

Semiconductor optoelectronic devices for fibre optic system applications —

Part 2: Measuring methods

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The UK participation in its preparation was entrusted to Technical Committee GEL/86, Fibre optics, which has the responsibility to:

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 62, an inside back cover and a back cover.

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Partie 2: Méthodes de mesure
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Teil 2: Meßverfahren
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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The texts of the International Standard IEC 62007-2:1997 and its amendment 1, prepared by IEC TC 86, Fibre optics, were submitted to the formal vote and were approved by CENELEC as EN 62007-2 on 2000-04-01 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2001-04-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-04-01

Annexes designated "informative" are given for information only.
In this standard, annex A is informative.

Endorsement notice

The texts of the International Standard IEC 62007-2: 1997 and its amendment 1 were approved by CENELEC as a European Standard without any modification.

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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 systems and subsystems.

2 Normative references

There are no normative references in this part of IEC 62007.

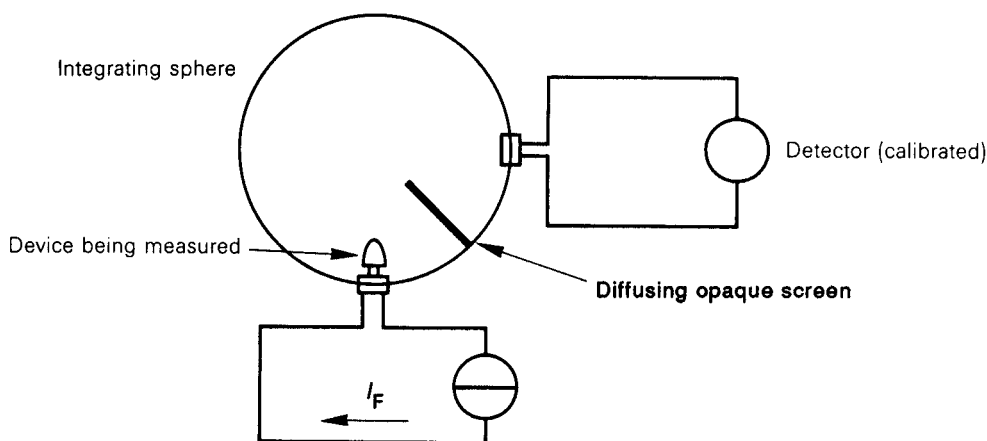
3 Measuring methods for photoemitters

3.1 Radiant power or forward current of light-emitting diodes (LED), infrared-emitting diodes (IRED) and laser diodes with or without pigtails

a) Purpose

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

b) Measuring equipment



IEC 1 029/91

Figure 1

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*

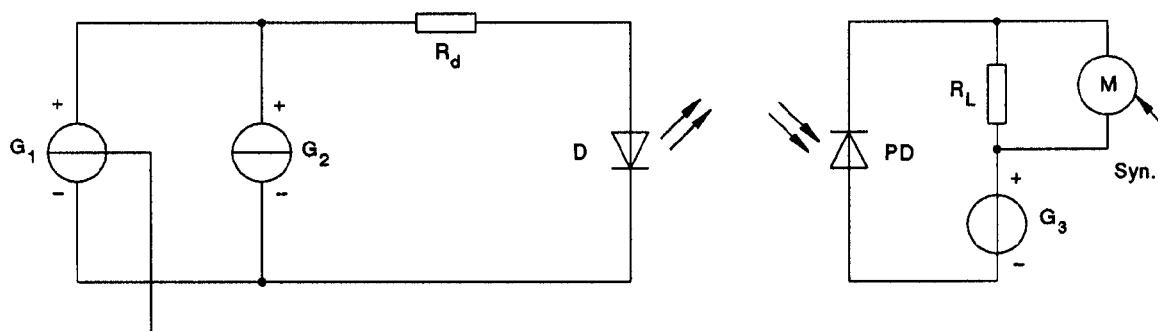
- Ambient or case temperature.
- Radiant power (when measuring forward current).
- Forward current (when measuring radiant power).

