INTERNATIONAL STANDARD

IEC 60747-14-1

First edition
2000-10

Semiconductor devices –

Part 14-1: Semiconductor sensors – General and classification

Dispositifs à semiconducteurs –

Partie 14-1: Capteurs à semiconducteurs – Généralités et classification

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SEMICONDUCTOR DEVICES –

Part 14-1: Semiconductor sensors – General and classification

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
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International Standard IEC 60747-14-1 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

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

FDIS	Report on voting
47E/157/FDIS	47E/170/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 3.

The committee has decided that the contents of this publication remain unchanged until 2005. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this standard may be issued at a later date.

INTRODUCTION

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

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

SEMICONDUCTOR DEVICES –

Part 14-1: Semiconductor sensors – General and classification

1 Scope

This part of IEC 60747-14 describes general items concerning the specifications for sensors, which are the basis for specfications given in other parts of this series for various types of sensors. Sensors described in this standard are basically made of semiconductor materials; however, the statements made in this standard are also applicable to sensors using materials other than semiconductor, for example dielectric and ferroelectric materials.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60747. For dated references, subsequent amendments to, or revisions of, any of these publictions do not apply. However, parties to agreements based on this part of IEC 60747 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60721-2-1:1982, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60721-3-0:1984, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Introduction*
Amendment 1 (1987)

IEC 60747-1:1983, *Semiconductor devices – Discrete devices – Part 1: General*

3 Definitions

For the purpose of this International Standard, the following definitions apply. This clause states terms and definitions with letter symbols used for sensors.

3.1
ambient conditions allowed
ambient conditions that may have serious effects on sensor operation such as temperature, acceleration, vibration, shock, ambient pressure (e.g. high altitudes), moisture, corrosive materials, and electromagnetic field

NOTE 1 The allowed ambient conditions for a sensor should be specified so that the sensor can perform within its specified tolerance.

NOTE 2 Refer to IEC 60721-2-1 and IEC 60721-3-0 for basic conditions.

3.2
full scale span (FSS)
the algebraic difference between the end-points of the output

NOTE The upper limit of sensor output over the measuring range is called the full scale output (FSO) which is the sum of the offset signal plus the full scale span (see figure 1).

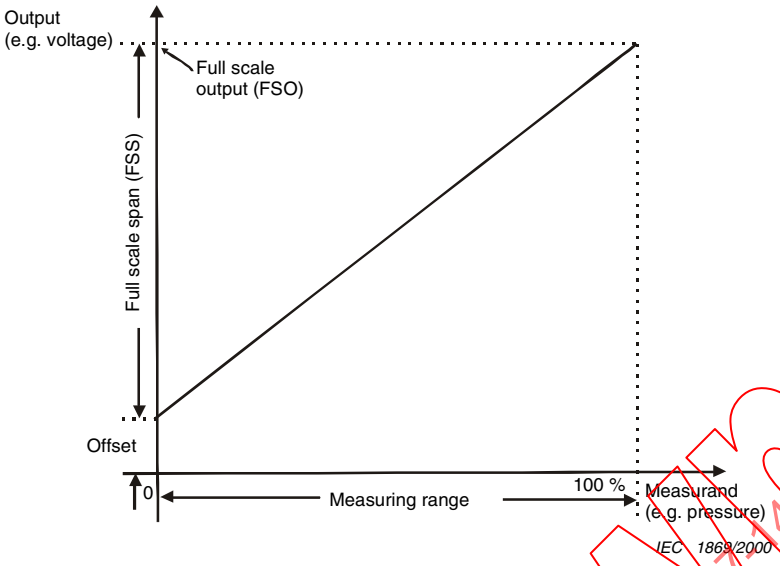

Figure 1 – Output-measurand relationship of a linear-output sensor with an offset

3.3
hysteresis
the maximum difference in output, at any measurand value, within the measuring range when the value is approached first with an increasing and then decreasing measurand (see figure 2)

NOTE Hysteresis is expressed in percent of FSO during one calibration cycle.

3.4
linearity
the closeness between the calibration curve and a specified straight line

NOTE There are two basic methods for calculating linearity: end-point straight line fit or a least squares best line fit. While a least squares fit gives the "best case" linearity error (lower numerical value), the calculations required are burdensome. Conversely, an end-point fit will give the "worst case" error (often more desirable in error budget calculations) and the calculations are more straightforward. The result is called the end-point or terminal linearity.

3.5
measuring range
the set of values for a measurand for which the error of a measuring instrument is intended to lie within specified limits (see figure 1)

NOTE 1 The upper and lower limits of the specified measuring range are sometimes called "maximum capacity" and "minimum capacity", respectively.

NOTE 2 In some other fields of knowledge, "range" is used to mean the difference between the greatest and the smallest values.

