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Semiconductor optoelectronic devices for fibre optic system applications – Part 2: Measuring methods

Dispositifs optoélectroniques à semiconducteurs pour application dans les systèmes à fibres optiques – Partie 2: Méthodes de mesure

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SEMICONDUCTOR OPTOELECTRONIC DEVICES FOR FIBRE OPTIC SYSTEM APPLICATIONS –

Part 2: Measuring methods

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International Standard IEC 62007-2 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 1997, and its amendment 1(1998). It is a technical revision.

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

a) descriptions related to analogue characteristics have been removed;
b) some definitions and terms have been revised for harmonisation with other standards originating from SC 86C.

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

FDIS	Report on voting
86C/868/FDIS	86C/870/RVD

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 of the IEC 62007 series can be found, under the general title *Semiconductor optoelectronic devices for fibre optic system applications*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

Semiconductor optical signal transmitters and receivers play important roles in optical information networks. This standard covers the measurement procedures for their optical and electrical properties that are intended for digital communication systems. These properties are essential to specify their performance.

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SEMICONDUCTOR OPTOELECTRONIC DEVICES FOR FIBRE OPTIC SYSTEM APPLICATIONS –

Part 2: Measuring methods

1 Scope

This part of IEC 62007 describes the measuring methods applicable to the semiconductor optoelectronic devices to be used in the field of fibre optic digital communication systems and subsystems.

All optical fibres and cables that are defined in IEC 60793 series, IEC 60794 series are applicable. All optical connectors that are defined in IEC 60874 series are applicable, if a pigtail is to be terminated with an optical connector.

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 referenced document (including any amendments) applies.

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IEC 60050-731:1991, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

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IEC 60793 (all parts), *Optical fibres*

IEC 60794 (all parts), *Optical fibre cables*

IEC 60874 (all parts), *Connectors for optical fibres and cables*

3 Terms, definitions and abbreviations

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

3.1 Terms and definitions

3.1.1
PIN photodiode
photodiode with a large intrinsic region sandwiched between p- and n-doped semiconducting regions used for the detection of optical radiation

[IEV 731-06-29]

3.1.2
avalanche photodiode
photodiode operating with a bias voltage such that the primary photocurrent undergoes amplification by cumulative multiplication of charge carriers

[IEV 731-06-30]

3.1.3
pigtail
short optical fibre or optical fibre cable that is attached to a device being measured

3.2 Abbreviations

LED light emitting diodes

LD laser diode

PD photodiode

TIA transimpedance amplifier

APD avalanche photodiode

4 Measuring methods for photoemitters

4.1 Outline of the measuring methods

The LEDs and LDs have various opto-electronic properties. Some of them are important specifications for using them in the optical communication systems. The measuring methods for their opto-electronic properties are described in the following subclauses. Each subclause consists of following items.

a) Purpose

b) “Equipment setup” or “Circuit diagram” for measurement

c) “Equipment descriptions and requirements” or “Circuit descriptions and requirements”

d) Precautions to be observed

e) Measurement procedures

f) Specified conditions

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4.2 Radiant power or forward current of LEDs and LDs with or without optical fibre pigtails

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a) Purpose

To measure the radiant power Φ_e or the forward current I_F of light-emitting diodes (LED) and laser diodes, with or without optical fibre pigtails, under specified conditions.

b) Measuring equipment

Figure 1 shows an equipment setup for measuring radiant power and forward current of LEDs and LDs.

