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Edition 1.0 2016-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Part 5-7: Optoelectronic devices – Photodiodes and phototransistors

Dispositifs à semiconducteurs – Partie 5-7: Dispositifs optoélectroniques – Photodiodes et phototransistors

IEC 60747-5-7:2016-02(en-fr)

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SEMICONDUCTOR DEVICES –

Part 5-7: Optoelectronic devices – Photodiodes and phototransistors

FOREWORD

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International Standard IEC 60747-5-7 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This standard replaces the clauses for photodiodes and phototransistors described in IEC 60747-5-1, IEC 60747-5-2 and IEC 60747-5-3 including their amendments.

IEC 60747-5-1, IEC 60747-5-2 and IEC 60747-5-3, including their amendments, are replaced by the publications of IEC 60747-5-4, IEC 60747-5-5, IEC 60747-5-6[1] and IEC 60747-5-7 as a result of reconstruction.

[1] To be published.

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

CDV	Report on voting
47E/471/CDV	47E/502/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.

A list of all parts in the IEC 60747 series, published under the general title *Semiconductor 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.

SEMICONDUCTOR DEVICES –

Part 5-7: Optoelectronic devices – Photodiodes and phototransistors

1 Scope

This part of IEC 60747 specifies the terminology, the essential ratings and characteristics as well as the measuring methods of photodiodes (hereinafter referred to as “PDs”) and phototransistors (hereinafter referred to as “PTs”).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

None.

3 Terms relating to physical concepts

3.1
electromagnetic radiation
radiation

1) emission or transfer of energy in the form of electromagnetic waves with the associated photons
2) these electromagnetic waves or these photons

[SOURCE: IEC 60050-845:1987, 845-01-01, modified – The note has been deleted.]

3.2
optical radiation

electromagnetic radiation of wavelengths between the region of transition to X-rays ($\lambda \approx 1$ nm) and the region of transition to radio waves ($\lambda \approx 1$ nm)

[SOURCE: IEC 60050- 845:1987, 845-01-02]

3.3
visible radiation

any optical radiation capable of causing a visual sensation directly

Note 1 to entry: There are no precise limits for the spectral range of visible radiation since they depend upon the amount of radiant power reaching retina and the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

[SOURCE: IEC 60050-845:1987, 845-01-03]

3.4
infrared radiation

optical radiation for which the wavelengths are longer than those for visible radiation

[SOURCE: IEC 60050-845:1987, 845-01-04, modified – The note has been deleted.]

3.5
ultraviolet radiation
optical radiation for which the wavelengths are shorter than those for visible radiation

[SOURCE: IEC 60050-845:1987, 845-01-05, modified – The note has been deleted.]

3.6
light
1) perceived light
2) visible radiation

Note 1 to entry: The word light is sometimes used in sense 2 for optical radiation extending outside the visible range, but this usage is not recommended.

[SOURCE: IEC 60050-845:1987, 845-01-06, modified – Note 2 has been deleted because it was not relevant.]

3.7
photoelectric effect
interaction between optical radiation and matter resulting in the absorption of photons and the consequent generation of mobile charge carriers, thereby generating an electric potential or current, or a change in electrical resistance, excluding electrical phenomena caused by temperature changes

4 Terms relating to types of devices

4.1
semiconductor photosensitive device
semiconductor device that utilizes the photoelectric effect for detection of optical radiation

4.2
semiconductor optoelectronic device
1) semiconductor device that emits or detects or that is responsive to coherent or non-coherent optical radiation
2) semiconductor device that utilizes such radiation for its internal purposes

4.3
photodiode
photoelectric detector in which a photocurrent is generated by absorption of optical radiation in the neighbourhood of a p-n junction between two semiconductors, or a junction between a semiconductor and a metal

[SOURCE: IEC 60050-845:1987,845-05-39]

4.4
phototransistor
transistor in which the current produced by the photoelectric effect in the neighbourhood of the emitter-base junction acts as base current, which is amplified

5 General terms

5.1
optical axis
line about which the principal radiation or sensitivity pattern is centered

Note 1 to entry: Unless otherwise stated, the optical axis coincides with the direction of maximum radiation or sensitivity.

