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Edition 2.1 2024-12
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

colour inside

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

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SEMICONDUCTOR DEVICES –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60747-5-4 edition 2.1 contains the second edition (2022-04) [documents 47E/783/FDIS and 47E/785/RVD] and its amendment 1 (2024-12) [documents 47E/819/CDV and 47E/841/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

IEC 60747-5-4 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices. It is an International Standard.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) References for the terms and definitions related to the lighting area, IEC 60050-845, are revised based on IEC 60050-845:2020;
b) Emission angle is changed to radiation angle in 3.3.2;
c) Definitions of rise time and fall time in 3.4.1 are revised based on the publication IEC 60050-521:2002;
d) Spectral linewidth is added to Table 1 in Clause 4;
e) Conditions for carrier-to-noise ratio of Table 1 in Clause 4 is amended.
f) Error in the equation for carrier-to-noise ratio in 5.2.2 is corrected;
g) Precaution against the equipment used for carrier-to-noise ratio measurement is added in 5.2.2;
h) Explanation for the measurement method of the small signal cut-off frequency in 5.3.2 of the first edition is deleted because it has been defined in the latest version of ISO 11554;
i) Reference document for the lifetime in 5.4 is amended;
j) Precaution against the measuring arrangement used for the half-intensity width and $1/e^2$-intensity is added in 5.5.3;
k) Reference tables in Annex A, Annex B and Annex C are revised by following the latest version of ISO publications.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

The committee has decided that the contents of this document and its amendment will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The first edition of this part of IEC 60747 was published in 2006 under close collaboration between IEC TC 47 SC 47E (IEC TC 47 SC 47C at that moment) and ISO TC 172 SC 9. The scope of IEC/TC47/SC47E includes laser diodes as one of the discrete semiconductor devices while that of ISO/TC172/SC9 includes laser diodes as one of the laser and laser-related equipment. Consequently, technical contents in this publication extend over IEC and ISO.

In order to harmonize the IEC and ISO laser-related standards in 1997, a joint working group (JWG) consisted of the experts from both IEC SC 47E and ISO TC 172 SC 9 was established. As a result of discussion, items based on the electrical and electronic technologies are dealt with by subcommittee 47E of IEC technical committee 47, while optical characteristics of the output beam are under the responsibility of subcommittee 9 of ISO technical committee 172. This was agreed, after long discussion, in 2002 between subcommittee 47E of IEC technical committee 47 and subcommittee 9 of ISO technical committee 172. Based on this agreement, terms and definitions, and test and measurement methods for the optical beam parameters in this part of IEC 60747-5-4 are referenced to the ISO standards that specify the topics.

The joint working group was disbanded in 2017. However, close co-operation and contact between two groups is indispensable in order to avoid any conflicts and to keep harmonization of IEC and ISO laser standards.

This second edition of IEC 60747-5-4 has been updated by following the revision and amendments in the latest versions of laser standards of both IEC and ISO.

SEMICONDUCTOR DEVICES –

Part 5-4: Optoelectronic devices – Semiconductor lasers

1 Scope

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 TR 62572-2, *Fibre optic active components and devices – Reliability standards – Part 2: Laser module degradation*

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

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

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Physical concepts

3.1.1
electromagnetic radiation, <phenomenon>
phenomenon by which energy in the form of electromagnetic waves or photons emanates from a source and is transferred through space

Note 1 to entry: The term “electromagnetic radiation” is also used for the electromagnetic waves or photons produced (see IEV 705-02-01).

Note 2 to entry: The physical concepts of photons and electromagnetic waves are used to describe the same phenomenon of transmission of radiant energy in different ways, depending on the nature of the interaction of the energy with the physical world (wave-particle dualism).

[SOURCE: IEC 60050-702:1992/AMD5:2019, 702-02-07]

3.1.2
electromagnetic radiation, <waves or photons>
energy that emanates from a source in the form of electromagnetic waves or photons and is transferred through space

Note 1 to entry: The term “electromagnetic radiation” is also used for the phenomenon producing the electromagnetic waves or photons (see IEV 702-02-07).

Note 2 to entry: The physical concepts of photons and electromagnetic waves are used to describe the same phenomenon of transmission of radiant energy in different ways, depending on the nature of the interaction of the energy with the physical world (wave-particle dualism).

