INTERNATIONAL STANDARD

IEC 60747-14-2

First edition
2000-11

Semiconductor devices –

**Part 14-2:
Semiconductor sensors – Hall elements**

Dispositifs à semiconducteurs –

*Partie 14-2:
Capteurs à semiconducteurs – Eléments à effet de Hall*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES –

Part 14-2: Semiconductor sensors – Hall elements

FOREWORD

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

FDIS	Report on voting
47E/158/FDIS	47E/171/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 will 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- withdrawn;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.

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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.

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SEMICONDUCTOR DEVICES –

Part 14-2: Semiconductor sensors – Hall elements

1 General

1.1 Scope

This part of IEC 60747 provides standards for packaged semiconductor Hall elements which utilize the Hall effect.

1.2 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 publications 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 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*

IEC 61340-5-1:1998, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

1.3 Definitions

For the purpose of this International Standard, the following definitions apply.

1.3.1
semiconductor Hall element
semiconductor device that generates the voltage upon application of a magnetic field with magnetic flux density, being proportional to the control voltage (see below) and the magnetic flux density

1.3.2
Hall mobility
electron mobility measured with the usage of the Hall effect

1.3.3
control current
current to be applied continuously to the input terminals of the device when the output terminals are not connected to external circuit

1.3.4
control voltage
voltage to be applied continuously to the input terminals of the device when the output terminals are not connected to external circuit

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1.3.5
offset voltage (or residual voltage)
voltage to be derived between the output terminals when a specified current or voltage is applied to the input terminals of the device without magnetic field

1.3.6
output Hall voltage
the difference between the voltage, which is derived across the output terminals when a specified current or voltage is applied to the input terminals of the device in a specified magnetic field, and the offset voltage

1.3.7
residual ratio
the ratio of the offset voltage to the output Hall voltage

1.3.8
input resistance
resistance between the input terminals of the device when the output terminals are not connected to external circuit

1.3.9
output resistance
resistance between the output terminals of the device when the input terminals are not connected to external circuit

1.3.10
temperature coefficient of output Hall voltage
relative change in output Hall voltage referred to the change in temperature

1.3.11
temperature coefficient of input resistance
relative change in input resistance referred to the change in temperature

1.4 Symbols

1.4.1 Clauses 2,3 and 4 of IEC 60747-1, chapter V, apply.

For the field of packaged Hall elements, the following additional special subscripts are recommended:

c control

o offset

H Hall

in input

out output

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Table 1 – Letter symbols

Name and designation	Letter symbol	Remarks
Hall mobility	μ_H	
Control current	I_c	
Control voltage	V_c	
Offset voltage or residual voltage	V_o	
Output Hall voltage	V_H	
Residual ratio	V_o/V_H	
Input resistance	R_{in}	
Output resistance	R_{out}	
Temperature coefficient of output Hall voltage	α_{VH}	
Temperature coefficient of input resistance	α_{Rin}	

1.4.2 Terminals

The terminal numbers and their designation for packaged Hall elements are shown in figure 1 and table 2. The designation of the terminals is listed below. The (+) and (–) signs of the output terminals assume that the magnetic line of force passes through from the top to the bottom of the Hall element.

Table 2 – Terminal numbers

Terminal number	Voltage/current
1	$V_c(+)$ or $I_c(+)$
2	$V_H(+)$
3	$V_c(–)$ or $I_c(–)$
4	$V_H(–)$

2 Essential ratings and characteristics

2.1 General

2.1.1 Element materials

Useful materials for Hall elements are semiconductor materials like GaAs, InSb, InAs, Si, etc. Ratings of Hall elements depend on the element materials.

2.1.2 Handling precautions

Due to a rather thin layer of semiconductor sensing region, the devices may be irreversibly damaged if an excessive voltage is allowed to build up, for example due to contact with electrostatically charged persons, leakage currents from soldering irons, etc.

When handling the devices, the handling precautions given in IEC 60747-1, chapter IX, clause 1, shall therefore be observed.

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2.2 Ratings (limiting values)

2.2.1 Temperatures

2.2.1.1 Minimum and maximum storage temperatures (T_{stg})

2.2.1.2 Minimum and maximum operating temperatures (T_{opr})

2.2.2 Bias

2.2.2.1 Maximum control current (I_{cmax})

2.2.2.2 Maximum control voltage (V_{cmax})

2.2.3 Derating curve

2.2.3.1 Control current derating curve

Maximum control current at each temperature shall be stated or be depicted in the form of a figure.