3.2 Switching times of infrared-emitting diode and light-emitting diode with or without pigtailed

a) *Purpose*

To measure the turn-on time t_{on} (turn-on delay time $t_{d(on)}$ + rise time t_r) and turn-off time t_{off} (turn-off delay time $t_{d(off)}$ + fall time t_f) of an infrared-emitting diode and light-emitting diode with or without pigtailed.

b) *Circuit diagram*



CEI 1 033/91

Figure 2

c) *Circuit description*

- G_1 = current pulse generator, with high impedance
- G_2 = d.c. current bias source
- G_3 = d.c. voltage bias source
- R_d = resistance for matching the impedance with the generator
- D = device being measured
- PD = photodiode
- R_L = load resistance
- M = measuring instrument
- Syn. = synchronization signal

d) *Precautions to be observed*

The switching time of the photodiode, the delay time of the test circuit and measuring instrument, the rise and fall times of the input current pulse shall be short enough not to affect the accuracy of the measurement.

The mean output power obtained at the top of the optical pulse (see figure 3) may not necessarily be equivalent to the c.w. radiant power at a current equal to the sum of the d.c. bias and input pulse current.

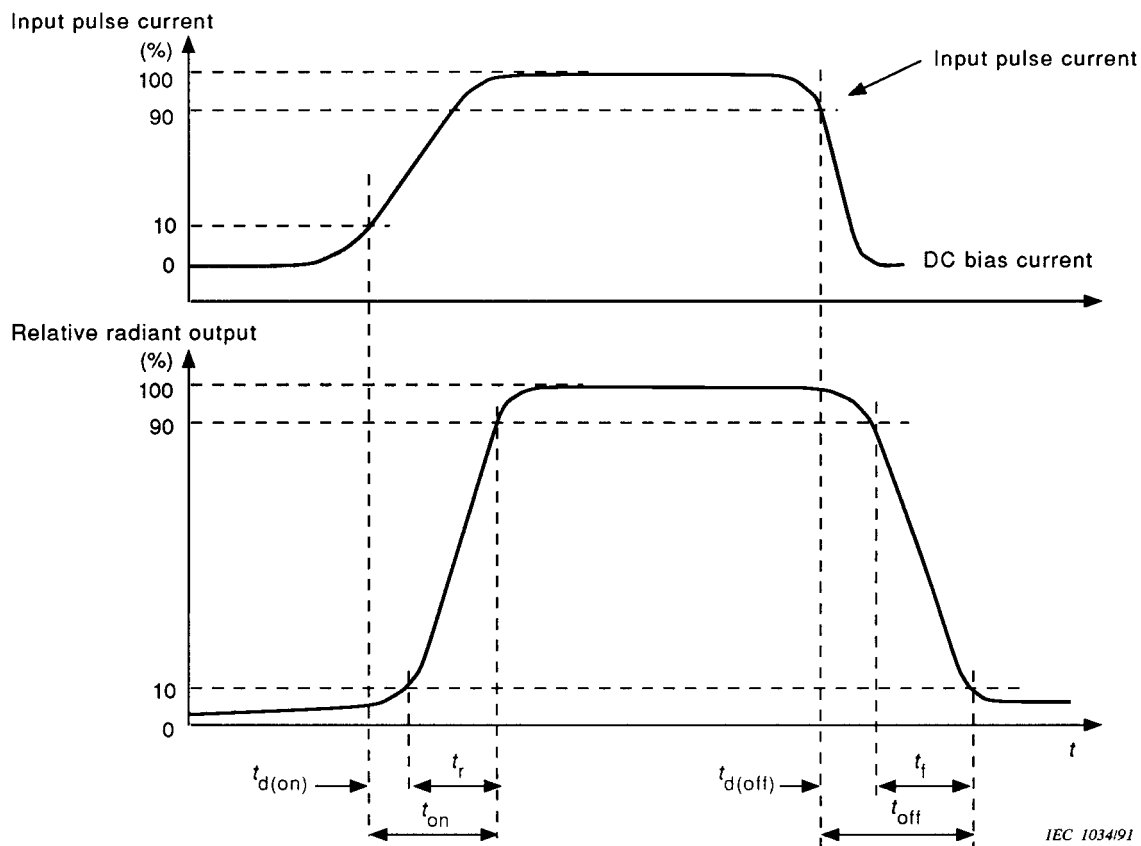
Only the optical port of the device being measured shall be considered.