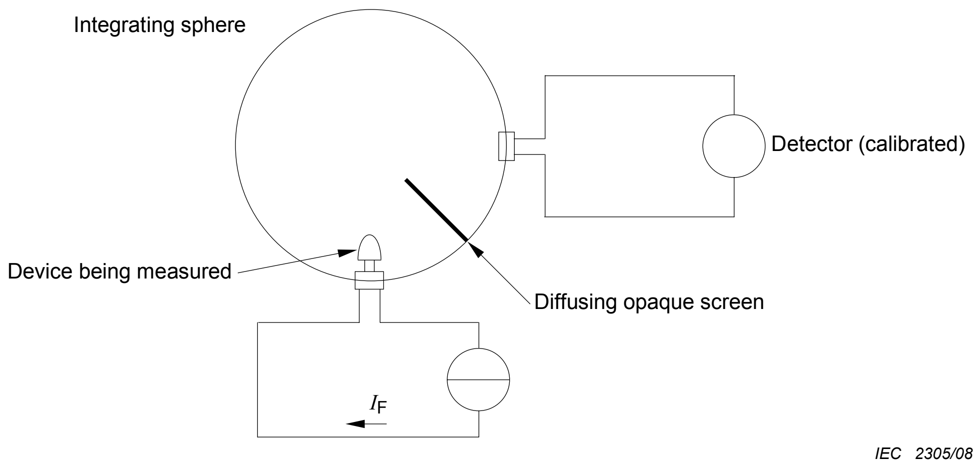

Figure 1 – Equipment setup for measuring radiant power and forward current of LEDs and LDs

c) Equipment description and requirements

The radiation emitted by the device is submitted to multiple reflections from the walls of the integrating sphere; this leads to a uniform irradiance of the surface proportional to the emitted flux. A detector located in the walls of the sphere measures this irradiance. An opaque screen shields the detector from the direct radiation of the device being measured.

d) *Precautions to be observed*

The device being measured, the screen and the apertures shall be small compared to the sphere surface.

The inner surface of the sphere and screen shall have a diffusing coating having a high uniform reflection coefficient (0,8 minimum).

The sphere and detector assembly shall be calibrated.

Change in peak-emission wavelength and flux due to power dissipation shall be taken into account.

When the device being measured is pulsed, the detector shall average the measured radiation.

e) *Measurement procedures*

The emitting device is set at the entrance of the integrating sphere, so that no direct radiation will reach the detector.

For measurement of radiant power, the specified forward current I_F is applied to the device and the radiant power is measured on the photodetector.

For measurement of forward current, a current is applied to the device until the specified radiant power (Φ_e) is achieved. The value of current is recorded.

f) *Specified conditions*

– Ambient or case temperature.

– Radiant power (when measuring forward current).

– Forward current (when measuring radiant power).

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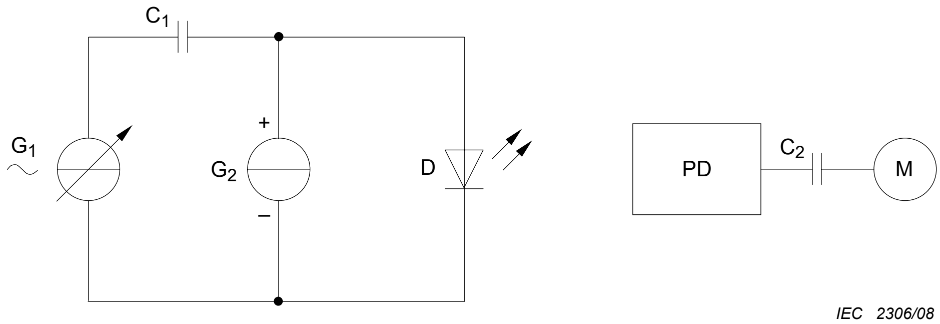
4.3 Small signal cut-off frequency (f_c) of LEDs and LDs with or without optical fibre pigtails

a) *Purpose*

To measure the small-signal cut-off frequency (f_c) of light-emitting diodes (LED) and laser diodes (LD) with or without optical fibre pigtails, under specified conditions.

b) *Circuit diagram*

Figure 2 shows a circuit diagram for measuring small-signal cut-off frequency LEDs and LDs.