2.2.3.2 Control voltage derating curve

Maximum control voltage at each temperature shall be stated or be depicted in the form of a figure.

2.3 Characteristics

Characteristics are to be given at 25 °C, except where otherwise stated; other temperatures should be taken from the list in IEC 60747-1, chapter VI, clause 5.

2.3.1 Unloaded electrical characteristics

2.3.1.1 Output Hall voltage (V_H)

Maximum and minimum values, at a specified magnetic flux density and control voltage or current, at an operating temperature of 25 °C.

2.3.1.2 Input resistance (R_{in})

Maximum and minimum values, at a specified voltage or current without any magnetic flux density, at an operating temperature of 25 °C.

2.3.1.3 Output resistance (R_{out})

Maximum and minimum values, at a specified voltage or current without any magnetic flux density, at an operating temperature of 25 °C.

2.3.1.4 Offset voltage (V_o)

Maximum and minimum values, at a specified control voltage or current without any magnetic flux density, at an operating temperature of 25 °C.

2.3.1.5 Temperature coefficient of output Hall voltage (α_{V_H})

Average value at a specified temperature range (understood as the range given in 3.6.4), at a specified control current under specified magnetic flux density.

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2.3.1.6 Temperature coefficient of input resistance (α_{Rin})

Average value at a specified temperature range (understood as the range given in 3.7.3), at a specified control current without any magnetic flux density.

2.3.1.7 Dielectric strength

Maximum and minimum values at a specified voltage with respect to any external surface of the device.

2.3.2 Dimensional drawing

2.3.2.1 Dimensions

The drawing shall provide dimensions with specified tolerance.

2.3.2.2 Position of terminals

The position of the four terminals shall be shown in the figure.

3 Measuring methods

3.1 General

3.1.1 General precautions

The general precautions are listed in chapter VII, clause 2, of IEC 60747-1. In addition, special care should be taken to use low-ripple d.c. supplies and to decouple adequately all bias supply voltages.

3.1.2 Handling precautions

Due to the rather thin layer of semiconductor sensing region, the devices may be irreversibly damaged if an excessive voltage is allowed to build up, for example due to contact with electrostatically charged persons, leakage currents from soldering irons, etc.

When handling the devices, the handling precautions given in IEC 60747-1, chapter IX, clause 1, or IEC 61340-5-1, shall, therefore, be observed.

3.2 Output Hall voltage (V_H)

3.2.1 Purpose

To measure output Hall voltage under specified conditions.

3.2.2 Principles of measurements

Measuring the output Hall voltage is to evaluate the sensitivity of the devices to the applied magnetic flux density, which is in turn a measure of how well the current devices match application circuits.

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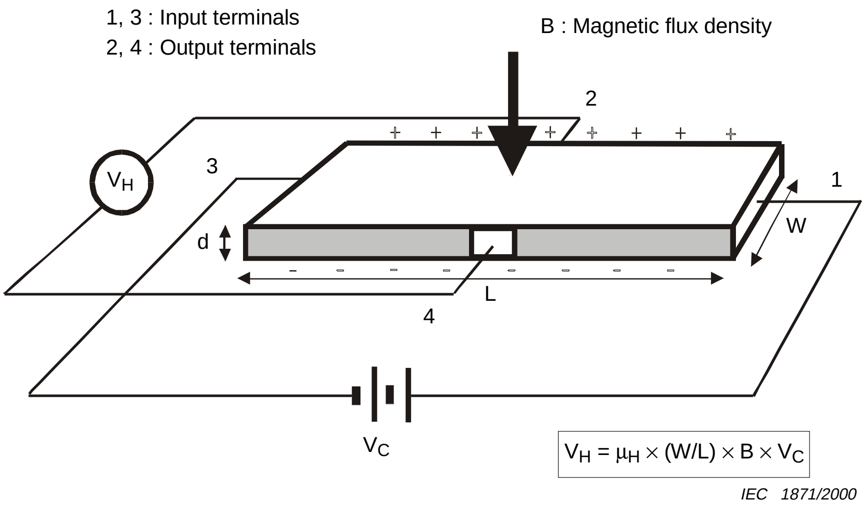

Figure 1 – The principles of Hall element

Measurements are based on the principle of the Hall element described here. In figure 1, the control current Ic flows through terminals 1 and 3 in an appropriate semiconducting material of thickness d. Upon application of a magnetic field with magnetic flux density B perpendicular to the wafer, the potential difference V_H develops between terminals 2 and 4. The output Hall voltage V_H is expressed as:

$$V_H = (K_H/d) \times I_c \times B$$

where K_H is termed Hall coefficient.