e) *Measurement procedure*

Apply the specified d.c. and pulse current to the device being measured.

Measure the switching times with the measuring instrument M.

The 100 % radiant output power level is the mean output power obtained at the top of the radiant pulse. The 0 % level is the output power obtained at the d.c. bias current.



$t_{d(on)}$ = turn-on delay time
 t_r = rise time
 $t_{d(off)}$ = turn-off delay time

t_f = fall time
 t_{on} = turn-on time
 t_{off} = turn-off time

Figure 3

f) Specified conditions

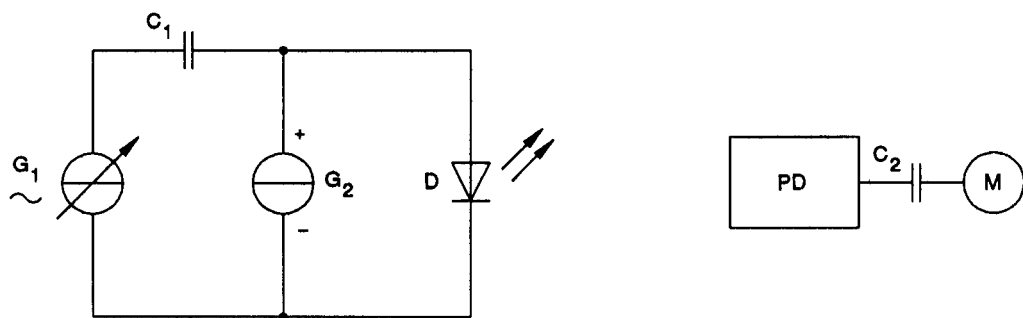
- Ambient or case temperature.
- DC bias current.
- Input pulse current, width and duty cycle.
- Optical port.
- Optical configuration.

3.3 Small signal cut-off frequency (f_c) of light-emitting diodes (LED), infrared-emitting diodes (IRED) and laser diodes with or without pigtailed

a) Purpose

To measure the small-signal cut-off frequency (f_c) of light-emitting diodes (LED), infrared-emitting diodes (IRED) and laser diodes with or without pigtailed, under specified conditions.

b) Circuit diagram



CEI 1 035/91

Figure 4

c) Circuit description and requirements

- 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

d) 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 .

e) Measurement procedure

For LED and IRED, 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.

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).

f) Specified conditions

For the light-emitting diodes (LED) and infrared-emitting diodes (IRED):

- ambient or case temperature;
- d.c. forward current or radiant power.

For the laser diodes:

- ambient, case or submount temperature;
- difference between (actual) d.c. forward current and threshold current or radiant power.

3.4 Threshold current of laser diodes with or without pigtails

a) *Purpose*

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

b) *Circuit diagram*

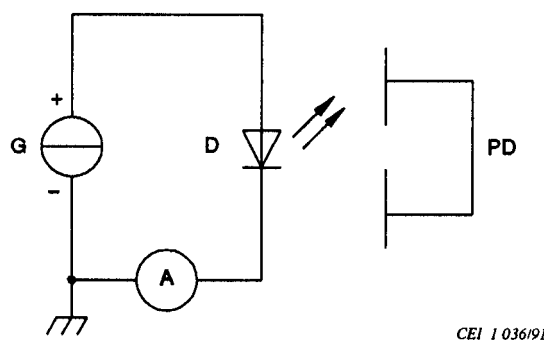


Figure 5

c) *Circuit description and requirements*

D = device being measured

PD = photodetector measuring incident radiant power

A = ammeter

G = generator (pulsed or d.c.)

