IEC 60747-14-5

Edition 1.0 2010-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices –
Part 14-5: Semiconductor sensors – PN-junction semiconductor temperature sensor

Dispositifs à semiconducteurs –
Partie 14-5: Capteurs à semiconducteurs – Capteur de température à semiconducteurs à jonction PN

IEC 60747-14-5:2010

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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FOREWORD

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International Standard IEC 60747-14-5 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/390/FDIS	47E/392/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.

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- withdrawn,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.

SEMICONDUCTOR DEVICES –

Part 14-5: Semiconductor sensors – PN-junction semiconductor temperature sensor

1 Scope

This standard is applicable to semiconductor PN-junction temperature sensors and defines terms, definitions, symbols, essential ratings, characteristics and test methods that can be used to determine the characteristics of semiconductor types of PN-junction temperature sensors.

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

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*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purpose of this document, the following terms and definitions apply. For the general terms and definitions, refer to IEC 60747-14-1.

3.1.1
voltage output style
output style of the temperature sensor where output change is expressed by voltage change

3.1.2
current output style
output style of the temperature sensor where output change is expressed by current change

3.1.3
supply voltage range
voltage range where the sensor operates normally

3.1.4
operating temperature range
temperature range where the sensor operates normally

3.1.5
line regulation
ratio of output voltage change to supply voltage change

NOTE The unit mV/V is usually used in the line regulation.

3.1.6
load regulation
ratio of output voltage change to output current change

NOTE The unit mV/mA is usually used in the load regulation.

3.2 Symbols

S sensitivity

ΔV_{out} full scale of output voltage change

ΔF full scale of temperature change

H hysteresis

H_{max} maximum difference between two outputs by the increasing input and decreasing input

Rx resistors

Qx transistors

R_{max} maximum difference between or among outputs

I_1 current at emitter of transistor Q_1

I_2 current at emitter of transistor Q_2

V_{BE1} voltage between base and emitter of transistor Q_1

V_{BE2} voltage between base and emitter of transistor Q_2

V_T equals $\frac{kT}{q}$

k Boltzmann constant

T absolute temperature

q electron charge

S_j junction area

V_F junction voltage

I_F forward current

N_a acceptor density

N_d donor density

D_p hole diffusion constant

D_n electron diffusion constant

L_p hole diffusion distance

L_n electron diffusion distance

n_i intrinsic carrier density

4 Essential ratings and characteristics

4.1 General

This clause gives ratings and characteristics required for specifying PN-junction temperature sensors.

4.2 Limiting values (absolute maximum rating system)

4.2.1 Electrical limiting values

Limiting values shall be specified as in Table 1.

Table 1 – Electrical limiting values

Subclause	Parameters	Min.	Max.
4.2.1.1	Bias supply voltage		+
4.2.1.2	Output terminal voltage		+

4.2.2 Temperatures

Operating temperature

Storage temperature

4.3 Electrical characteristics

The characteristics shall apply over the full operating temperature range, unless otherwise specified.

The parameters shall be specified as in Table 2.

Table 2 – Parameters electrical characteristics

Subclause	Parameters	Min.	Typical	Max.
4.3.1	Temperature sensitivity	+	+	+
4.3.2	Bias supply operating current		+	+
4.3.3	Output voltage	+	+	+
4.3.4	Nonlinearity		+	
4.3.5	Line regulation			+
4.3.6	Load regulation			+

5 Measuring methods

5.1 General

This clause prescribes measuring methods for electrical characteristics of PN-junction temperature sensors.

5.2 Circuit diagrams of PN-junction temperature sensors

Circuit diagrams of PN-junction temperature sensors are shown as follows. Figure 1 is a typical circuit diagrams of a PN-junction temperature sensor with a negative temperature coefficient.

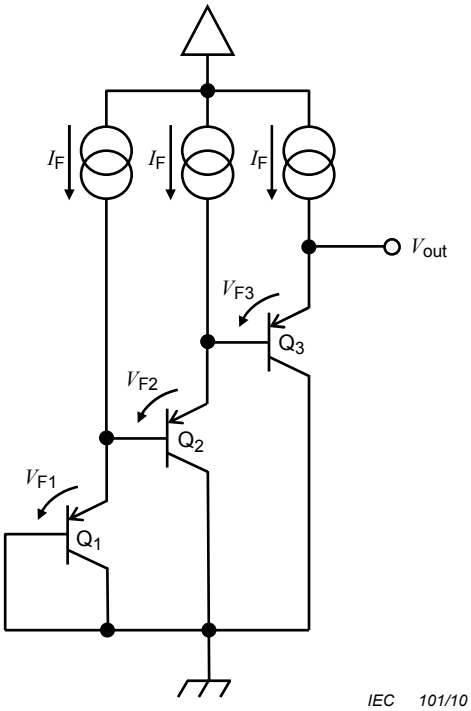
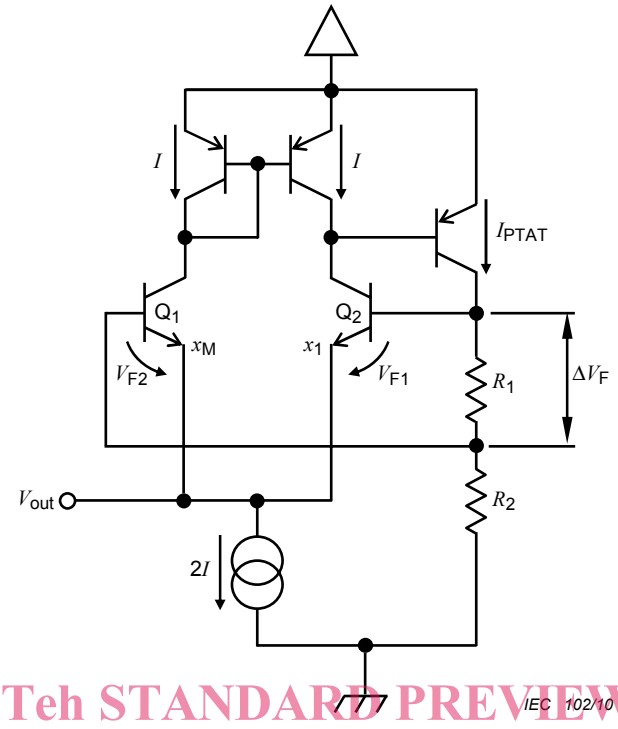


