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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Semiconductor devices – Discrete devices – Part 14-4: Semiconductor accelerometers

Dispositifs à semiconducteurs – Dispositifs discrets – Partie 14-4: Accéléromètres à semiconducteurs

IEC 60747-14-4:2011

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Part 14-4: Semiconductor accelerometers

Dispositifs à semiconducteurs – Dispositifs discrets –
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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 60747-14-4 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This part of IEC 60747 should be read in conjunction with IEC 60747-1:2006. It provides basic information on semiconductor

– terminology;
– letter symbols;
– essential ratings and characteristics;
– measuring methods;
– acceptance and reliability.

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

FDIS	Report on voting
47E/405/FDIS	47E/409/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.

A list of all the parts in the IEC 60747 series, under the general title *Semiconductor devices – Discrete devices*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

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INTRODUCTION

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning following items.

a) Measurement technique and apparatus for matrix sensitivity in "definition of sensitivity matrix of an accelerometer" given in Subclause 4.1.5 and Annex A.
b) Measurement technique and apparatus for the dynamic linearity measurement of AC accelerometers in "dynamic linearity measurement using an impact acceleration generator" given in Annex B.
c) Measurement technique and apparatus for the frequency response measurement of accelerometers under the frequency bandwidth control in "method of controlling the frequency bandwidth of the shock acceleration" given in Clause C.5.
d) Measurement technique and apparatus for the dynamic response and peak sensitivity measurement of accelerometers in the form of matrix using elastic pulse in "definition of sensitivity matrix of an accelerometer" given in Annex A.
e) Projectiles for frequency bandwidth control in "method of controlling the frequency bandwidth of the shock acceleration" given in Clause C.5 and for the dynamic response and peak sensitivity measurement of accelerometers in the form of matrix using elastic pulse in "definition of sensitivity matrix of an accelerometer" given in Annex A.

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SEMICONDUCTOR DEVICES –
DISCRETE DEVICES –

Part 14-4: Semiconductor accelerometers

1 Scope

This part of IEC 60747 applies to semiconductor accelerometers for all types of products.

This standard applies not only to typical semiconductor accelerometers with built-in electric circuits, but also to semiconductor accelerometers accompanied by external circuits.

This standard does not (or should not) violate (or interfere with) the agreement between customers and suppliers in terms of a new model or parameters for business.

NOTE 1 This standard, although directed toward semiconductor accelerometers, may be applied in whole or in part to any mass produced type of accelerometer.

NOTE 2 The purpose of this standard is to allow for a systematic description, which covers the subjects initiated by the advent of semiconductor accelerometers. The tasks imposed on the semiconductor accelerometers are not only common to all accelerometers but also inherent to them and not yet totally solved. The descriptions are based on latest research results. One typical example is the multi-axis accelerometer. This standard states the method of measuring acceleration as a vector quantity using multi-axis accelerometers.

NOTE 3 This standard does not conflict in any way with any existing parts of either ISO 16063 or ISO 5347. This standard intends to provide the concepts and the procedures of calibration of the semiconductor multi-axis accelerometers which are used not only for the measurement of acceleration but also for the control of motion in the wide frequencies ranging from DC.

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 60747-1:2006, *Semiconductor devices – Part 1:General*

IEC 60749 (all parts), *Semiconductor devices – Mechanical and climate test methods*

IEC 60749-1, *Semiconductor devices – Mechanical and climate test methods – Part 1: General*

IEC 60749-5, *Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test*

IEC 60749-6, *Semiconductor devices – Mechanical and climatic test methods – Part 6: Storage at high temperature*

IEC 60749-10, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-11, *Semiconductor devices – Mechanical and climatic test methods – Part 11: Rapid change of temperature – Two-fluid-bath method*

IEC 60749-12, *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

IEC 60749-13, *Semiconductor devices – Mechanical and climatic test methods – Part 13: Salt atmosphere*

IEC 60749-25, *Semiconductor devices – Mechanical and climatic test methods – Part 25: Temperature cycling*

IEC 61000-4 (all parts), *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*

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

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4:Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*

ISO 5347 (all parts), *Methods for the calibration of vibration and shock pick-ups*

ISO 5347-11:1993, *Methods for the calibration of vibration and shock pick-ups – Part 11: Testing of transverse vibration sensitivity*

ISO/IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

3 Terminology and letter symbols

3.1 Terms and definitions

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

3.1.1
accelerometer
device whose output is a vector representing the projection of the acceleration in a multidimensional space of the acceleration applied to it

3.1.2
AC accelerometer
accelerometer which has a high-pass filter in either real or equivalent signal processing circuits in characteristics

NOTE It responds to AC band domain input in its frequency characteristics. This type of accelerometer is useful for measurement of vibration, shock and sway.

3.1.3
DC accelerometer
accelerometer that responds to the input from DC to specified AC band domain in its frequency characteristics

NOTE It has the second order open-loop system or closed-loop system. This type of accelerometer is useful for measurement of inclination angle, velocity and displacement by integration of output.

3.1.4
semiconductor accelerometer
accelerometer manufactured by the semiconductor technology for at least one acceleration sensing element

NOTE A typical example might be a combination of a silicon seismic system by micro-machining with sensing mechanism and an electrical circuit.

3.1.5
one-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension one

3.1.6
two-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension two

3.1.7
three-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension three

3.1.8
four-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension four

3.1.9
five-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension five

3.1.10
six-dimensional accelerometer
accelerometer whose characteristics are measured in the calibration acceleration vector space with dimension six

3.1.11
level 1 accelerometer
accelerometer with a sensitivity that is not defined in a form of a matrix

NOTE The sensitivity along the input axis is separated from the cross axis sensitivity.

