IEC 63155

Edition 1.0 2020-04

INTERNATIONAL STANDARD

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colour inside

Guidelines for the measurement method of power durability for surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices in radio frequency (RF) applications

Lignes directrices relatives à la méthode de mesure de la durabilité de puissance des appareils à ondes acoustiques de surface (OAS) et des appareils à ondes acoustiques de volume (OAV) dans les applications de radiofréquence (RF)

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GUIDELINES FOR THE MEASUREMENT METHOD OF POWER DURABILITY FOR SURFACE ACOUSTIC WAVE (SAW) AND BULK ACOUSTIC WAVE (BAW) DEVICES IN RADIO FREQUENCY (RF) APPLICATIONS

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
49/1339/FDIS	49/1342/RVD

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,
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- amended.

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INTRODUCTION

Radio frequency (RF) surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices are now widely used in various communication systems owing to their features such as small size, light weight, little or no need for tuning, high stability and high reliability.

One of the most important applications of the devices is the antenna duplexer in mobile communication devices which separates incoming receiving (Rx) signals from base-stations and outgoing transmitting (Tx) signals in the frequency domain. It is known that acoustic vibration can accelerate destruction of electrode metals in the inter-digital transducers (IDTs) employed, which results in device failure. Thus, the device life time (time to failure, TF) is dependent on not only the chip temperature but also on input power level and frequency of the applied radio frequency signal. It should be noted that chip temperature can be somewhat different from the environmental temperature because the input power level of Tx signals in the above-mentioned applications is about 1 W at maximum, and heat generation due to power consumption is not negligible.

The requisite TF of the SAW/BAW duplexers is usually specified by input power level, exposure frequency range and environmental temperature. Nevertheless, TF measurement under given specifications is not realistic because the requisite TF is too long (could be up to many years). Accelerated life time testing is applied to shorten the TF. TF is measured in more severe situations, namely at higher power and/or higher ambient temperature. TF under given specifications is estimated by extrapolation based on the Arrhenius model including the inverse power law. Although the model explains the variation of the TF with respect to input power level and temperature well, the parameters appearing in the model need to be determined experimentally, and its procedures have not been well established. Therefore, measurement methods will be specifically established for TF estimation of RF SAW/BAW devices.

This document has been compiled in response to a generally expressed desire on the part of both users and manufacturers for general information on testing condition guidance of RF SAW/BAW filters, so that the filters may be used to their best advantage. To this end, general and fundamental characteristics have been explained in this document.

GUIDELINES FOR THE MEASUREMENT METHOD OF POWER DURABILITY FOR SURFACE ACOUSTIC WAVE (SAW) AND BULK ACOUSTIC WAVE (BAW) DEVICES IN RADIO FREQUENCY (RF) APPLICATIONS

1 Scope

This document defines the measurement method for the determination of the durability of radio frequency (RF) surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices, such as filters and duplexers, with respect to high power RF signals, which are used in telecommunications, measuring equipment, radar systems and consumer products. RF BAW devices include two types: those based on the film bulk acoustic resonator (FBAR) technology and those based on the solidly mounted resonator (SMR) technology.

This document includes basic properties of failure of RF SAW/BAW devices, and guidelines to set up the measurement system and to establish the procedure to estimate the time to failure (TF). Since TF is mainly governed by the RF power applied in the devices, discussions are focused on the power durability.

It is not the aim of this document to explain the theory, or to attempt to cover all the eventualities which can arise in practical circumstances. This document draws attention to some of the more fundamental questions which will need to be considered by the user before he/she places an order for an RF SAW/BAW device for a new application. Such a procedure will be the user's means of preventing unsatisfactory performance related to premature device failure resulting from high-power exposure of RF SAW/BAW devices.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

3.1 General terms

3.1.1
BAW
bulk acoustic wave
acoustic wave, propagating between the top and bottom surface of a piezoelectric structure and then traversing the entire thickness of the piezoelectric bulk

Note 1 to entry: The wave is excited by metal electrodes attached to both sides of the piezoelectric layer.