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

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.

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 6). The forward current at this point is the threshold current I_{TH} .

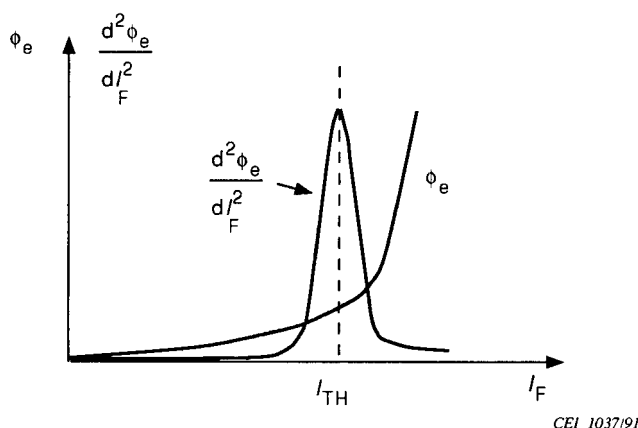


Figure 6

f) *Specified conditions*

- Ambient, case or submount temperature.
- For pulse measurement, repetition frequency and pulse duration of the forward current.

3.5 Relative intensity noise of light-emitting diodes (LED), infrared-emitting diodes (IRED) and laser diodes with or without pigtails

a) *Purpose*

To measure the relative intensity noise (RIN) of LED, IRED and laser diodes, with or without pigtails, under specified conditions.

b) *Circuit diagram*

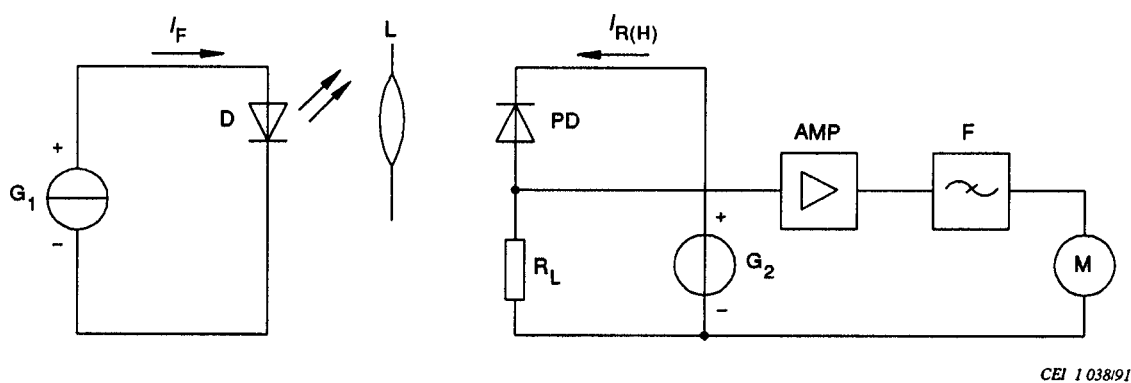


Figure 7

c) *Description of the circuit*

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_o and equivalent noise bandwidth Δf_N
M	= measuring instrument (for example level meter, etc.)

d) *Precautions to be observed*

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

e) *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 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:

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

It is expressed in Hz^{-1} .

f) *Specified conditions*

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

3.6 Switching times of a laser diode with or without pigtailed

a) *Purpose*

To measure the switching times (turn-on delay time $t_{d(on)}$, rise time t_r , turn-off delay time $t_{d(off)}$ and the fall time t_f) of a laser diode with or without pigtailed under specified conditions.