Key

D device being measured

G_1 adjustable frequency a.c. generator

G_2 d.c. generator

PD photodetector

M measuring instrument for a.c. radiant power

C_1, C_2 coupling capacitors

Figure 2 – Circuit diagram for measuring small-signal cut-off frequency LEDs and LDs

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c) *Precautions to be observed*

The radiant power reflected back into the laser-diode shall be minimized so as to avoid distortions, which could affect the accuracy of the measurements. The photodetector must have a frequency response greater than f_c.

d) *Measurement procedure*

For LEDs, the specified direct forward current or the direct forward current required to obtain the specified radiant power is applied to the device being measured.

For laser diodes, the forward current is adjusted to a value equal to the continuous forward current above the threshold or specified radiant power.

The forward current is modulated using generator G_1 at a low frequency (less than f_c /100) and the a.c. radiant power is measured on M (see Figure 2).

The modulation frequency is increased, keeping the modulation level constant until the output radiant power measured on M has halved.

This frequency is the small-signal cut-off frequency (f_c).

e) *Specified conditions*

For the light-emitting diodes (LED):

– ambient or case temperature;

– d.c. forward current or radiant power.

For the laser diodes (LD):

– ambient, case or submount temperature;

– difference between (actual) d.c. forward current and threshold current or radiant power.

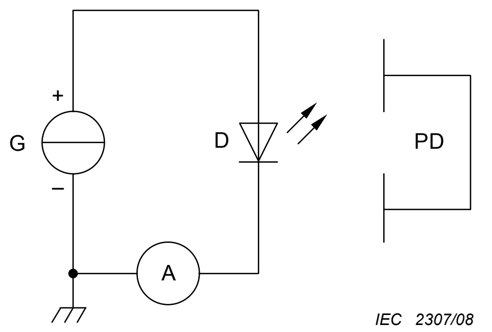
4.4 Threshold current of LDs with or without optical fibre pigtails

a) *Purpose*

To measure the threshold current of a laser diode, with or without optical fibre pigtails.

b) *Circuit diagram*

Figure 3 shows a circuit diagram for measuring threshold current of a laser diode.



Key

D device being measured

PD photodetector measuring incident radiant power

A ammeter

G generator (pulsed or d.c.)

Figure 3 – Circuit diagram for measuring threshold current of a LD

c) *Circuit description and requirements*

For pulse measurement, the current generator, G, shall provide current pulses of the required amplitude, duration and repetition rate.

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d) *Precautions to be observed*

Radiant power reflected back into the laser diode shall be minimized. The limiting values of the laser diode (I_F and Φ_e) shall not be overstepped.

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e) *Measurement procedure*

A forward current is applied to the diode and the relation between the incident radiant power from the diode and the forward current is recorded.

The forward current at which the second derivative of the recorded curve showing incident radiant power versus the forward current has its first maximum is determined (see Figure 4). The forward current at this point is the threshold current I_{TH}.

f) *Specified conditions*

– Ambient, case or submount temperature.

– For pulse measurement, repetition frequency and pulse duration of the forward current.

Figure 4 shows a graph to determine threshold current of lasers.