[SOURCE: IEC 62575-1:2015, 3.1.1]

3.1.2
BAW filter
bulk acoustic wave filter
filter characterised by a bulk acoustic wave which is usually generated by a pair of electrodes and propagates along a thin film thickness direction

[SOURCE: IEC 62575-1:2015, 3.1.2]

3.1.3
cut-off frequency
frequency of the pass band at which the relative attenuation reaches a specified value

[SOURCE: IEC 60862-1:2015, 3.1.2.4, modified – The reference to Figure 1 has been deleted.]

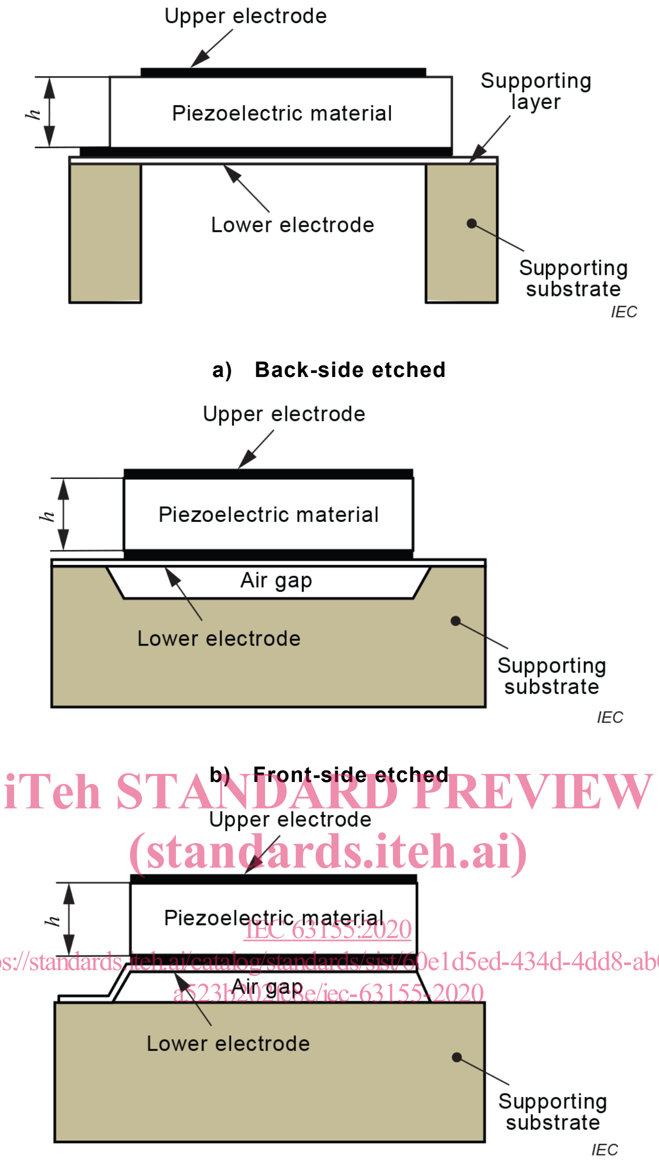
3.1.4
duplexer
device used in the frequency division duplex system, which enables the system to receive and transmit signal through a common antenna simultaneously

[SOURCE: IEC 62761:2014, 3.1.5]

3.1.5
film bulk acoustic resonator
FBAR
thin film BAW resonator consisting of a piezoelectric layer sandwiched between two electrode layers with stress-free top and bottom surfaces supported mechanically at the edge on a substrate with cavity structure as shown in Figure 1 or membrane structure as an example

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 62575-1:2015, 3.1.3, modified – Figure 1 c) has been added.]



c) Sacrificial-layer etched

Figure 1 – FBAR configuration

3.1.6
solidly mounted resonator
SMR
BAW resonator, supporting the electrode/piezoelectric layer/electrode structure by a sequence of additional thin films of alternately low and high acoustic impedance Z_a with quarter wavelength layer, and these layers act as acoustic reflectors and decouple the resonator acoustically from the substrate as shown in Figure 2 as an example

