

Semiconductor devices — Discrete devices —

Part 5-4: Optoelectronic devices — Semiconductor lasers

ICS 31.080.01; 31.260

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Summary of pages

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Discrete devices –**

**Part 5-4:
Optoelectronic devices –
Semiconductor lasers**



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SEMICONDUCTOR DEVICES – DISCRETE DEVICES –

Part 5-4: Optoelectronic devices – Semiconductor laser

1 Scope

This part of IEC 60747 deals with the terminology, the essential ratings and characteristics as well as the measuring methods of semiconductor lasers.

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 reference document (including any amendments) applies.

IEC 62007-1, *Semiconductor optoelectric devices for fibre optic system applications – Part 1: Essential ratings and characteristics*

IEC 62007-2, *Semiconductor optoelectric devices for fibre optic system applications – Part 2: Measuring methods*

ISO 11145, *Optics and optical instruments – Lasers and laser related equipment – Vocabulary and symbols*

ISO 11146-1, *Lasers and laser-related equipment – Test methods for laser beam widths, divergence angles and beam propagation ratios – Part 1: Stigmatic and simple astigmatic beams*

ISO 11146-2, *Lasers and laser-related equipment – Test methods for laser beam widths, divergence angles and beam propagation ratios – Part 2: General astigmatic beams*

ISO 11146-3, *Lasers and laser-related equipment – Test methods for laser beam widths, divergence angles and beam propagation ratios – Part 3: Intrinsic and geometrical laser beam classification, propagation and details of test methods*

ISO 11554, *Optics and optical instruments – Lasers and laser-related equipment – Test methods for laser beam power, energy and temporal characteristics*

ISO 11670, *Lasers and laser-related equipment – Test methods for laser beam parameters – Beam positional stability*

ISO 12005, *Lasers and laser-related equipment – Test methods for laser beam parameters – Polarization*

ISO 13694, *Optics and optical instruments – Lasers and laser-related equipment – Test methods for laser beam power (energy) density distribution*

ISO 13695, *Optics and photonics – Laser and laser-related equipment – Test methods for the spectral characteristics of lasers*

ISO 17526, *Optics and optical instruments – Lasers and laser related equipment – Lifetime of lasers*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1 Physical concepts

- a) (Electromagnetic) radiation (IEV 845-01-01)
- b) Optical radiation (see IEV 845-01-02)
- c) Visible radiation (IEV 845-01-03)

NOTE There are no precise limits for the spectral range of visible radiation since they depend upon the amount of output power available 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.

- d) Infrared radiation (see IEV 845-01-04, specialized)
- e) Ultraviolet radiation (see IEV 845-01-05, specialized)
- f) Light (IEV 845-01-06, without Note 2 which is not relevant)
 - Perceived light (IEV 845-02-17)
 - Visible radiation (IEV 845-01-03)

3.2 Types of devices – Semiconductor laser (laser diode)

Semiconductor diode that emits coherent optical radiation through stimulated emission resulting from the recombination of free electrons and holes when an electric current exceeds the threshold current of the diode.

NOTE The laser diode chip is mounted on a submount or in a package with or without coupling means (e.g. lens, fibre pigtail).

3.3 General terms

3.3.1

beam axis

(see ISO 11145)

3.3.2

optical port

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.

NOTE The geometrical configuration should be specified by the manufacturer by means of geometrical information, e.g.:

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

Example:

Signification of annotations in the figure:

