IEC 60747-5-4

Edition 2.1 2024-12
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.080.01; 31.260

ISBN 978-2-8327-0000-0

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
3.1 Physical concepts 8
3.2 Types of devices 9
3.3 General terms 9
3.4 Terms related to ratings and characteristics 10
3.4.1 Switching times 10
3.4.2 Output and current characteristics 12
3.5 Spatial profiles and spectral characteristics 15
4 Essential rating and characteristics 15
4.1 Type 15
4.2 Semiconductor 16
4.2.1 Material 16
4.2.2 Structure 16
4.3 Details of outline drawing and encapsulation 16
4.4 Limiting values (absolute maximum ratings over the operating temperature range, unless otherwise stated) 16
4.5 Electrical and optical characteristics 16
4.6 Supplementary information 18
5 Measurement methods 18
5.1 Power measurement 18
5.2 Output stability 18
5.2.1 Relative intensity noise 18
5.2.2 Carrier-to-noise ratio 18
5.2.3 Output power stability 20
5.2.4 Output energy stability 20
5.2.5 Temporal pulse shape 20
5.3 Time domain profile 20
5.3.1 Switching times 20
5.3.2 Small signal cut-off frequency (f_c) 22
5.4 Lifetime 22
5.5 Optical characteristics of the laser beam 23
5.5.1 Polarization 23
5.5.2 Half-intensity angle $\theta_{1/2}$ and $1/e^2$-intensity angle θ_{1/e^2} 23
5.5.3 Half-intensity width $D_{1/2}$ and $1/e^2$-intensity width D_{1/e^2} 25
5.5.4 Spectral characteristics and other spatial profile 26
Annex A (informative) Reference list of technical terms and definitions related to spatial profile and spectral characteristics 27
Annex B (informative) Reference list of measurement methods related to spatial profile and spectral characteristics 31
Annex C (informative) Reference list of technical terms and definitions, and measurement methods, related to power measurement and lifetime 32
Bibliography 33

Figure 1 – Example of the device with window but without lens 10
Figure 2 – Switching times 12
Figure 3 – Threshold current of a laser diode 14
Figure 4 – Basic circuit diagram 19
Figure 5 – Basic circuits diagram 21
Figure 6 – Typical pulse response diagram 22
Figure 7 – Half-intensity angle 23
Figure 8 – Relationship between the specified plane and the mechanical reference plane 23
Figure 9 – Basic measurement setup diagram 24
Figure 10 – Measuring arrangement for $D_{1/2}$ and D_{1/e^2} 25

Table 1 – Electrical and optical characteristics 17

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

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*

CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
3.1 Physical concepts 8
3.2 Types of devices 9
3.3 General terms 9
3.4 Terms related to ratings and characteristics 10
3.4.1 Switching times 10
3.4.2 Output and current characteristics 12
3.5 Spatial profiles and spectral characteristics 15
4 Essential rating and characteristics 15
4.1 Type 15
4.2 Semiconductor 15
4.2.1 Material 15
4.2.2 Structure 15
4.3 Details of outline drawing and encapsulation 16
4.4 Limiting values (absolute maximum ratings over the operating temperature range, unless otherwise stated) 16
4.5 Electrical and optical characteristics 16
4.6 Supplementary information 18
5 Measurement methods 18
5.1 Power measurement 18
5.2 Output stability 18
5.2.1 Relative intensity noise 18
5.2.2 Carrier-to-noise ratio 18
5.2.3 Output power stability 20
5.2.4 Output energy stability 20
5.2.5 Temporal pulse shape 20
5.3 Time domain profile 20
5.3.1 Switching times 20
5.3.2 Small signal cut-off frequency (f_c) 22
5.4 Lifetime 22
5.5 Optical characteristics of the laser beam 23
5.5.1 Polarization 23
5.5.2 Half-intensity angle $\theta_{1/2}$ and $1/e^2$-intensity angle θ_{1/e^2} 23
5.5.3 Half-intensity width $D_{1/2}$ and $1/e^2$-intensity width D_{1/e^2} 25
5.5.4 Spectral characteristics and other spatial profile 26
Annex A (informative) Reference list of technical terms and definitions related to spatial profile and spectral characteristics 27
Annex B (informative) Reference list of measurement methods related to spatial profile and spectral characteristics 31
Annex C (informative) Reference list of technical terms and definitions, and measurement methods, related to power measurement and lifetime 32
Bibliography 33

Figure 1 – Example of the device with window but without lens 10
Figure 2 – Switching times 12
Figure 3 – Threshold current of a laser diode 14
Figure 4 – Basic circuit diagram 19
Figure 5 – Basic circuits diagram 21
Figure 6 – Typical pulse response diagram 22
Figure 7 – Half-intensity angle 23
Figure 8 – Relationship between the specified plane and the mechanical reference plane 23
Figure 9 – Basic measurement setup diagram 24
Figure 10 – Measuring arrangement for $D_{1/2}$ and D_{1/e^2} 25

Table 1 – Electrical and optical characteristics 17

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

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].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted 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.

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*