Thus, the Hall element generates the output voltage V_H proportionate to the product of the control current I_c and the magnetic flux density B.

3.2.3 Circuit diagram

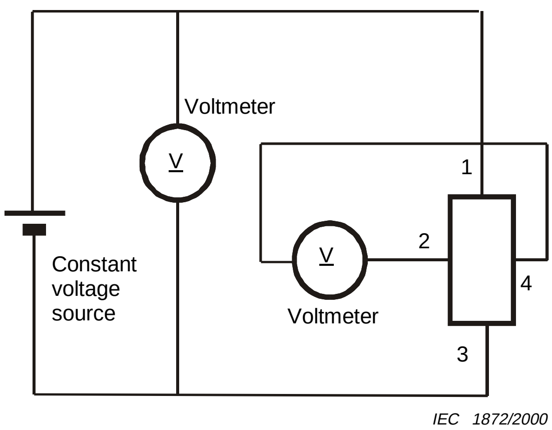

Figure 2a – Constant voltage

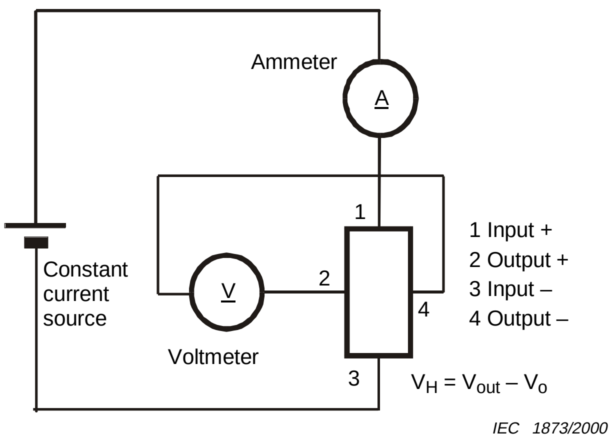

Figure 2b – Constant current

Figure 2 – Basic circuit for the measurement of output Hall voltage

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3.2.4 Circuit description and requirements

Internal impedances of the meters and/or measuring instrument shall not significantly affect the performance and the test results of the circuit to be measured.

3.2.5 Precautions to be observed

Precautions should be taken with respect to the position of the device placed among a magnetic field as follows:

a) the magnetic field should be even and practically perpendicular to all the magnetic sensitive areas of the device;

b) there should not be any residual magnetic field around the measuring system;

c) consideration should be given to the effect of terrestrial magnetism. The direction of the device relative to terrestrial magnetism should not be changed while measuring the output Hall voltage so that terrestrial magnetism does not affect the results;

d) the magnetic flux density should be specified whereby the output Hall voltage is linear with respect to the density.

3.2.6 Measuring procedure

a) Place the device with the four terminals connected to the circuit among a specified magnetic flux.

b) Apply a specified voltage or current to the input terminals of the device, using the circuit shown in figure 2.

c) Measure the output voltage of the device V_{out}.

d) Measure the offset voltage (V_o) according to the procedure described in 3.3.

e) Calculate the output Hall voltage using equation (1).

$$V_H = V_{out} - V_o \tag{1}$$

3.2.7 Specified conditions

– Ambient or reference temperature.

– Magnetic flux density.

– Input voltage or current.

3.3 Offset voltage (V_o)

3.3.1 Purpose

To measure the offset voltage under specified conditions.

3.3.2 Principles of measurements

Measuring the offset voltage is to evaluate the noise level of the devices which reflects the non-uniformity of the semiconductor layer used in the devices.

3.3.3 Circuit diagram

The same diagram as that described in 3.2.3 shall be used.

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3.3.4 Circuit description and requirements

Specifications for d.c. supply, meter and measuring instruments are the same as those described in 3.2.4 without taking any precautions with respect to magnetic flux density.

3.3.5 Measuring procedure

a) Place the device with the four terminals connected to the circuit without magnetic flux.

b) Apply a specified voltage or current to the input terminals of the device, using the circuit shown in figure 2.

c) Measure the output voltage, which is just the value of the offset voltage.

3.3.6 Specified conditions

Specify the same conditions as those described in 3.2.7.

3.4 Input resistance (R_{in})

3.4.1 Purpose

To measure the input resistance of a device, under specified conditions.

3.4.2 Circuit diagram

A source should be a constant voltage or a constant current source.