α = acceptance angle or emission angle



= optical port with diameter D

Ref. = reference locus for the definition of the optical port

Packaged devices

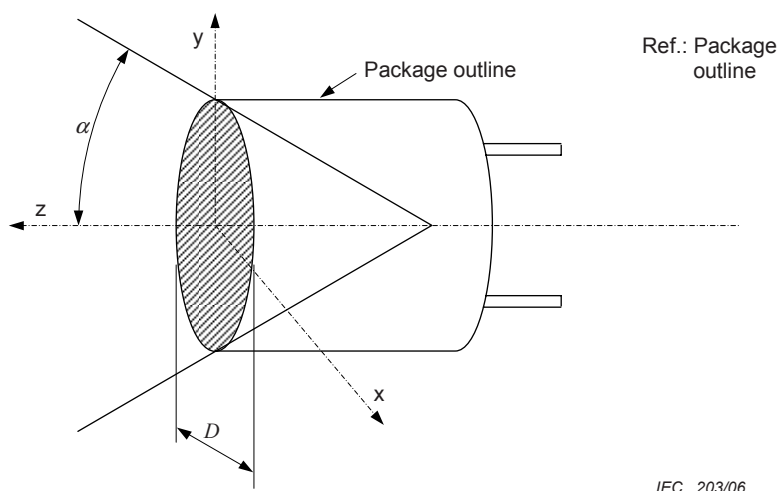


Figure 1 – Device with window but without lens

3.4 Terms related to ratings and characteristics

3.4.1 switching times

NOTE The specified lower and upper limit values referred to in 3.4.1.1 to 3.4.1.6 are usually 10 % and 90 % of the amplitude of the pulses (see Figure 3).

3.4.1.1 rise time

t_r
(see ISO 11554)

3.4.1.2 fall time

t_f
(see ISO 11554)

NOTE In the most recent edition of ISO 11554, there is no definition regarding fall time. For the time being, the descriptions of Figure 2 should be referred to until the complete version of fall time definition is fixed in ISO 11554.

3.4.1.3 turn-on delay time

$t_{d(on)}$
time interval between the instant the electrical input signal reaches a specified level (10 % unless otherwise stated) and the instant the optical output signal reaches a specified level (10 % of the steady-state maximum unless otherwise stated)

3.4.1.4 turn-on time

t_{on}
time interval between the instant the electrical input signal reaches a specified level (10 % unless otherwise stated) and the instant the optical output signal reaches a specified level (90 % of the steady-state maximum unless otherwise stated)

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

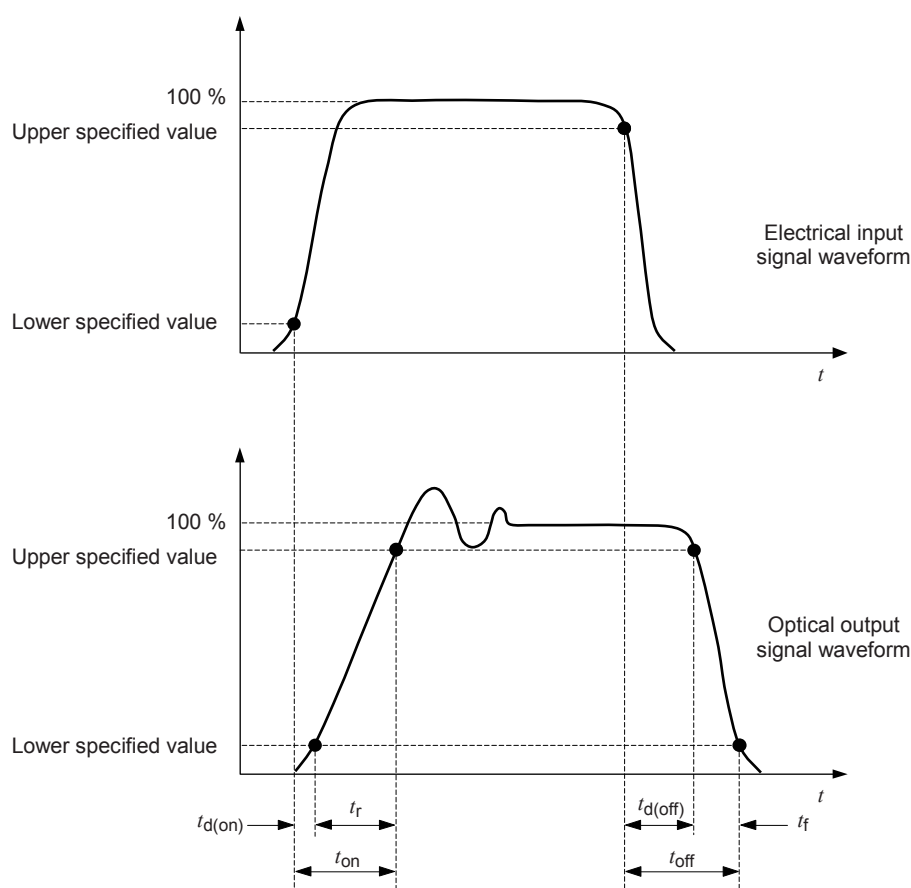
3.4.1.5**turn-off delay time** $t_{d(off)}$

time interval between the instant the electrical input signal downs a specified level (90 % unless otherwise stated) and the instant the optical output signal downs a specified level (90 % of the steady-state maximum unless otherwise stated)

3.4.1.6**turn-off time** t_{off}

time interval between the instant the electrical input signal downs a specified level (90 % unless otherwise stated) and the instant the optical output signal downs a specified level (10 % of the steady-state maximum unless otherwise stated).

