

This is a preview - click here to buy the full publication



IEC 60747-5-6

Edition 2.0 2021-07

# INTERNATIONAL STANDARD

---

**Semiconductor devices –  
Part 5-6: Optoelectronic devices – Light emitting diodes**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 31.080.99

ISBN 978-2-8322-9853-4

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

## CONTENTS

FOREWORD .....	8
1 Scope .....	10
2 Normative references .....	10
3 Terms, definitions and abbreviations .....	11
3.1 General terms and definitions .....	11
3.2 Terms and definitions relating to the measurement of the quantity of radiation .....	14
3.3 Terms and definitions relating to the measurement of the photometric quantity .....	17
3.4 Terms and definitions relating to the measurement of the thermal quantity .....	21
3.5 Abbreviations .....	22
4 Absolute maximum ratings .....	22
5 Electrical and optical characteristics .....	23
6 Measuring method .....	24
6.1 Basic requirements .....	24
6.1.1 Measuring conditions .....	24
6.1.2 Measuring instruments and equipment .....	25
6.1.3 Essential requirements .....	26
6.1.4 General precautions .....	27
6.2 Forward voltage ( $V_F$ ) measurement .....	27
6.2.1 Purpose .....	27
6.2.2 Circuit diagram .....	27
6.2.3 Requirements .....	27
6.2.4 Measurement procedure .....	29
6.2.5 Precautions to be observed .....	29
6.2.6 Specified conditions .....	29
6.3 Reverse voltage ( $V_R$ ) measurement .....	29
6.3.1 Purpose .....	29
6.3.2 Circuit diagram .....	29
6.3.3 Measurement procedure .....	29
6.3.4 Precautions to be observed .....	30
6.3.5 Specified conditions .....	30
6.4 Differential resistance ( $r_f$ ) measurement .....	30
6.4.1 Purpose .....	30
6.4.2 Circuit diagram .....	30
6.4.3 Requirements .....	30
6.4.4 Measurement procedure .....	30
6.4.5 Precautions to be observed .....	31
6.4.6 Specified conditions .....	31
6.5 Reverse current ( $I_R$ ) measurement .....	31
6.5.1 Purpose .....	31
6.5.2 Circuit diagram .....	31
6.5.3 Provisions .....	32
6.5.4 Measurement procedure .....	32
6.5.5 Precautions to be observed .....	32

6.5.6	Specified conditions.....	32
6.6	Measurement of capacitance between terminals ( $C_t$ ).....	32
6.6.1	General .....	32
6.6.2	Measurement using LCR meter.....	33
6.6.3	Measurement using AC bridge.....	33
6.7	Measurement of junction temperature ( $T_j$ ) and thermal resistance ( $R_{th(j-X)el}$ , $R_{th(j-X)real}$ ) .....	35
6.7.1	Purpose.....	35
6.7.2	Measurement principle.....	35
6.7.3	Measurement procedure .....	37
6.7.4	Precautions to be observed .....	42
6.7.5	Specified conditions.....	42
6.8	Response time measurement.....	42
6.8.1	Purpose.....	42
6.8.2	Circuit diagram .....	42
6.8.3	Provisions.....	43
6.8.4	Measurement procedure .....	43
6.8.5	Precautions to be observed .....	43
6.8.6	Specified conditions.....	44
6.9	Frequency response and cut-off frequency ( $f_c$ ) measurement .....	44
6.9.1	Purpose.....	44
6.9.2	Circuit diagram .....	44
6.9.3	Provisions.....	45
6.9.4	Measurement procedure .....	45
6.9.5	Precautions to be observed .....	46
6.9.6	Specified conditions.....	46
6.10	Luminous flux ( $\Phi_V$ ) measurement.....	46
6.10.1	Purpose.....	46
6.10.2	Measurement principle.....	46
6.10.3	Measuring circuit .....	46
6.10.4	Measurement procedure .....	47
6.10.5	Precautions to be observed .....	47
6.10.6	Measurement conditions to be defined.....	48
6.11	Radiant flux ( $\Phi_e$ ) measurement.....	48
6.11.1	Purpose.....	48
6.11.2	Measurement principle.....	48
6.11.3	Measuring circuit .....	49
6.11.4	Measurement procedure .....	49
6.11.5	Precautions to be observed .....	49
6.11.6	Measurement conditions to be defined.....	50
6.12	Luminous intensity ( $I_V$ ) measurement .....	50
6.12.1	Purpose.....	50
6.12.2	Measurement principle.....	50
6.12.3	Measuring circuit .....	51
6.12.4	Measurement procedure .....	52
6.12.5	Precautions to be observed .....	52
6.12.6	Measurement conditions to be defined.....	52
6.13	Radiant intensity ( $I_e$ ) measurement .....	52