Figure 1 – The circuit diagram of a PN-junction temperature sensor with a negative temperature coefficient

$$I_F = S_{jq} \cdot \left(\frac{D_p}{L_p N_d} + \frac{D_n}{L_n N_a} \right) \cdot n_i^2 \cdot \exp\left(\frac{qV_F}{kT} \right) \quad (1)$$

Figure 2 shows typical circuit diagrams of a PN-junction temperature sensor with a positive temperature coefficient.



M emitter size ratio of Q_1 and Q_2

Figure 2 – The circuit diagram of a PN-junction temperature sensor with a positive temperature coefficient

$$\Delta V_F = V_{F1} - V_{F2}$$

$$= \frac{kT}{q} \ln(M) \tag{2}$$

$$I_{PTAT} = \frac{\Delta V_F}{R_1} \tag{3}$$

$$V_{out} = \left(1 + \frac{R_2}{R_1}\right) \Delta V_F - V_{F1}$$

$$= \left(1 + \frac{R_2}{R_1}\right) \frac{kT}{q} \ln(M) - V_{F1} \tag{4}$$

5.3 Temperature sensitivity

5.3.1 Purpose

To measure the temperature sensitivity under specified conditions.

5.3.2 Circuit diagram

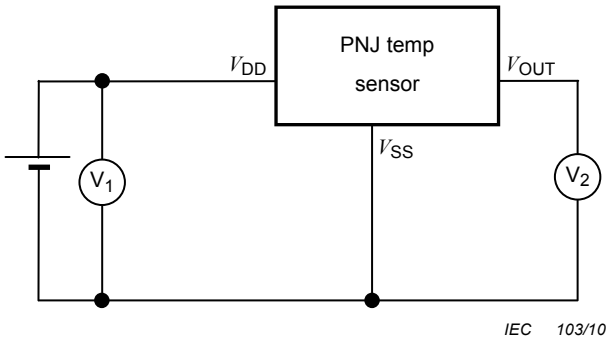


Figure 3 – Circuit diagram for the measurement of the temperature sensitivity

5.3.3 Principle of measurement

Temperature sensitivity α_{SE} is derived from the output voltages at low measuring temperature T_L and high measuring temperature T_H as follows:

$$\alpha_{SE} = \frac{V_{outH} - V_{outL}}{T_H - T_L} \quad (5)$$

where

V_{outH} is the output voltage at high measuring temperature T_H;

V_{outL} is the output voltage at low measuring temperature T_L;

α_{SE} is expressed with the unit mV/°C. See Figure 4.

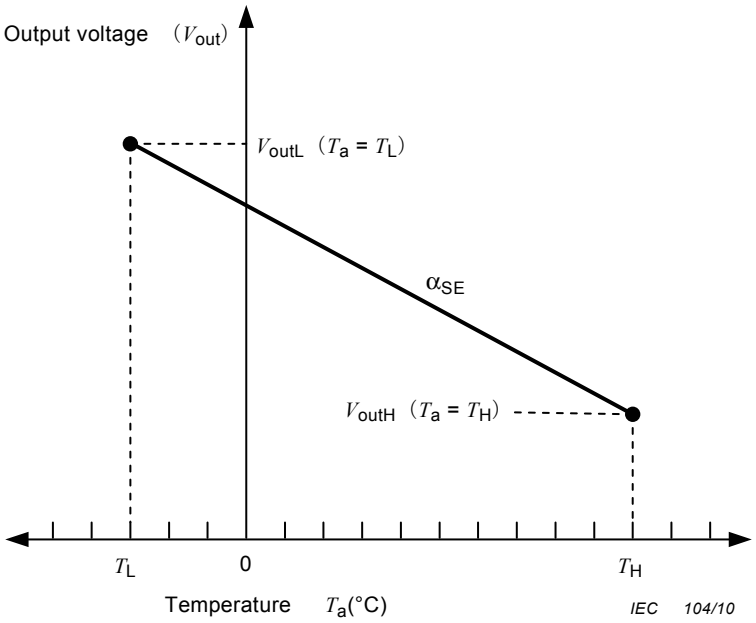


Figure 4 – Circuit diagram for the measurement of the temperature sensitivity

5.3.4 Measurement procedure

The supply voltage shall be applied as specified.