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



IEC 204/06

NOTE Lower and upper specified values indicate 10 % and 90 %, respectively, unless otherwise stated.

Figure 2 – Switching times

3.4.2 output power

P
(see ISO 13694)

3.4.3 differential output (radiant) power efficiency

η_d
output power efficiency for small-signal modulation:

$$\eta_d = dP / dI_F$$

NOTE 1 Dimension of η_d is W/A.

NOTE 2 The term "small-signal modulation efficacy" is used as a synonym.

NOTE 3 Differential output power quantum efficiency = $q/h\nu$ η_{ed} is also applicable, where

q is the electron charge,

ν is the optical frequency,

h is equal $6,62 \times 10^{-34}$ Js (Planck's constant).

3.4.4 threshold current (of a semiconductor laser)

I_{TH}
forward current derived from one of the following two methods:

a) Derivative threshold current $I_{TH(D)}$

The forward current at which the second derivative of the curve showing output power P versus forward current I_F has its first maximum (see Figure 3a).

b) Extrapolated threshold current

The forward current at which the extrapolated two straight lines of the stimulated emission and the spontaneous emission cross each other (see Figure 3b).

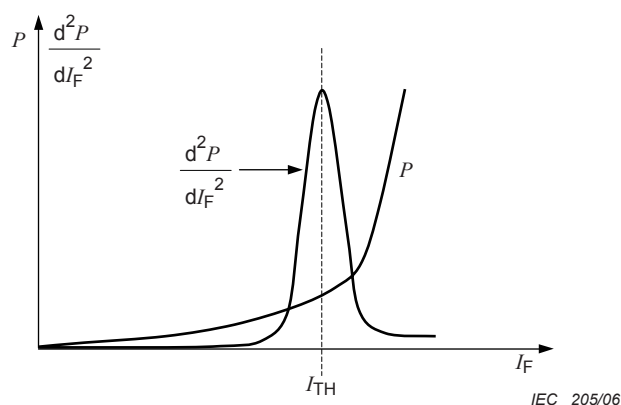


Figure 3a – Derivative threshold current of a laser diode

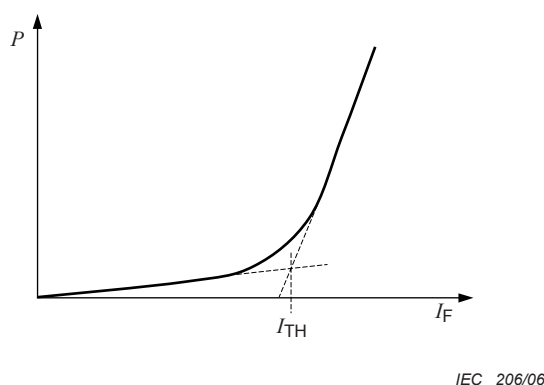


Figure 3b – Extrapolated threshold current of a laser diode

Figure 3 – Threshold current of a laser diode

3.4.5 noise characteristics (of a semiconductor laser)

3.4.5.1 relative intensity noise

RIN
(see ISO 11554)

3.4.5.2 carrier-to-noise ratio

CIN
The quotient of:

- the mean square radiant power at the specified frequency, to
- the mean square radiant power fluctuations normalized to a frequency band of unit width centered on the carrier frequency

3.4.6 small signal cut-off frequency

f_c
(see ISO 11554)

3.4.7 optical characteristics of the laser beam

(see ISO 11146-1, ISO 11146-2, ISO 1146-3, ISO 11670, ISO 13694 and ISO 13695)

3.4.7.1 spatial profile

(see ISO 11146-1, ISO 11146-2, ISO 11146-3, ISO 11670 and ISO 13694)

3.4.7.2 spectral characteristics

(see ISO 13695)

3.4.8 half-intensity angle

$\theta_{1/2}$
in a radiation diagram, the angle within which the radiant intensity is greater than or equal to half of the maximum intensity