[SOURCE: IEC 60050-705:1995/AMD4:2019, 705-02-01]

3.1.3
optical radiation
electromagnetic radiation at wavelengths between the region of transition to X-rays ($\lambda \approx 1$ nm) and the region of transition to radio waves ($\lambda \approx 1$ mm)

Note 1 to entry: This entry was numbered 845-01-02 in IEC 60050-845:1987.

[SOURCE: IEC 60050-845:2020, 845-21-002]

3.1.4
light, <psychophysical> noun
radiation that is considered from the point of view of its ability to excite the visual system

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

Note 2 to entry: This entry was numbered 845-01-06 in IEC 60050-845:1987.

[SOURCE: IEC 60050-845:2020, 845-21-012]

3.1.5
light, <photometric> noun
radiation within the spectral range of visible radiation

Note 1 to entry: Sometimes, the term "light" is also used in physics as a synonym of optical radiation, covering the spectral range from 100 nm to 1 mm and sometimes even covering the X-ray spectral range. This misuse of the term ‘‘light'' should be avoided.

[SOURCE: IEC 60050-845:2020, 845-21-013]

3.1.6
visible radiation
optical radiation (IEV 845-21-002) 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 flux reaching the 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.

Note 2 to entry: This entry was numbered 845-01-03 in IEC 60050-845:1987.

Note 3 to entry: ISO 20473:2007 Optics and photonics – Spectral bands defines from 380 nm to 780 nm for the range of visible radiation.

[SOURCE: IEC 60050-845:2020, 845-021-003, modified – Note 3 has been added.]

3.2 Types of devices

3.2.1
semiconductor laser
laser diode
semiconductor diode that emits coherent optical radiation through stimulated emission resulting from the recombination of conduction electrons and holes when excited by an electric current that exceeds the threshold current of the diode

Note 1 to entry: The laser diode is mounted on a submount or in a package with or without coupling means (e.g. lens, fibre pigtail).

[SOURCE: IEC 60050-521:2002, 521-04-37, modified – The term "laser diode" has been replaced by "semiconductor laser".]

3.3 General terms

3.3.1
beam axis
straight line connecting the centroids defined by the first spatial moments of the cross-sectional power (energy) density distribution function at successive locations in the direction of propagation (z) of the beam in a homogeneous medium

[SOURCE: ISO 11145:2018, 3.2.1]

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

EXAMPLE

Signification of annotations in the Figure 1:

α = acceptance angle or radiation angle

= optical port with diameter D

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

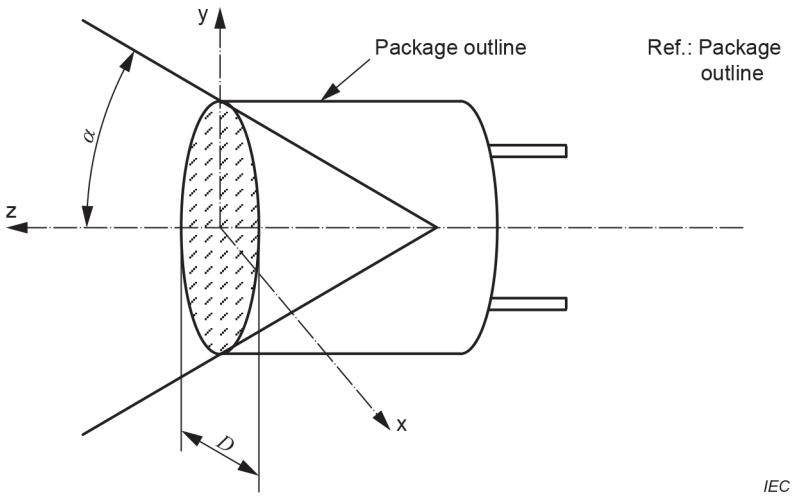

Figure 1 – Example of the device with window but without lens

Note 1 to entry: 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.

3.4 Terms related to ratings and characteristics

3.4.1 Switching times

Relation between the electrical input signal and the optical output signal is shown in Figure 2 with the indication of switching times.

