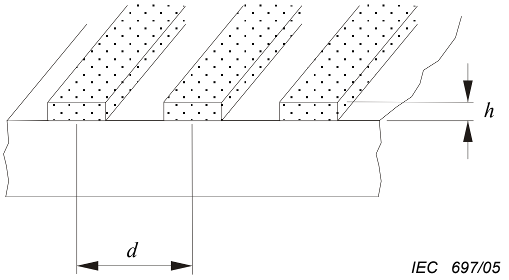
The reflector for SAW resonators consists of a periodically arranged array of reflective elements, called a grating reflector. As cross-sections show in Figure 4, possible array elements are:

a) metal strips or dielectric ridges;

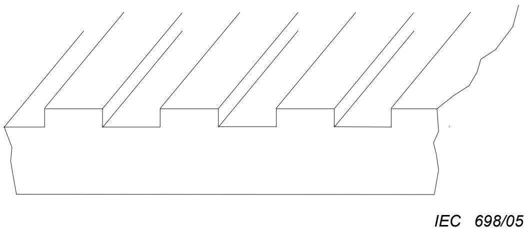
b) grooves;

c) ion-implanted or metal-diffused strips.

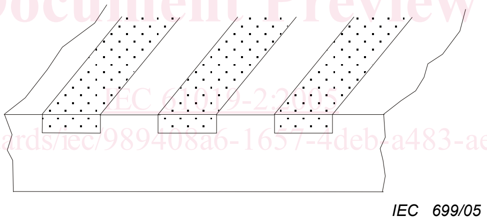
For example, an aluminum strip on ST-cut quartz, whose thickness h is 1 % of wave length $\lambda(h/\lambda_0)$ and whose width w is half the spatial period ($w = d/2 = \lambda_0/4$), has a small reflection coefficient ε of approximately 0,5 %. A groove with 1 % depth has almost the same ε. This periodic perturbation causes efficient reflection of SAW energy, if its wavelength equals twice its periodicity.



4a – Metal strips or dielectric ridges



4b – Grooves



4c – Ion-implanted or metal diffused strips

Figure 4 – Grating reflector configurations

A grating reflector without loss with a finite number of array elements has a frequency range of nearly total reflection called the stop band. The fractional stop bandwidth to centre frequency is $2\varepsilon/\pi$, where ε is the reflection coefficient for one element. Figure 5 indicates the frequency dependency on the total reflectivity $|\Gamma|$ for the grating reflector with a finite number N_R of array elements. Theoretically, the reflectivity maximum value is derived as:

$$|\Gamma|_\mathrm{max} = \tanh(N_\mathrm{R} \times \varepsilon)$$

at the centre frequency f_0 of the stop band. A greater reflectivity makes SAW resonator Q value higher, due to decreasing the leakage of SAW energy stored in the cavity between two grating reflectors.