b) Circuit diagram

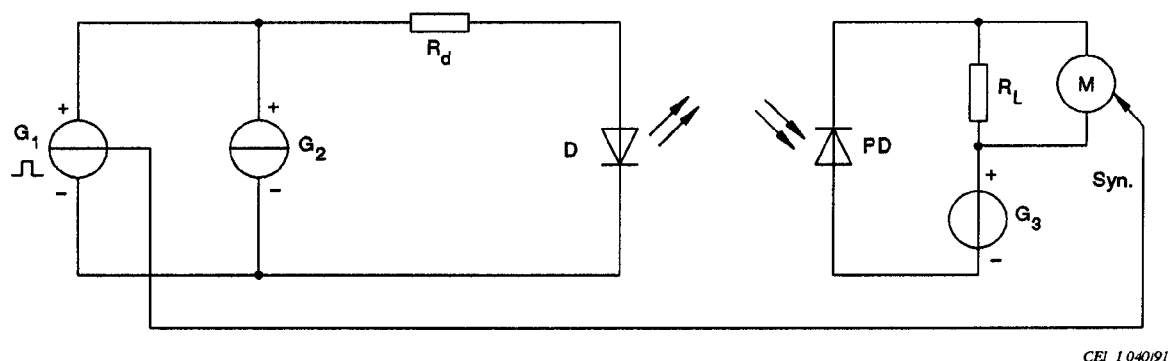


Figure 8

c) Circuit description

- G_1 = current pulse generator
- G_2 = d.c. current bias source
- G_3 = d.c. voltage bias source
- R_d = resistance for matching the impedance with the generator
- D = device being measured
- PD = photodiode
- R_L = load resistance
- M = measuring instrument capable of measuring input and output waveforms simultaneously
- Syn. = synchronization signal.

d) Precautions

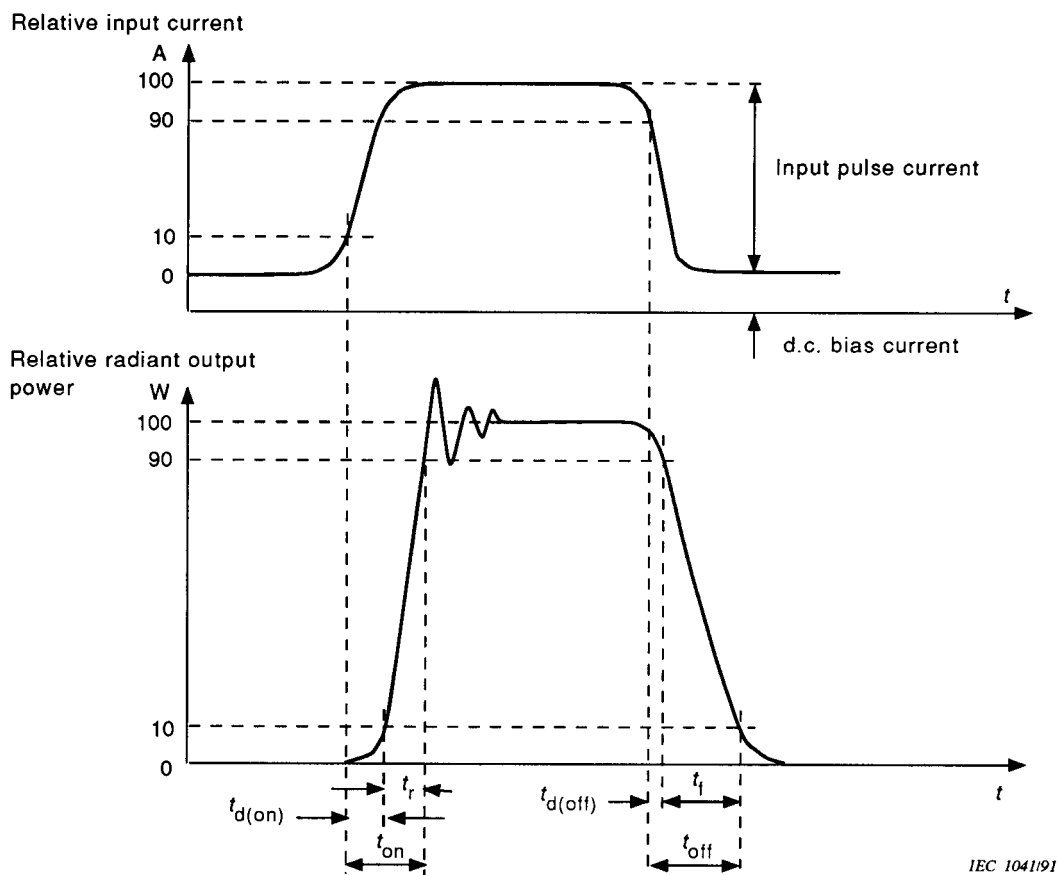
- Radiant power reflected back into the laser diode shall be minimized.
- The pulse width and the duty cycle shall be chosen in order to avoid significant thermal effects.
- A surge current due to switching on/off the circuit, contact with electrostatically charged bodies, etc., shall be avoided.
- The d.c. source G_2 shall have a sufficiently high impedance that does not distort the output of the current pulse generator G_1 .
- The switching time of the photodiode PD, and the delay time of the test circuit and measuring instrument should be fast enough not to affect the accuracy of the measurement.