5.2
optical port,<semiconductor optoelectronic devices>
geometrical configuration, referenced to an external plane or surface of the device, that is used to specify the optical radiation emitted from an emitting device or accepted by a detecting device

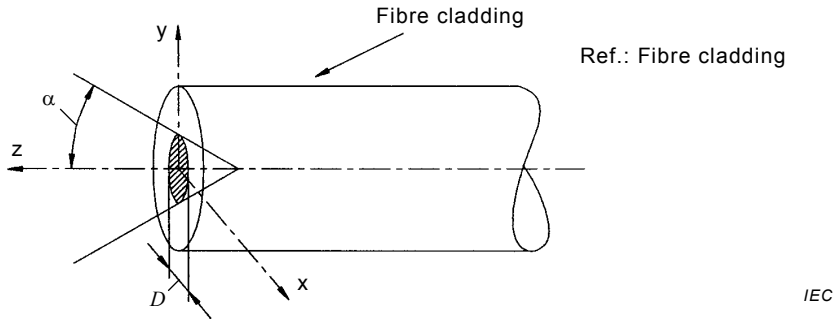


Figure 1a – Device with bare fibre pigtail

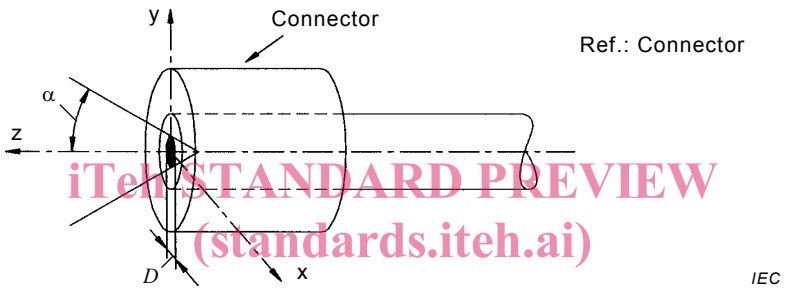


Figure 1b – Device with fibre pigtail connector attached

Key

α emission or acceptance angle

D diameter of the optical port

Ref. reference locus for the definition of the optical port

Figure 1 – Optical port for devices with pigtail (emitter or detector)

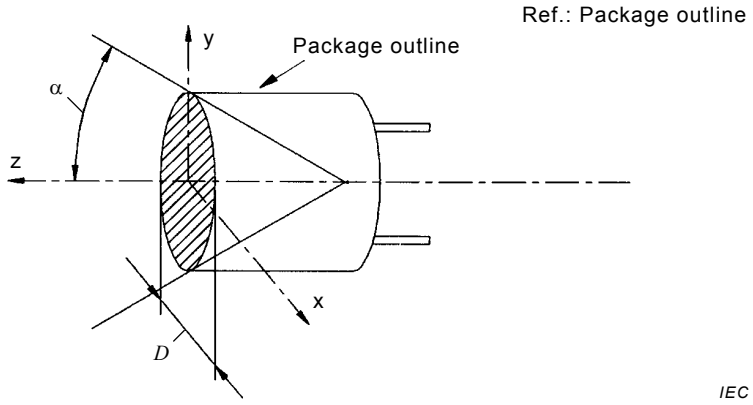
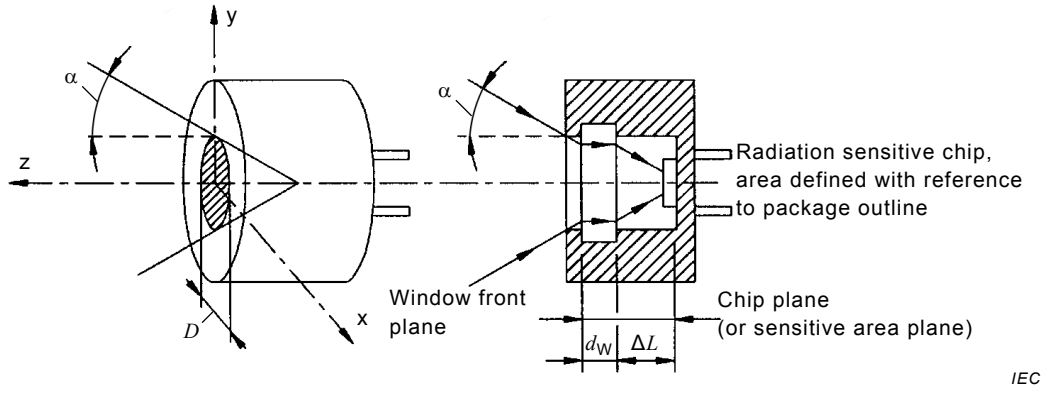