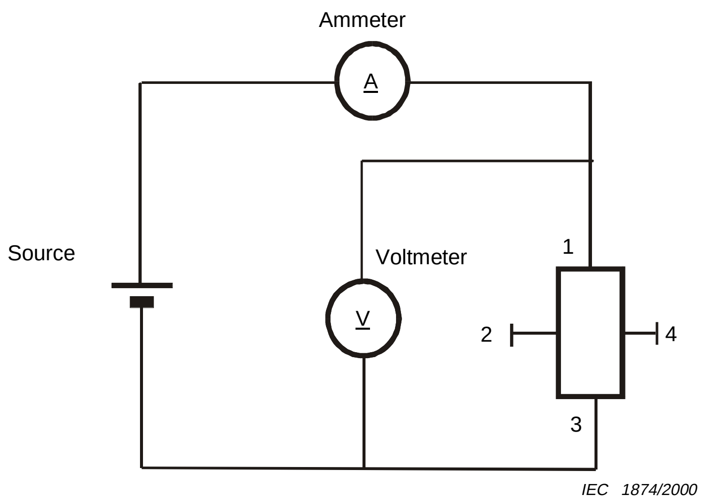

Figure 3 – Basic circuit for the measurement of input resistance

3.4.3 Measurement procedure

a) Connect the two input terminals 1 and 3 of the device to the circuit.

b) Apply a specified voltage V_s or current I_s to the input terminals of the device, using the circuit shown in figure 3.

c) Measure the current I_m or the voltage V_m through or across two terminals.

d) Calculate the input resistance using equation (2) or (3).

$$R_{in} = V_s/I_m \qquad (2)$$

$$R_{in} = V_m/I_s \qquad (3)$$

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3.4.4 Specified conditions

– Ambient or reference temperature.

– Supply voltage or current.

3.5 Output resistance (R_{out})

3.5.1 Purpose

To measure the output resistance of a device, under specified conditions.

3.5.2 Circuit diagram

The same diagram as that described in 3.4.2 shall be used.

3.5.3 Measurement procedure

a) Using the circuit shown in figure 3 but with terminals 2 and 4 connected instead of terminals 1 and 3, apply a specified voltage V_s or current I_s to the output terminals of the device.

b) Measure the current I_m or the voltage V_m through or across two terminals.

c) Calculate the output resistance using equation (4) or (5).

$$R_{out} = V_s/I_m \tag{4}$$

$$R_{out} = V_m/I_s \tag{5}$$

3.5.4 Specified conditions

– Ambient or reference temperature.

– Supply voltage or current.

3.6 Temperature coefficient of output Hall voltage (α_{V_H})

3.6.1 Purpose

To measure the temperature coefficient of output Hall voltage for the device, under specified conditions.

3.6.2 Circuit diagram

The same circuit as that described in 3.2.3 shall be used.

3.6.3 Circuit description and requirements

Specifications for d.c. supply, meters, and measuring instruments are the same as those described in 3.2.4.

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3.6.4 Measuring procedure

a) Following the measuring procedure described in 3.2.6, measure the output Hall voltages at the two specified temperatures T_1 and T_2.

b) Calculate the temperature coefficient of the output Hall voltage using equation (6) or (7).

$$\alpha = 1/V_H \times dV_H / dT$$

$$\cong (\ln V_H(T_1) - \ln V_H(T_2))/(T_1 - T_2) \qquad (6)$$

$$\cong (1/V_H(T_1)) \times (V_H(T_1) - V_H(T_2))/(T_1 - T_2) \qquad (7)$$

3.6.5 Specified conditions

– Temperatures at which the measurements are carried out.

– Magnetic flux density.

– Input voltage or current.

3.7 Temperature coefficient of input resistance (α_{Rin})

3.7.1 Purpose

To measure the temperature coefficient of the input resistance of the device, under specified conditions.

3.7.2 Circuit diagram

The same circuit as that described in 3.4.2 shall be used.

3.7.3 Measuring procedure

a) Following the measuring procedure described in 3.4.3, measure the input resistance at the two specified temperatures T_1 and T_2.

b) Calculate the temperature coefficient of input resistance using equation (8) or (9).

$$\alpha_{Rin} = 1/R_{in} \times dR_{in}/dT$$

$$\cong (\ln R_{in}(T_1) - \ln R_{in}(T_2))/(T_1 - T_2) \qquad (8)$$

$$\cong (1/R_{in}(T_1)) \times (R_{in}(T_1) - R_{in}(T_2))/(T_1 - T_2) \qquad (9)$$

3.7.4 Specified conditions

– Temperatures at which the measurements are carried out.

– Supply voltage or current.

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