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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices –
Part 14-3: Semiconductor sensors – Pressure sensors

Dispositifs à semiconducteurs –
Partie 14-3: Capteurs à semiconducteurs – Capteurs de pression

IEC 60747-14-3:2009

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SEMICONDUCTOR DEVICES –

**Part 14-3: Semiconductor sensors –
Pressure sensors**

FOREWORD

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International Standard IEC 60747-14-3 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition, published in 2001, and constitutes a technical revision.

The major technical changes with regard to the previous edition are as follows: added a new Subclause 5.9 (measuring method of linearity) (technical)

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

CDV	Report on voting
47E/362/CDV	47E/376/RVC

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.

This part of IEC 60747 should be read in conjunction with IEC 60747-1:2006.

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

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- withdrawn;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.

INTRODUCTION

This part of IEC 60747 provides basic information on semiconductors:

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

SEMICONDUCTOR DEVICES –

Part 14-3: Semiconductor sensors – Pressure sensors

1 Scope

This part of IEC 60747 specifies requirements for semiconductor pressure sensors measuring absolute, gauge or differential pressures.

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 60747-14-1:2000, *Semiconductor devices – Part 14-1: Semiconductor sensors – General and classification*

3 Terminology and letter symbols

3.1 General terms

3.1.1 Semiconductor pressure sensors

A semiconductor pressure sensor converts the difference between two pressures into an electrical output quantity. One of the two pressures may be a reference pressure (see 3.2.3). It includes linear and on-off (switch) types of sensors.

A linear sensor produces electrical output quantity changes linearly with the pressure difference.

An on-off sensor switches an electrical output quantity on and off between two stable states when the increasing or decreasing pressure differences cross given threshold values.

In this standard, the electrical output quantity is described as a voltage: output voltage. However, the statements made in this standard are also applicable to other output quantities such as those described in 3.8 of IEC 60747-14-1: changes in impedance, capacitance, voltage ratio, frequency-modulated output or digital output.

3.1.2 Sensing methods

3.1.2.1 Piezoelectric sensing

The basic principle of piezoelectric devices is that a piezoelectric material induces a charge or induces a voltage across itself when it is deformed by stress. The output from the sensor is amplified in a charge amplifier which converts the charge generated by the transducer sensor into a voltage that is proportional to the charge. The main advantages of piezoelectric sensing are the wide operating temperature range (up to 300 °C) and high-frequency range (up to 100 kHz).

3.1.2.2 Piezoresistive sensing

The basic principle of a piezoresistor is the change of the resistor value when it is deformed by stress. The sensing resistors can be either p- or n-type doped regions. The resistance of piezoresistors is very sensitive to strain, and thus to pressure, when correctly placed on the diaphragm of a pressure sensor. Four correctly oriented resistors are used to build a strain gauge in the form of a resistor bridge.

An alternative to the resistor bridge is the transverse voltage strain gauge. It is a single resistive element on a diaphragm, with voltage taps centrally located on either side of the resistor. When a current is passed through the resistor, the voltages are equal when the element is not under strain, but when the element is under strain, a differential voltage output appears.

3.1.2.3 Capacitive sensing

A small dielectric gap between the diaphragm and a plate makes a capacitance which changes with the diaphragm movement. Single capacitance or differential capacitance techniques can be used in open- or closed-loop systems. Capacitance and capacitive changes can be measured either in a bridge circuit or using switched-capacitor techniques. Any of the capacitive sensing techniques used in a micromachined structure require an a.c. voltage across the capacitor being measured. Capacitive sensing has the following advantages: small size of elements, wide-operating temperature range, ease of trimming, good linearity, and compatibility to CMOS signal conditioning.

3.1.2.4 Silicon vibrating sensing

The vibrating element of a silicon micromachined structure is maintained in oscillation, either by piezoelectric or electrical field energy. The application of pressure to the silicon diaphragm produces strain on the micromachined structure and the vibration frequency is measured to determine applied pressure.

3.1.2.5 Signal conditioning

Semiconductor pressure sensors are mainly micromachined structures including a sensing element. Other electrical components or functions can be performed at the same time and in the same package on the process line. Most pressure sensors offer integrated signal conditioning.

Signal conditioning transforms a raw sensor output into a calibrated signal. This process may involve several functions, such as calibration of initial zero pressure offset and pressure sensitivity, compensation of non-linear temperature errors of offset and sensitivity, compensation of the non-linearity and output signal amplification of the pressure.

3.1.2.6 Temperature compensation

Semiconductor sensors are temperature sensitive. Some are temperature non-compensated sensors while others are compensated with added circuitry or materials designed to counteract known sources of error.

When non-compensated, the variations due to the temperature follow physical laws and a temperature coefficient (α) is representative of this physical phenomena.

When compensated, the temperature remaining error is also dependant on the way the compensation is performed. In this case, a maximum temperature deviation (Δ) better represents this error.

3.2 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60747-1 and the following apply.