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 62575-1:2015, 3.1.4]

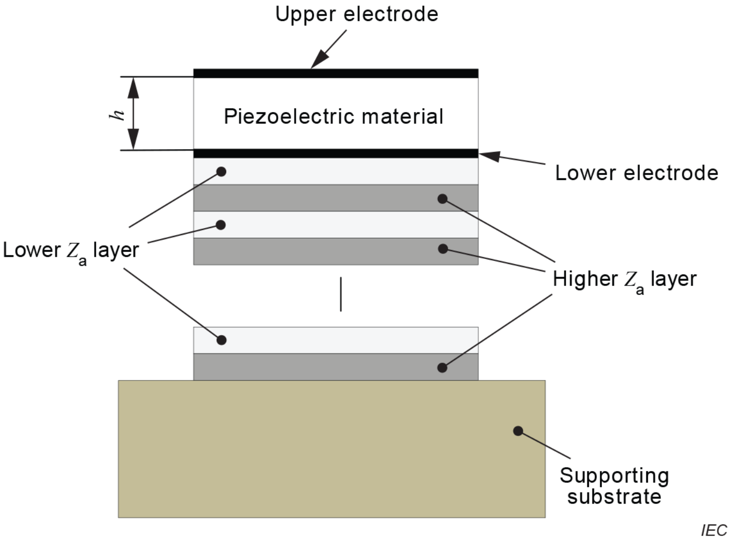


Figure 2 – SMR configuration

3.1.7
response characteristic
SEE: Figure 3

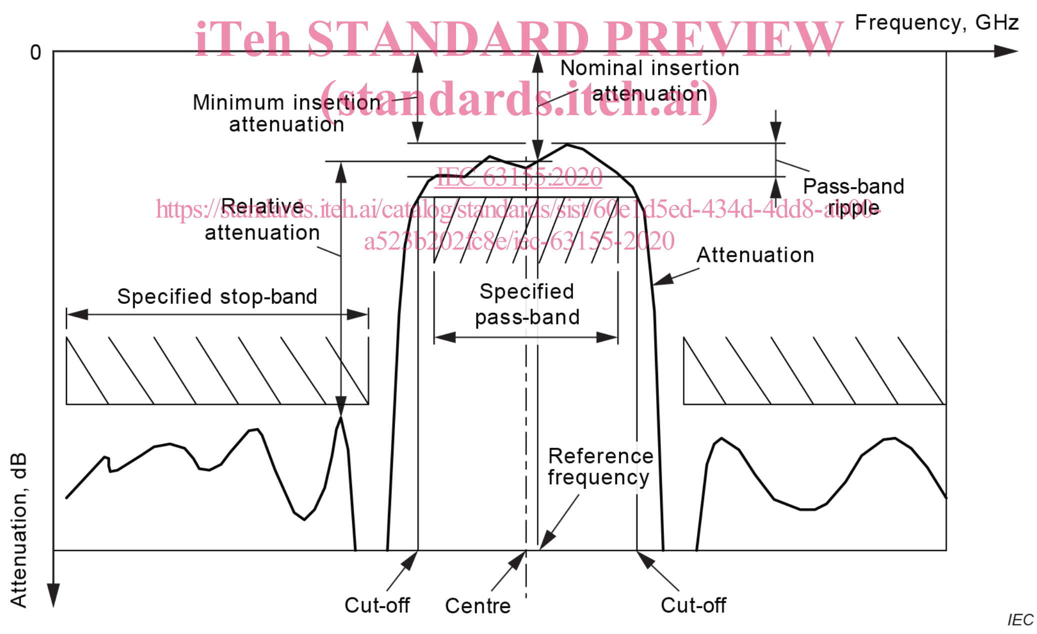


Figure 3 – Frequency response of an RF SAW/BAW filter

3.1.8
input impedance
impedance presented by the filter/duplexer to the signal source when the output is terminated by a specified load impedance

[SOURCE: IEC 62604-1:2015, 3.1.2.22, modified – "duplexer" has been replaced by "filter/duplexer".]