e) Measurement procedure

The specified d.c. and pulse current are applied to the device being measured D.

Values of $t_{d(on)}$, t_r , $t_{d(off)}$ and t_f are determined by the measuring instrument.

NOTE – Mean output power at the top of the relative radiant output pulse may not necessarily be equivalent to the c.w. optical power at a current equal to the sum of the d.c. bias and input pulse current.



NOTE 1 – The switching times are defined in figure 9 unless otherwise stated. The 100 % level is the mean output power obtained at the top of the optical pulse. The 0 % level is the output power obtained with only the d.c. bias current.

NOTE 2 – The switching times t_r and t_f are defined between 10 % and 90 % of the mean radiation output power, unless otherwise stated.

Figure 9

f) *Specified conditions*

- Ambient, case or submount temperature.
- Bias current or radiant power.
- Input pulse current, width and duty cycles.

3.7 Carrier to noise ratio of light-emitting diodes, infrared-emitting diodes, laser diodes and a laser module with or without pigtailed

a) *Purpose*

To measure the carrier to noise ratio at a specified radiant power level (cw) under specified modulation conditions.

b) Circuit diagram

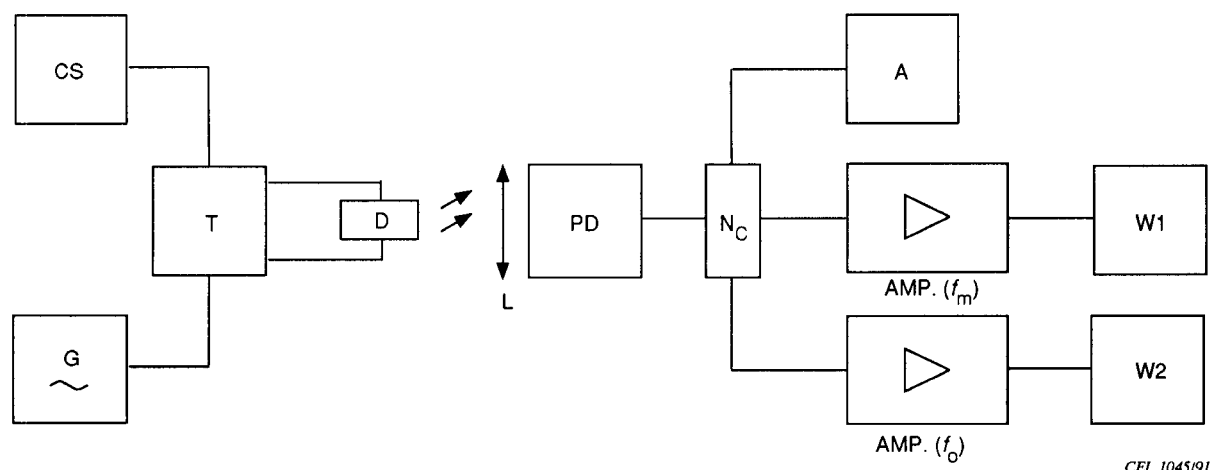


Figure 10

c) Circuit description and requirements

- CS = d.c. current source
D = device being measured
G = a.c. generator
T = bias T or passive biasing circuit
L = focusing lens systems
PD = photodetector
A = current measuring instrument
AMP(f_m) = amplifier suitable for use at frequency f_m
W1 = power meter
AMP(f_o) = amplifier and filter suitable for use at frequency f_o
W2 = power meter
 N_C = impedance matching and signal dividing network

d) Precautions to be observed

The associated "photodetector + ammeter" shall be calibrated as a radiant power meter unit over the wavelength range under consideration.

The focusing systems shall be designed:

- to avoid radiation being reflected back into the laser diode or the laser module;