6.13.1	Purpose .....	52
6.13.2	Measurement principle.....	52
6.13.3	Measuring circuit .....	53
6.13.4	Measurement procedure .....	53
6.13.5	Measurement conditions to be defined.....	53
6.14	Luminance ( $L_V$ ) measurement .....	53
6.14.1	Purpose .....	53
6.14.2	Measuring circuit .....	54
6.14.3	Measurement procedure .....	54
6.14.4	Measurement conditions to be defined.....	54
6.15	Emission spectrum distribution, peak emission wavelength ( $\lambda_p$ ), and spectral half bandwidth ( $\Delta\lambda$ ) measurement .....	55
6.15.1	Purpose .....	55
6.15.2	Measuring circuit .....	55
6.15.3	Measurement procedure .....	56
6.15.4	Measurement conditions to be defined.....	57
6.16	Chromaticity measurement.....	57
6.16.1	Purpose .....	57
6.16.2	Measurement principle.....	57
6.16.3	Measuring circuit .....	60
6.16.4	Measurement procedure .....	60
6.16.5	Measuring conditions to be defined.....	60
6.17	Directional characteristics and full width half maximum of an intensity measurement.....	60
6.17.1	Purpose .....	60
6.17.2	Measuring circuit .....	61
6.17.3	Measurement procedure .....	61
6.17.4	Measuring conditions to be defined.....	62
6.18	Illuminance ( $E_V$ ) measurement.....	63
6.18.1	Purpose .....	63
6.18.2	Measuring circuit .....	63
6.18.3	Measurement procedure .....	63
6.18.4	Measuring conditions to be defined.....	63
7	Items to be indicated on the package.....	63
8	Quality evaluation .....	64
8.1	General.....	64
8.2	Classification of quality evaluations .....	64
8.2.1	General .....	64
8.2.2	Classification I.....	64
8.2.3	Classification II.....	64
8.2.4	Classification III.....	64
8.2.5	Precautions to be observed .....	64
8.3	Quality evaluation test .....	70
8.3.1	General .....	70
8.3.2	Specimens.....	71
8.4	Lot quality inspection .....	71
8.4.1	General .....	71
8.4.2	Specimens.....	71

8.5	Periodical quality inspection.....	71
8.5.1	General .....	71
8.5.2	Specimens.....	71
8.5.3	Inspection period .....	71
8.6	Easing of the lot quality inspection standards.....	71
8.7	Periodical evaluation maintenance tests .....	72
8.7.1	Test items and specimens .....	72
8.7.2	Test period .....	72
8.8	Long-term storage products .....	72
8.9	Continuous current test.....	72
8.9.1	General .....	72
8.9.2	Initial measurement .....	72
8.9.3	Test circuits.....	72
8.9.4	Test conditions .....	73
8.9.5	Post-treatment.....	73
8.9.6	Final measurement .....	73
Annex A (normative)	Standard luminous efficiency.....	74
Annex B (normative)	How to obtain the self-absorption correction factor .....	77
B.1	Purpose .....	77
B.2	LED light sources for self-absorption measurement .....	77
B.3	Method .....	77
Annex C (normative)	How to obtain the colour correction factor .....	79
C.1	Purpose .....	79
C.2	Method .....	79
C.2.1	Luminous flux and luminous intensity measurement.....	79
C.2.2	Radiant flux and radiant intensity measurement.....	80
Annex D (normative)	Calibration of the luminance meter.....	81
D.1	Purpose .....	81
D.2	How to perform the calibration .....	81
Annex E (normative)	Colour-matching function of the <i>XYZ</i> colour system .....	83
Annex F (normative)	Spectral chromaticity coordinates .....	88
Annex G (normative)	Illuminance meter calibration .....	93
G.1	Purpose .....	93
G.2	How to perform the calibration .....	93
Bibliography.....		94
Figure 1 – Radiant intensity .....		15
Figure 2 – Radiance.....		16
Figure 3 – Radiant exitance .....		16
Figure 4 – Irradiance.....		17
Figure 5 – Spectral luminous efficiency.....		18
Figure 6 – Circuit diagram for $V_F$ measurement .....		27
Figure 7 – Circuit diagram for $V_F$ measurement with a constant voltage source and a current-limiting resistor .....		28
Figure 8 – Circuit diagram for $V_F$ measurement using an SMU.....		28
Figure 9 – Circuit diagram for $V_R$ measurement.....		29