3.2.1
piezoresistance coefficient
measure of the piezoresistance effect derived from the semiconductor materials under the application of strain

3.2.2
absolute pressure
pressure using absolute vacuum as the datum point

3.2.3
reference pressure
pressure against which pressures are defined, usually absolute vacuum or ambient atmospheric pressure

3.2.4
differential pressure
difference between the two (absolute) pressures that act simultaneously on opposite sides of the membrane

3.2.5
relative pressure
differential pressure when one of the two pressures is considered to be a reference pressure with respect to which the other pressure is being measured

3.2.6
gauge pressure
relative pressure when the ambient atmospheric pressure is used as the reference pressure

3.2.7
system pressure (or common-mode pressure)
static pressure that acts on the sensor but does not represent the pressure to be converted, in the case of a differential pressure sensor

3.2.8
over-pressure capability
maximum pressure that may be applied to the sensor without damage or loss of calibration accuracy

3.2.9
differential output resistance
first derivative of output voltage as a function of output current at the specified pressure. Refers to a basic sensor (without integrated signal amplification)

NOTE In practice, the differential resistance value can be expressed as the quotient of the change of the output voltage over the change in output current resulting from a small change in output load resistance.

3.2.10
input resistance
supply voltage divided by the supply current

3.2.11
isolation resistance
resistance between all the connected electrical terminals of the sensor and the sensor part which is in contact with the sensed element

NOTE In practice, this is not applicable when the sensed element, such as gas or oil, is not conductive.

3.2.12
calibrated pressure range
range of pressure within which the device is designed to operate and for which limit values of the conversion characteristics are specified

3.2.13
temperature coefficient of offset voltage
change in offset voltage relative to the change in temperature

3.2.14
temperature coefficient of full-scale span voltage
change in full-scale span voltage relative to the change in temperature

3.2.15
temperature coefficient of the pressure sensitivity
change in the pressure sensitivity relative to the change in temperature

3.2.16
maximum temperature deviation of the offset voltage
maximum deviation of the offset voltage for a specified temperature range, compared to the output offset voltage at the reference temperature

3.2.17

maximum temperature deviation of the full-scale span voltage

maximum deviation of the full-scale span voltage in a specified temperature range, compared to the full-scale span voltage at reference temperature

3.2.18
full-scale pressure
pressure that defines the upper limit for the calibrated pressure range

3.2.19
zero-scale pressure
pressure that defines the lower limit for the calibrated pressure range

3.2.20
null offset (also called zero pressure offset)
electrical output present when the pressure sensor is at null, i.e. when the pressure on each side of the sensing diaphragm is equal

3.2.21
burst pressure
pressure that causes an irreversible damage of the sensor

3.2.22
(End-point) Linearity error
difference between the actual value of the output voltage and, at the given pressure, the value that would result if the output voltage changed linearly with pressure between the zero-scale pressure and the full-scale pressure

3.2.23
total error
difference between the actual value of the output voltage and, at the given pressure, the value that would result if the actual voltages were equal to their nominal values at the zero-scale pressure and at the full-scale pressure and changed linearly with pressure between these points

3.2.24
accuracy
maximum deviation of actual output from nominal output over the entire pressure range and temperature range, as a percentage of the full-scale span at 25 °C, due to all sources of error such as linearity, hysteresis, repeatability and temperature shifts

3.2.25
hysteresis
sensor's ability to reproduce the same output for the same input, regardless of whether the input is increasing or decreasing. Pressure hysteresis is measured at a constant temperature, while temperature hysteresis is measured at a constant pressure within the operating range

3.2.25.1
pressure-cycle hysteresis
difference in the output at any given pressure in the operating pressure range when this pressure is approached from the minimum operating pressure as compared to when approached from the maximum operating pressure at room temperature

3.2.25.2
temperature-cycle hysteresis
difference in the output at any temperature in the operating pressure range when the temperature is approached from the minimum operating temperature as compared to when approached from the maximum operating temperature, with fixed pressure applied

3.2.26

pressure-cycling drift of output voltage
difference between the final value of the output voltage at a given pressure after a series of pressure cycles and the initial value at that same pressure when all other operating conditions are being held constant

3.2.27
temperature-cycling drift of output voltage
difference between the final value of the output voltage at a given temperature after a series of temperature cycles and the initial value at that same temperature when all other operating conditions are being held constant

3.2.28
pressure-cycling instability range of output voltage
difference between the extreme values of output voltage that were observed at a given pressure during a series of pressure cycles when all other operating conditions are being held constant

3.2.29
temperature-cycling instability range of output voltage
difference between the extreme values of output voltage that were observed at a given temperature during a series of temperature cycles, when all other operating conditions are being held constant

3.2.30
full-scale span sensitivity
quotient of the full-scale span voltage over the calibrated pressure range

3.2.31
temperature coefficient of full-scale span sensitivity
full-scale span sensitivity relative to the change in temperature