Figure 2a – Device with window, but without lens



Key

d_W window thickness

α emission or acceptance angle

n refractive index of window material

ΔL distance between window back plane and chip plane

Figure 2b – Detector with window, but without lens (chip referenced)

Figure 2c – Detector with lens

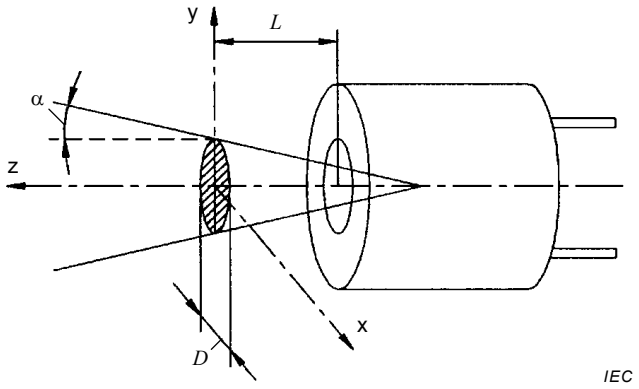


Figure 2d – IRED with optical port that is not located on the output window of the package

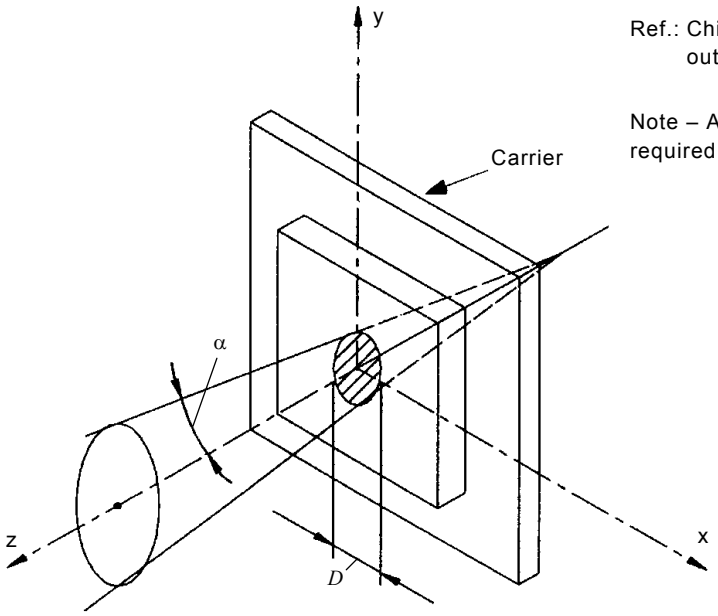
Key

α emission or acceptance angle

D diameter of the optical port

Ref. reference locus for the definition of the optical port

Figure 2 – Optical port for packaged devices (emitter or detector), without pigtail



Key

α	emission or acceptance angle
D	diameter of the optical port
Ref.	reference locus for the definition of the optical port

Figure 3 – Optical port for non-packaged devices (emitter or detector) without pigtail

Note 1 to entry: The geometrical configuration shall be specified by the manufacturer by means of geometrical information, e.g.:

– location, shape and size of the area of emission or acceptance,
– angle of emission or acceptance,
– other parameters, e.g. numerical aperture of optical fibre,
– orientation of optical axis.

Note 2 to entry: Figures 1, 2 and 3 above show examples of the optical port for emitting and detecting devices.

5.3
cladding
optical cladding
dielectric material of an optical fibre surrounding the core

[SOURCE: IEC 60050-731:1991, 731-02-05, modified – The term "optical cladding" has been added.]

6 Terms relating to ratings and characteristics

6.1 Switching times

NOTE The specified lower and/or upper limit values referred to in concepts 6.1.1 to 6.1.7 are usually 10 % and 90 % of the amplitude of the pulses. Figure 4 illustrates the concept of switching times, and shows the relation between switching times and the specified lower and/or upper limit values.