- to bring into focus the optical port of the device being measured onto the optical port of the photodetector.

e) Measurement procedure

The specified supply and drive conditions are applied to the device being measured D.

The photocurrent (I_{ph}) resulting from the illumination (ϕ_e specified) of the photodetector is measured first and noted. R.F. modulation is applied to the device being measured through the biasing circuit: sinewave frequency f_m , modulation depth m . The electrical power P_1 at frequency f_m is measured on the power meter W1. This electrical power P_1 is related to the modulated radiant power squared as follows:

$$(\Delta\phi_m)^2 = \frac{P_1}{S^2 \times R_C}$$

where:

S = responsivity on the photodetector PD

R_C = load resistance of PD [input of AMP(f_m)]

The noise electrical power N_{tot} at frequency f_o in the frequency band Δf is measured on the power meter W2 (f_o should be as close as technically possible to f_m). This is the sum of the pure shot noise associated with the photocurrent I_{ph} and the excess noise due to the radiation source intensity fluctuations. The pure shot noise must be measured under the same illumination conditions (same I_{ph}) using a "broad optical spectrum" radiation source. The electrical noise power corresponding to the pure shot noise equivalent radiant power fluctuations (N_s) can be measured on W2:

$$\left(\frac{C}{N}\right)_{lin} = \frac{(\Delta\phi_m)^2}{\langle \Delta\phi_e^2 \rangle} = \frac{P_1}{(N_{tot} - N_s)} \times (\Delta f)$$

or

$$\left(\frac{C}{N}\right) = 10 \log_{10} \left(\frac{C}{N}\right)_{lin}$$

f) *Specified conditions*

- Ambient, case or submount temperature.
- Measurement bias conditions (ϕ_e , I_F or ΔI_F).
- Frequency and bandwidth (f_o , Δf).
- Drive frequency (f_m).
- Modulation depth (m).

3.8 S_{11} parameter of infrared emitting diodes, light-emitting diodes, laser diodes, laser modules with or without 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.