3.4.1.1
rise time
t_r
time interval between the instants at which the magnitude of the pulse at the output terminals reaches specified lower and upper limits respectively when the semiconductor device is being switched from its non-conducting to its conducting state

Note 1 to entry: The lower and upper limits are usually 10 % and 90 % respectively of the final amplitude of the output pulse.

[SOURCE: IEC 60050-521:2002, 521-05-22]

3.4.1.2
fall time
t_f
time interval between the instants at which the magnitude of the pulse at the output terminals reaches specified upper and lower limits respectively when a semiconductor device is being switched from its conducting to its non-conducting state

Note 1 to entry: The upper and lower limits are usually 90 % and 10 % respectively of the initial amplitude of the output pulse.

[SOURCE: IEC 60050-521:2002, 521-05-24]

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 specifies 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 specifies 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).

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

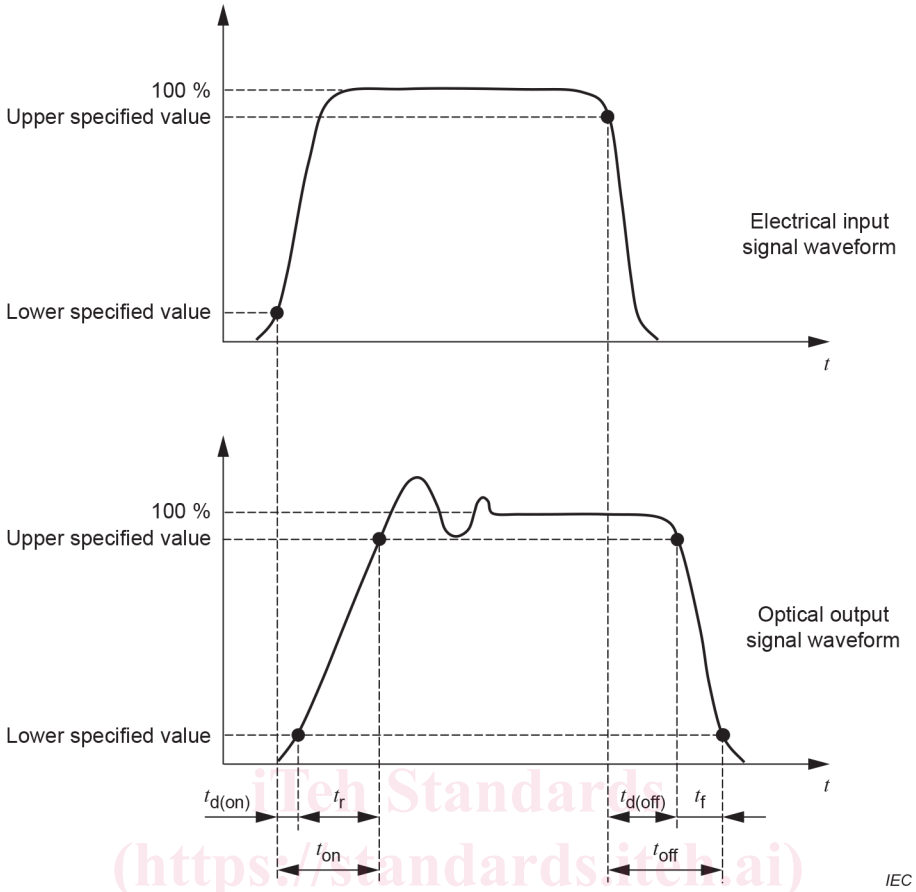

Figure 2 – Switching times

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

3.4.2 Output and current characteristics

3.4.2.1
output power, <of a semiconductor laser>
P
radiant power transferred from the semiconductor laser through the optical port

~~[SOURCE: ISO 11145:2018, 3.18, modified – The symbol "$R(f)$"has been replaced by "RIN".]~~

3.4.2.2
radiant flux
radiant power
Φ_e
change in radiant energy with time

$$\Phi_e = \frac{dQ_e}{dt}$$

where Q_e is the radiant energy emitted, transferred or received, and t is time

Note 1 to entry: The corresponding photometric quantity is "luminous flux". The corresponding quantity for photons is "photon flux".

Note 2 to entry: The term "radiant flux" is the preferred term for most radiometric applications, with the notable exception of laser radiometry where the term "radiant power" is more commonly used.

Note 3 to entry: The radiant flux is expressed in watt (W).