

Surface acoustic wave (SAW) resonators —

Part 2: Guide to the use

The European Standard EN 61019-2:2005 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 61019-2:2005. It is identical with IEC 61019-2:2005. It supersedes BS EN 61019-2:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/49, Piezo-electric devices for frequency control and selection, which has the responsibility to:

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Foreword

The text of document 49/714/FDIS, future edition 2 of IEC 61019-2, prepared by IEC TC 49, Piezoelectric and dielectric devices for frequency control and selection, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61019-2 on 2005-06-01.

This European Standard supersedes EN 61019-2:1997.

The main changes with respect to EN 61019-2:1997 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 LiNbO₃ (64° Y) have been added;
- in Table 3, the clause and subclause numbers have been corrected in order to be consistent with EN 61019-1:2005.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2006-03-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2008-06-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61019-2:2005 was approved by CENELEC as a European Standard without any modification.

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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).

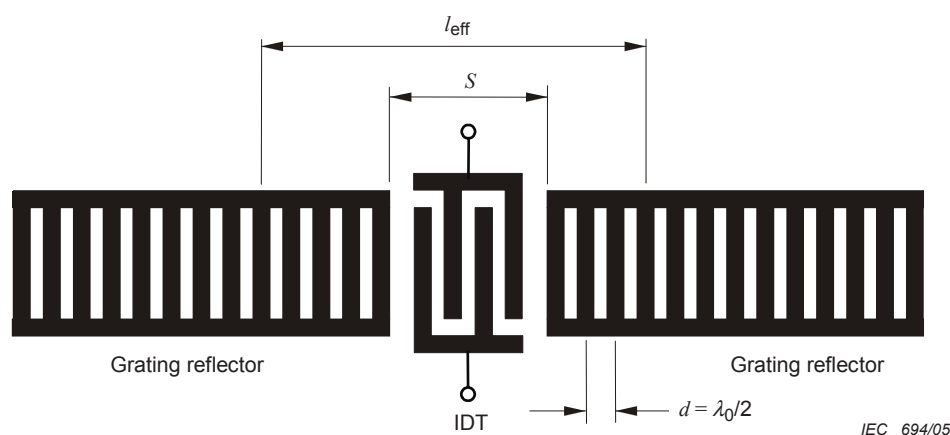


Figure 1 – One-port SAW resonator configuration

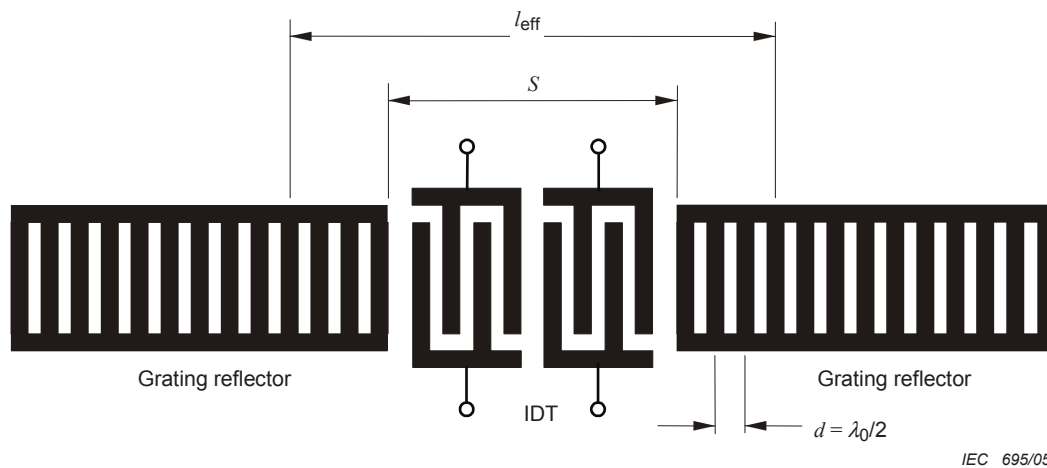


Figure 2 – Two-port SAW resonator configuration

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.

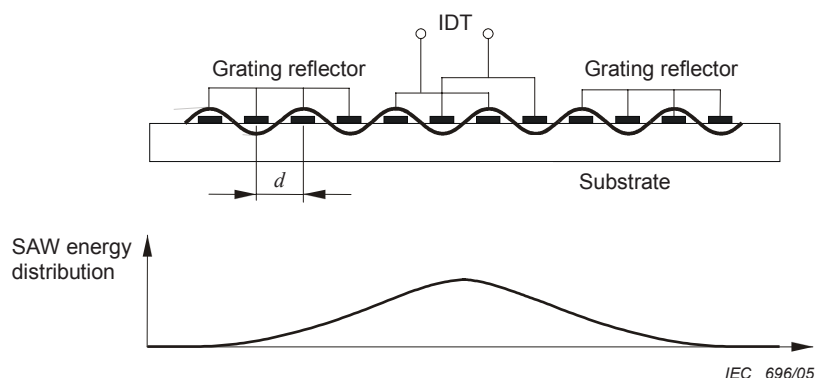


Figure 3 – Standing wave pattern and SAW energy distribution

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.