Figure 10 – Circuit diagram for $r_f$ measurement .....	30
Figure 11 – Circuit diagram for $I_R$ measurement .....	32
Figure 12 – Circuit diagram for $C_t$ measurement .....	33
Figure 13 – Circuit diagram for $C_t$ measurement .....	34
Figure 14 – An example of the temperature dependence of $\eta_{PE}$ .....	35
Figure 15 – Heating time duration dependence of the measured thermal resistance .....	36
Figure 16 – Cumulative thermal capacitance versus cumulative thermal resistance characteristics (structural function) .....	37
Figure 17 – Circuit diagram for measurement of change in $V_F$ .....	38
Figure 18 – Change in $V_F$ during the measurement.....	39
Figure 19 – Example of the time variation in $V_F$ .....	40
Figure 20 – Transient vibration waveform immediately after the heating is off.....	40
Figure 21 – Circuit diagram for response time measurement.....	42
Figure 22 – Waveform of response time measurement.....	44
Figure 23 – Circuit diagram for $f_c$ measurement.....	45
Figure 24 – Circuit diagram for $\Phi_V$ measurement.....	47
Figure 25 – Circuit diagram for $\Phi_e$ measurement.....	49
Figure 26 – Schematic diagram for $I_V$ measurement.....	51
Figure 27 – Circuit diagram for $I_V$ measurement .....	51
Figure 28 – Circuit diagram for $I_e$ measurement .....	53
Figure 29 – Circuit diagram for $L_V$ measurement.....	54
Figure 30 – Circuit diagram for $\lambda_p$ measurement.....	55
Figure 31 – Circuit diagram for $\lambda_p$ measurement.....	56
Figure 32 – Schematic diagram of $\Delta\lambda$ measurement.....	57
Figure 33 – Chromaticity .....	59
Figure 34 – Circuit diagram for chromaticity measurement.....	61
Figure 35 – Directional characteristics (example 1).....	62
Figure 36 – Directional characteristics (example 2).....	62
Figure 37 – Circuit diagram for $E_V$ measurement.....	63
Figure 38 – Circuit diagram for continuous current test .....	73
Figure B.1 – Schematic diagram for self-absorption measurement.....	77
Figure D.1 – Schematic diagrams for calibration .....	82
Figure G.1 – Schematic diagram for calibration.....	93
Table 1 – Absolute maximum ratings .....	22
Table 2 – Electrical and optical characteristics.....	23
Table 3 – CIE averaged LED intensity measurements.....	51
Table 4 – Items for the screening test and their conditions(reference).....	64
Table 5 – Quality evaluation tests .....	65
Table 6 – Lot quality inspection.....	67

Table 7 – Periodical quality inspection .....	70
Table A.1 – Definitive values of the spectral luminous efficiency function for photopic vision $V(\lambda)$ .....	74
Table E.1 – Colour-matching function of the $XYZ$ colour system .....	83
Table F.1 – Spectral chromaticity coordinates .....	88

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### SEMICONDUCTOR DEVICES –

### Part 5-6: Optoelectronic devices – Light emitting diodes

#### 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60747-5-6 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 2016. This edition constitutes a technical revision.

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

- a) ultraviolet-emitting diodes (UV LED) and their related technical contents were added;
- b) power efficiency ( $\eta_{PE}$ ) as part of electrical and optical characteristics were added;
- c) new measuring methods related to thermal resistance were added;
- d) hydrogen sulphide corrosion test was added to quality evaluation;
- e) some standards were added to the bibliography.



The text of this International Standard is based on the following documents:

FDIS	Report on voting
47E/745/FDIS	47E/752/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://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 will remain unchanged until the stability date indicated on the IEC website under [webstore.iec.ch](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

## SEMICONDUCTOR DEVICES –

### Part 5-6: Optoelectronic devices – Light emitting diodes

#### 1 Scope

This part of IEC 60747 specifies the terminology, the essential ratings and characteristics, the measuring methods and the quality evaluations of light emitting diodes (LEDs) for general industrial applications such as signals, controllers, sensors, etc.

LEDs for lighting applications are out of the scope of this part of IEC 60747.

LEDs are classified as follows:

- a) LED package;
- b) LED flat illuminator;
- c) LED numeric display and alpha-numeric display;
- d) LED dot-matrix display;
- e) infrared-emitting diode (IR LED);
- f) ultraviolet-emitting diode (UV LED).

LEDs with a heat spreader or having a terminal geometry that performs the function of a heat spreader are within the scope of this part of IEC 60747.

An integration of LEDs and controlgears, integrated LED modules, semi-integrated LED modules, integrated LED lamps or semi-integrated LED lamps, are out of the scope of this part of IEC 60747.

#### 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 60051 (all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60068-2-17, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60747-5-13, *Semiconductor devices – Part 5-13: Optoelectronic devices – Hydrogen sulphide corrosion test for LED packages*

IEC 60749-6, *Semiconductor devices – Mechanical and climatic test methods – Part 6: Storage at high temperature*

IEC 60749-10, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-12, *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

IEC 60749-14, *Semiconductor devices – Mechanical and climatic test methods – Part 14: Robustness of terminations (lead integrity)*

IEC 60749-15, *Semiconductor devices – Mechanical and climatic test methods – Part 15: Resistance to soldering temperature for through-hole mounted devices*

IEC 60749-20, *Semiconductor devices – Mechanical and climatic test methods – Part 20: Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat*

IEC 60749-21, *Semiconductor devices – Mechanical and climatic test methods – Part 21: Solderability*

IEC 60749-24, *Semiconductor devices – Mechanical and climatic test methods – Part 24: Accelerated moisture resistance – Unbiased HAST*

IEC 60749-25, *Semiconductor devices – Mechanical and climatic test methods – Part 25: Temperature cycling*

IEC 60749-36, *Semiconductor devices – Mechanical and climatic test methods – Part 36: Acceleration, steady state*

ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*