3.1.9
input level
power, voltage or current value applied to the input port of a filter/duplexer

[SOURCE: IEC 62604-1:2015, 3.1.2.19, modified – "duplexer" has been replaced by "filter/duplexer".]

3.1.10
insertion attenuation
logarithmic ratio of the power delivered directly to the load impedance before insertion of the filter/duplexer to the power delivered to the load impedance after insertion of the filter/duplexer

[SOURCE: IEC 62604-1:2015, 3.1.2.2, modified – "duplexer" has been replaced by "filter/duplexer".]

3.1.11
operating temperature range
range of temperatures, over which the SAW/BAW filter/duplexer will function while maintaining its specified characteristics within specified tolerances

[SOURCE: IEC 62575-1:2015, 3.1.16, modified – "BAW filter" has been replaced by "SAW/BAW filter/duplexer".]

3.1.12
output impedance
impedance presented by the filter/duplexer to the load when the input is terminated by a specified source impedance

[SOURCE: IEC 62604-1:2015, 3.1.2.23, modified – "duplexer" has been replaced by "filter/duplexer".]

3.1.13
output level
power, voltage or current value delivered to the load circuit

[SOURCE: IEC 62604-1:2015, 3.1.2.20]

3.1.14
pass band
band of frequencies in which the relative attenuation is equal to or less than a specified value

[SOURCE: IEC 62604-1:2015, 3.1.2.5]

3.1.15
pass bandwidth
separation of frequencies between which the relative attenuation is equal to or less than a specified value

[SOURCE: IEC 62604-1:2015, 3.1.2.6]

3.1.16
reflectivity
dimensionless measure of the degree of mismatch between two impedances Z_a and Z_b:

$$\frac{Z_a - Z_b}{Z_a + Z_b},$$

where Z_a and Z_b represent, respectively, the input and source impedance or the output and load impedance

Note 1 to entry: The absolute value of reflectivity is called the reflection coefficient.

[SOURCE: IEC 62604-1:2015, 3.1.2.17]

3.1.17
Rx filter
filter used in a receiver part to eliminate unnecessary/unwanted signals

Note 1 to entry: The Rx filter is a basic part of a duplexer.

[SOURCE: IEC 62604-1:2015, 3.1.3.4, modified – "RX" has been replaced by "Rx" in the term, "/unwanted" has been added to the definition and Note 2 to entry has been omitted.]

3.1.18
SAW filter
filter characterised by one or more surface acoustic wave transmission line or resonant elements, where the surface acoustic wave is usually generated by an interdigital transducer and propagates along a material surface

[SOURCE: IEC 62604-1:2015, 3.1.1.2, modified – The term "surface acoustic wave filter" has been omitted.]

3.1.19
stop band
band of frequencies in which the relative attenuation is equal to or greater than a specified value

3.1.20
SAW
surface acoustic wave
acoustic wave, propagating along a surface of an elastic material, whose amplitude decays exponentially with the depth

[SOURCE: IEC 60862-1:2015, 3.1.1.1]

3.1.21
Tx filter
filter used in a transmitter part to eliminate unnecessary/unwanted signals

Note 1 to entry: This is a basic part of a duplexer.

[SOURCE: IEC 62604-1:2015, 3.1.3.3, modified – "TX" has been replaced by "Tx" in the term, "/unwanted" has been added to the definition and Note 2 to entry has been omitted.]

3.2 Durability related terms

3.2.1
accelerated life time testing
testing strategy whereby the engineer extrapolates a product's failure behaviour at normal conditions from life data obtained at accelerated stress levels

Note 1 to entry: Since products fail more quickly at higher stress levels, this sort of strategy allows the engineer to obtain reliability information about a product (e.g., mean life, probability of failure at a specific time, etc.) in a shorter time.

3.2.2
acceleration factor
ratio of the product's life at the used stress level to its life at an accelerated stress level

Note 1 to entry: For example, if the product has a life of 100 h at the used stress level, and it is being tested at an accelerated stress level which reduces its life to 50 h, then the acceleration factor is 2.