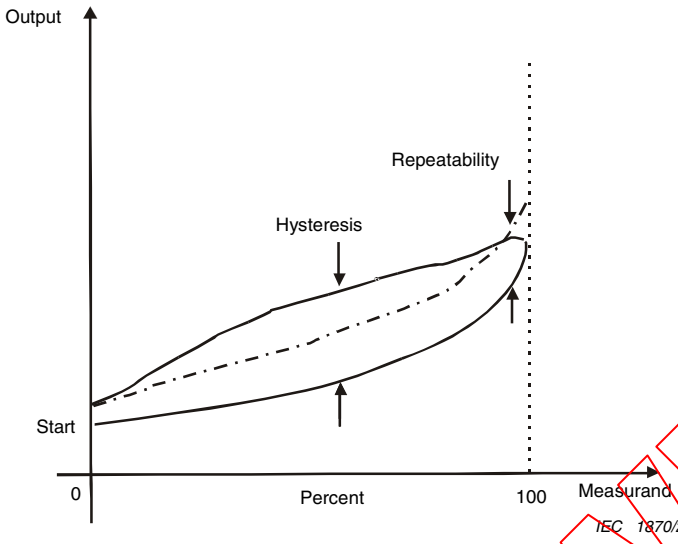

Figure 2 – Hysteresis and repeatability

3.6
offset
the output of a sensor, under room-temperature condition, unless otherwise specified, with zero measurand applied (see figure 1)

3.7
operating life
the minimum duration over which the sensor will operate, either continuously or over a number of on-off cycles whose duration is specified, without changing performance characteristics beyond specified tolerances

3.8
output quantity
quantity, usually electrical and a function of the measurable, produced by a sensor

NOTE 1 The output format includes analogue output (e.g. a continuous function of the measurand, such as voltage amplitude, voltage ratio, and changes in capacitance).

NOTE 2 Frequency output (i.e. the number of cycles or pulses per second as a function of the measurand) and frequency-modulated output (i.e. frequency deviation from a centre frequency) are also forms of analogue output.

NOTE 3 Another output format is the digital output which represents the measurand in the form of discrete quantities coded in some system of notation (e.g. binary code).

3.9
overload (or overrange)
the maximum magnitude of measurand that can be applied to a sensor without causing a change in performance beyond specified tolerances

NOTE A key parameter of the overload characteristics is the recovery time, which is the amount of time allowed to elapse after removal of an overload condition before the sensor performs again within the specified tolerances.

3.10
repeatability
the ability of a sensor to reproduce output readings at room temperature, unless otherwise specified, when the same measurand is applied to it consecutively, under the same conditions and in the same direction (see figure 2)

NOTE It is expressed as the maximum difference between output readings as determined by two calibration cycles (see figure 2). It is usually stated as "within × % FSO".

3.11
resolution
the minimal change of the measurand value necessary to produce a detectable change at the output

NOTE When the measurand increment is from zero, it is called the threshold.

3.12
selectivity
the ability of a sensor to measure one measurable (e.g. one chemical component) in the presence of others

3.13
sensitivity
the quotient of the change in sensor output to the change in the value of the measurable

NOTE 1 It is the slope of the calibration curve (see figure 1). For a sensor in which the output y is related to the measurand x by the equation $y = f(x)$, the sensitivity $S(x_a)$, at point x_a is:

$$S(x_a) = \left|\frac{dy}{dx}\right|_{x=x_a}$$

NOTE 2 It is desirable to have a high and, if possible, constant sensitivity. For a sensor having $y = kx+b$, where k and b are constants, the sensitivity S is k for the entire measuring range. For a sensor having $y = kx^2+b$, the sensitivity S is $2kx$ and changes from one point to another over the measuring range.

3.14
sensor
device which is affected by the measurand (stimulus) and provides an output quantity (response)

3.15
span
modulus of the difference between the two limits of the range and applies to measurand and output

3.16
stability
the ability of a sensor to maintain its performance characteristics for a certain period of time

NOTE Unless otherwise stated, stability is the ability of a sensor to reproduce output readings, obtained during the original calibration, and under constant room conditions, for a specified period of time. It is typically expressed as a percentage of FSO.

3.17
time of response
the time interval, with the apparatus in a warmed-up condition, between the time when an instantaneous variation in volume ratio is produced at the apparatus inlet and the time when the response reaches a stated percentage (x) of the final indication

4 Semiconductor sensors

The word "sensor" is derived from the Latin word *sentire* which means "to perceive". The word "sensor" has some connection with our human senses. It may provide us with information about physical and chemical signals, which could not otherwise be directly perceived by our senses, by detecting an input signal (or energy) and converting it to another form of output signal (or energy). The Concise Oxford Dictionary states the word "sensor" as "a device that responds to a physical (or chemical) stimulus (such as heat, light, sound, pressure, magnetism, or particular motion) and transmits a resulting impulse (as for measurement or operating a control)". Semiconductor sensors are semiconductor devices in which the semiconductor materials are mainly responsible for sensing.

Another term closely related to sensor is "transducer" which is derived from the Latin word *transducere*, meaning "to lead across". Signals as well as energy can be "lead across" a transducer, as it is a device that converts energy from one system to another in the same or in a different form. The essential differences between sensors and transducers are not significant. A sensor performs a transducing action and the transducer shall of course sense some signals of the surrounding environment.

5 Classification scheme for semiconductor sensors

Table 1 lists the measurands which are defined as the input quantities, properties, or conditions that are to be detected or measured by sensors. For example, if the measurand is heat, it is measured by a thermal sensor; if it is pressure, it is measured by a pressure sensor. The measurands, arranged in alphabetical order, are: acoustic, biological, chemical, electrical, magnetic, mechanical, optical, radiational, and thermal properties. Each entry in table 1 not only represents the measurand itself, but also its temporal or spatial distribution.