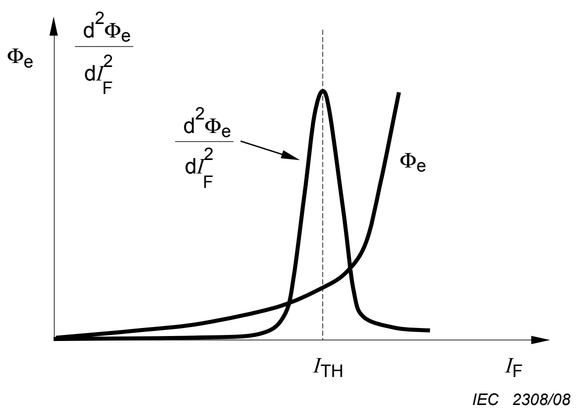


Figure 4 – Graph to determine threshold current of lasers

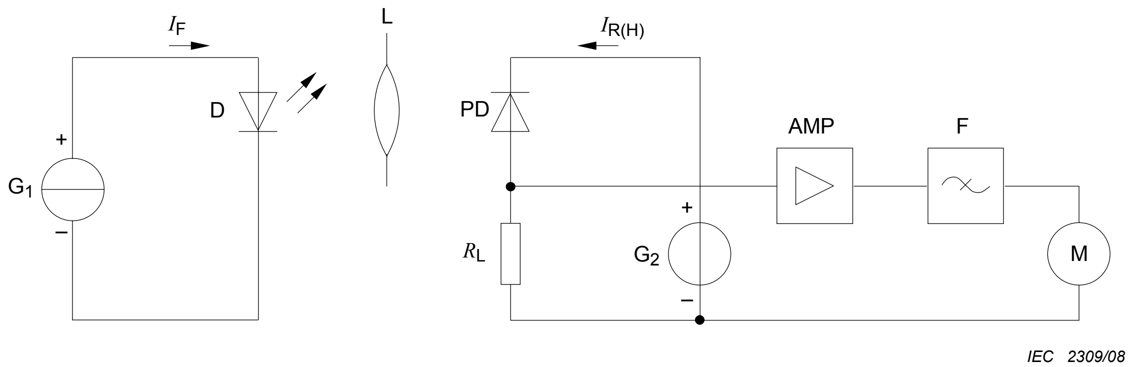
4.5 Relative intensity noise of LEDs and LDs with or without optical fibre pigtails

a) *Purpose*

To measure the relative intensity noise (RIN) of light emitting diodes (LED) and laser diodes (LD), with or without optical fibre pigtails, under specified conditions.

b) *Circuit diagram*

Figure 5 shows a circuit diagram for measuring RIN of LEDs and LDs.



Key

G_1	d.c. current generator
D	device being measured
L	lens system
I_F	forward current
PD	photodetector
R_L	load resistance
$I_{R(H)}$	reverse current of the photodetector under optical radiation
G_2	d.c. voltage bias generator
AMP	a.c. amplifier with gain G
F	filter with centre frequency f_0 and equivalent noise bandwidth Δf_N
M	measuring instrument (for example level meter, etc.)

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Figure 5 – Circuit diagram for measuring RIN of LEDs and LDs

c) *Precautions to be observed*

Radiant power reflected back into the laser diode shall be minimized to avoid distortions affecting accuracy of the measurements.

d) *Measurement procedure*

A d.c. current corresponding to the specified radiant power Φ_e is applied to the device. The noise power N_t is measured by the measuring instrument M and is replaced by reverse current $I_{R(H)}$ of the photodetector, under optical radiation, which is measured simultaneously.

The photo-emitting device being measured is replaced by a radiation source with broad spectral radiation bandwidth in the same wavelength range.

The irradiant power is adjusted to obtain the same reverse current $I_{R(H)}$ of the photodetector under optical radiation as previously measured. The noise power N_d , which corresponds to the photodetector shot-noise plus amplifier noise, is measured by the measuring instrument.

RIN is calculated using the formula:

$$\text{RIN} = \frac{N_t - N_d}{R_L \times G \times \Delta f_N \times I_{R(H)}}$$

It is expressed in Hz–1.

e) Specified conditions

- Ambient, case or submount temperature.
- Radiant power.
- Centre frequency and equivalent noise bandwidth.

4.6 S_{11} parameter of LEDs, LDs and LD modules with or without optical fibre pigtails

a) Purpose

To measure the real and imaginary parts (or modulus and phase) of the input characteristic of a device at a specified radiant power level and at a specified frequency.

The S_{11} parameter is the ratio of the high-frequency reflected voltage V_{rl} to the high-frequency incident voltage V_{il} at the device electrical input port.

$$S_{11} = \frac{V_{rl}}{V_{il}}$$

The equivalent working equation is the following:

$$S_{11} = \frac{Z_1 - Z_0}{Z_1 + Z_0}$$

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where Z_1 is the input impedance of the device being measured and Z_0 the characteristic impedance of the measuring equipment.

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b) Circuit diagram

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Figure 6 shows the circuit diagram for measuring the S_{11} parameter LEDs, LDs and LD modules.

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