6.1.1
turn-on delay time
$t_{d(on)}$
time interval between the lower specified value on the leading edge of the applied input pulse and the lower specified value on the leading edge of the output pulse

6.1.2
rise time
t_r
time interval between the lower specified value and the upper specified value on the leading edge of the output pulse

6.1.3
turn-on time
t_{on}
time interval between the lower specified value on the leading edge of the applied input pulse and the upper specified value on the leading edge of the output pulse

$t_{on} = t_{d(on)} + t_r$

6.1.4
turn-off delay time
$t_{d(off)}$
time interval between the upper specified value on the trailing edge of the applied input pulse and the upper specified value on the trailing edge of the output pulse

Note 1 to entry: If the turn-off delay time is mainly due to carrier storage (e.g. in the output transistor of a photocoupler), the term "(carrier) storage time" and the letter symbol t_s are in use.

6.1.5
fall time

t_f
time interval between the upper specified value and the lower specified value on the trailing edge of the output pulse

6.1.6
turn-off time
t_{off}
time interval between the upper specified value on the trailing edge of the applied input pulse and the lower specified value on the trailing edge of the output pulse

$t_{off} = t_{d(off)} + t_f$

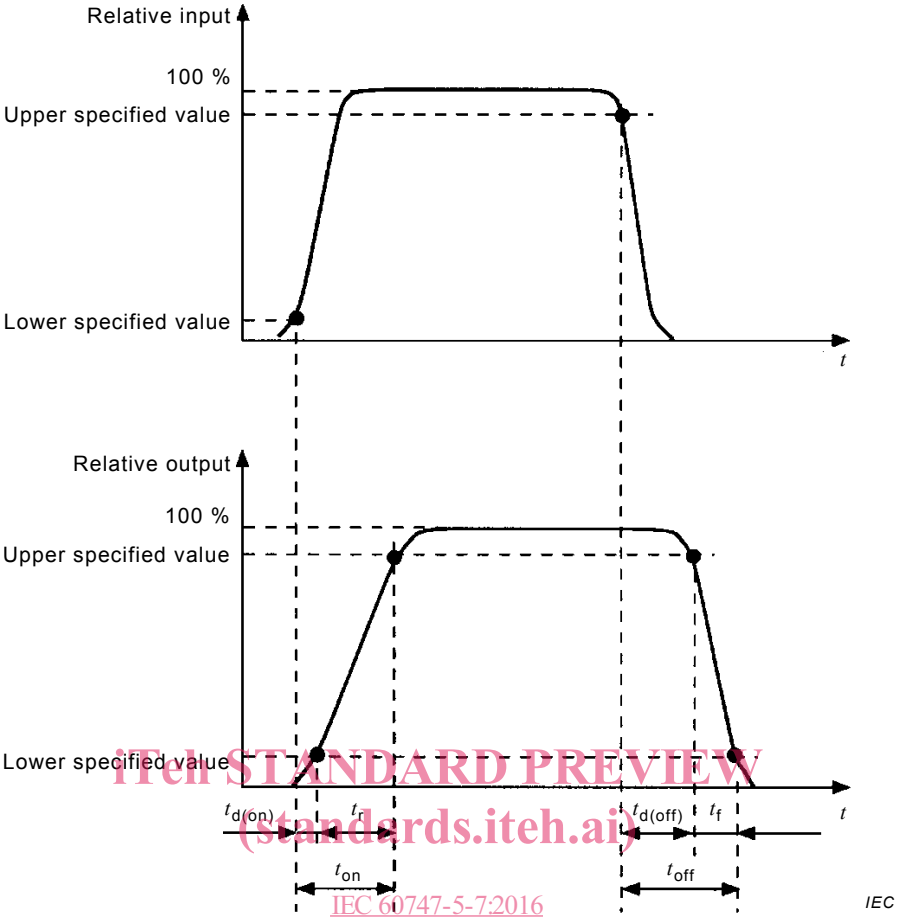


Figure 4 – Switching times

6.2 Photosensitive devices characteristics

NOTE The subscripts D for dark and P for photo are still under consideration.