3.1.12
level 2 accelerometer
accelerometer with sensitivity in the form of a matrix in which all components of the matrix are constant as a function of frequency and other parameters if necessary

3.1.13
level 3 accelerometer
accelerometer with sensitivity in the form of a matrix in which some of the components are defined as functions of frequency and other parameters if necessary

3.1.14
level 4 accelerometer
accelerometer with sensitivity in the form of a matrix in which all of the components are defined as functions of frequency and other parameters if necessary

3.1.15
input acceleration vector space
real motion vector space where the input acceleration is an element of a set

NOTE Input acceleration vector space is divided into the application acceleration vector space and the calibration acceleration vector space.

3.1.16
accelerometer output vector space
vector space where the output signal from an accelerometer is an element of a set

3.1.17
gravitational acceleration
acceleration due to gravity

NOTE The symbol *g* denotes a unit of acceleration equal in magnitude to the value of local gravity and the symbol g_n represents the standard value of *g* under international agreement, g_n=9,80665 m/s^2.

3.1.18
input axis
axis along or about which the accelerometer output for the applied acceleration indicates a maximum value

NOTE Neither misalignment nor cross-axis sensitivity compensation is employed. The IA direction only may be marked on the external package.

3.1.19
input reference axis
direction of an axis that is nominally parallel to the input axis

NOTE It is defined by the package mounting surfaces or external package markings.

3.1.20
output axis
axis along or about which the output of the accelerometer is measured

NOTE In some cases, it is referred to as the hinge or flexure axis.

3.1.21
output reference axis
direction of an axis that is nominally parallel to the output axis

NOTE It is defined by the package mounting surfaces or external package markings.

3.1.22
pendulum axis
axis through the proof mass centre in pendulum accelerometers

NOTE It is perpendicular to and intersecting the output axis.

3.1.23
pendulum reference axis
direction of an axis that is nominally parallel to the pendulum axis

NOTE It is defined by the package mounting surfaces or external package markings.

3.1.24
misalignment
angle between an input axis and the corresponding input reference axis that is indicated on the accelerometer package, when the device is at a 0 *g* position

3.1.25
pick-off
device that indicates the displacement of proof mass generated by input acceleration

3.1.26
proof mass
mass whose inertia produces an acceleration signal

NOTE Pendulum-mass or translational-mass is generally used.

3.1.27
bias
outputs without any acceleration along the input axis

NOTE It may be represented by the algebraic means between the peak outputs given when acceleration is applied equally along both directions of the input axis.

3.1.28
bias discrepancy
difference between the bias values at the 1 *g* and the 0 *g* positions

NOTE It is a function of the non-linear characteristics of sensitivity.

3.1.29
bias error
algebraic difference between the bias of a device and the nominal bias in the specification

NOTE The bias specification of the device is comprised of the variation due to temperature and voltage.

3.1.30
temperature coefficient of bias
change in bias per unit change in temperature relative to the bias at the specified temperature

3.1.31
ratiometricity
proportionality of the output acceleration to the supply voltage change on the accelerometer

3.1.32
supply voltage range
maximum and minimum supply voltage values among which the device can operate normally

3.1.33
measurement range
maximum and minimum acceleration values that are measurable

3.1.34
input acceleration limits
extreme values of the input acceleration, within which the accelerometer can keep the specified performance

3.1.35
first resonant frequency
lowest frequency at which the ratio of output versus input acceleration takes a peak value

3.1.36
dynamic linearity
linearity that is concerned with the relationship between the transient input signals and output signals

NOTE See Annex B.

3.1.37
sensitivity matrix
matrix that transforms the input acceleration vector space to the output signal vector space under the assumption that the transformation is linear

NOTE 1 Diagonal terms and non-diagonal terms correspond to normal sensitivities and cross-sensitivities, respectively.

NOTE 2 Calibration of an accelerometer should be recognized as the process of determining all of the components of the sensitivity matrix.

NOTE 3 Matrix sensitivity can be used to describe the sensitivity of accelerometers of level 2, 3 and 4. It is used to place an emphasis on the difference between the conventional sensitivity of the level 1 and level 2, 3 and 4 accelerometers (see 4.1.5: Classification)

3.1.38
peak sensitivity matrix
matrix with the components of peak sensitivity considered along the normal sensitivity axis as the diagonal terms and the components of peak sensitivity considered along the cross-sensitivity axis as the non-diagonal terms

3.1.39
sensitivity
output change per unit change of input acceleration in either static or dynamic state

NOTE 1 Sensitivity in steady state of level 1 accelerometers is generally evaluated as the slope of the straight line that can be fitted by the least square method applied to input-output data obtained by varying the input within the measurement range.

NOTE 2 Sensitivity for level 2, 3 and 4 accelerometers is expressed by a matrix.

3.1.40
sensitivity error
algebraic difference between a sensitivity of a device and the nominal sensitivity in the specification, with the percentage expression applied with the nominal sensitivity

NOTE The sensitivity of the device possesses the maximum and the minimum values among the over-all figures containing the temperature coefficient, etc.

3.1.41
temperature coefficient of sensitivity
change in sensitivity per unit change in temperature relative to the sensitivity at the specified temperature

3.1.42
normal sensitivity
sensitivity defined along the axis with the maximum sensitivity of an accelerometer

3.1.43
cross-sensitivity
sensitivity defined by the output along the specified axis perpendicular to the input along the normal sensitivity axis

3.1.44
cross-axis sensitivity
maximum sensitivity in the plane perpendicular to the measuring direction relative to the sensitivity in the measuring direction

NOTE 1 The maximum sensitivity in the perpendicular plane is obtained as the geometric sum of the sensitivities in two perpendicular directions in this plane.

NOTE 2 Transverse sensitivity can be used in stead of cross-axis sensitivity.