6.2.1
reverse current under optical radiation, <photodiode>
$I_{R(H)}$
$I_{R(e)}$
I_R
total reverse current when the photodiode is exposed to incident optical radiation

6.2.2
dark current, <photodiode>
$I_{R(D)}$
reverse current in the absence of incident optical radiation

6.2.3
photocurrent, <photodiode>
I_p
part of the reverse current that is caused by incident optical radiation

$I_P = I_{R(H)} - I_{R(D)}$

6.2.4
collector current under optical radiation, <phototransistor>
$I_{C(H)}$
$I_{C(e)}$
I_C
total collector current when the phototransistor is exposed to incident optical radiation

6.2.5
collector-emitter dark current, <phototransistor>
I_{CEO}
collector current in the absence of incident optical radiation

6.2.6
diode sensitivity, <photodiode>
sensitivity, <photodiode>
S_D
S
quotient of the photocurrent I_P, by the irradiance E_e (or illuminance E_v) at the optical port of the photodiode

$$S_D = \frac{I_P}{E_e} \text{ or } S_D = \frac{I_P}{E_v}$$

Note 1 to entry: If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

6.2.7
fibre-input sensitivity, <photodiode irradiated or illuminated from the front end of an optical fibre >
S_{FD}
quotient of the photocurrent I_P, by the radiant power ϕ_e (or luminous flux ϕ_v) emitted from the optical fibre, for specified values of the radial displacement r and the distance z of the front end of the optical fibre, relative to the optical port of the photodiode as shown in Figure 5

$$S_{FD} = \frac{I_P}{\phi_e} \text{ or } S_{FD} = \frac{I_P}{\phi_v}$$

Note 1 to entry: If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

Note 2 to entry: In specifications, usually curves are given showing S_{FD} as a function of r and z.

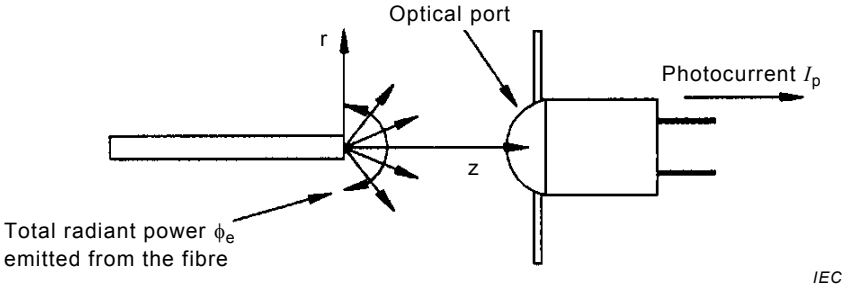


Figure 5 – Fibre-input sensitivity S_{FD}

6.2.8
small-signal cut-off frequency, <photodiode>
f_{cd}
f_c
frequency at which, for constant small signal modulation depth of the input radiant power, the demodulated signal power has decreased to half its low-frequency value

Note 1 to entry: When, for the measurement of f_c, in the case that the photocurrent of the photodiode or the output voltage across the load resistance is observed, it should be noted that 1-to-2 decrease in the demodulated signal power corresponds to 1-to-square root 2 decrease in the photocurrent or output voltage.

6.2.9
large-signal cut-off frequency, <photodiode>
f_{CL}
f_C
frequency at which, for constant large signal modulation depth of the input radiant power, the demodulated signal power has decreased to half its low-frequency value

Note 1 to entry: Measurement should be done within the range that the linear response between the input radiant power and the output photocurrent is assured.

6.2.10
sensitivity diagram, <photosensitive devices>
diagram that characterizes the distribution of sensitivity

$S = f(\theta)$

SEE: Figures 6a and 6b.

Note 1 to entry: The orientation of θ is indicated in Figures 6a and 6b. Unless otherwise stated, the distribution of sensitivity should be specified in a plane. This plane includes the mechanical axis z.

Note 2 to entry: If the sensitivity pattern has a rotational symmetry to the z axis, the sensitivity diagram shall be specified for one plane only.

Note 3 to entry: If the sensitivity pattern has no rotational symmetry to the z axis, sensitivity diagrams for various angles θ shall be specified. Then the x, y and z directions shall be defined by a drawing in the detail specification.

6.2.11
half-sensitivity angle, <photosensitive devices>
$\theta_{S/2}$

in a sensitivity diagram, angle within which the sensitivity is greater than or equal to half the maximum sensitivity

SEE: Figure 6b.

6.2.12
misalignment angle, <photosensitive devices>
$\Delta\theta$
in a sensitivity diagram, angle between the direction for maximum sensitivity (optical axis) and the mechanical axis z

SEE: Figure 6b.