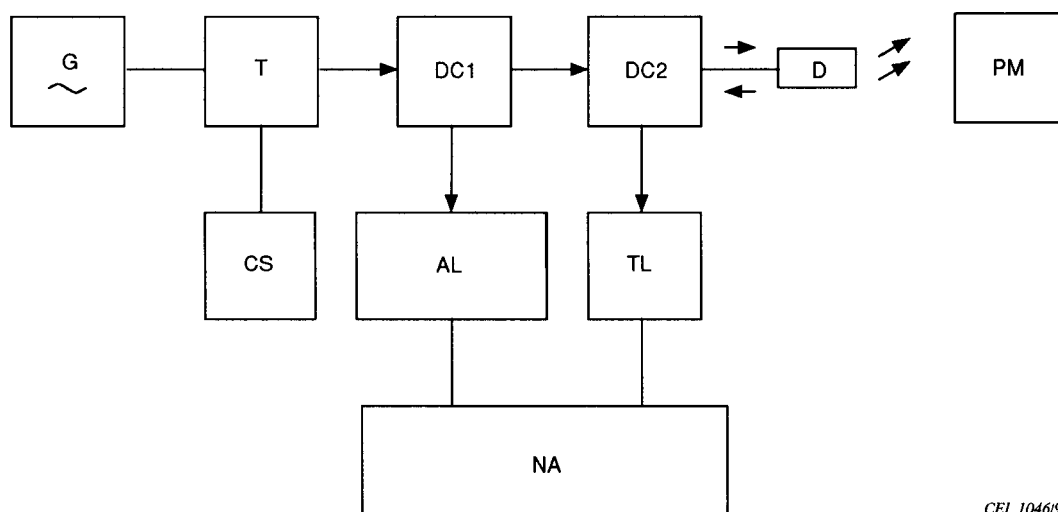
$$S_{11} = \frac{V_{rl}}{V_{il}}$$

The equivalent working equation is the following:

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

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

b) *Circuit diagram*



CEI 1046/91

Figure 11

c) *Circuit description and requirements*

G	= RF generator
T	= biasing circuit
CS	= d.c. current source
DC1	= directional coupler forward
DC2	= directional coupler reverse
AL	= adjustable transmission line
NA	= network analyzer
D	= device being measured
PM	= radiant power meter
TL	= test transmission line

d) *Precautions to be observed*

The characteristic impedance of the transmission lines, generator, attenuators, device measuring socket, T-biasing circuit and loads is matched to a common impedance (usually 50 Ω) over the specified frequency range.

The RF power shall remain low enough to allow for linear operation of the device being measured D.

Ensure that the optical ports of the device D and the meter PM are aligned.

e) *Measurement procedure*

Calibration:

The adjustable line shall balance the test line.

A short circuit is connected to the input line at the location of the device being measured.

The a.c. signal frequency is scanned around the specified frequency f , and the adjustable line length is altered in order to obtain one single point S_{11} on the Smith Chart (modulus equal to unity and phase equal to 180°).

Measurement:

The "calibration" short-circuit is replaced by the device being measured D , the bias conditions are applied as specified (ϕ_e , T_{case} , or T_{amb} , T_{sub}), the value of S_{11} corresponding to the reflection coefficient of the device D is read.

f) *Specified conditions*

- Ambient, case or submount temperature.
- Supply and drive conditions: ϕ_e or I_F or ΔI_F , f , m (modulation depth).

3.9 Tracking error for a laser module with pigtails, with or without cooler

a) *Purpose*

To measure the maximum variations of the tracking ratio between the fibre output radiant power and the monitor diode photocurrent of a laser module over a specified temperature range.

b) *Circuit diagrams*

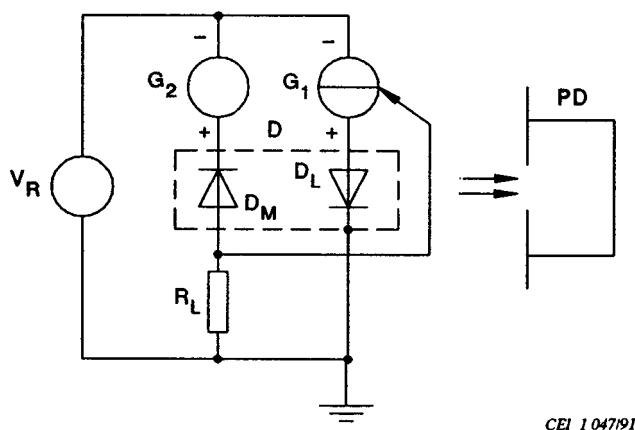


Figure 12a – Laser diode: cathode connected to the package

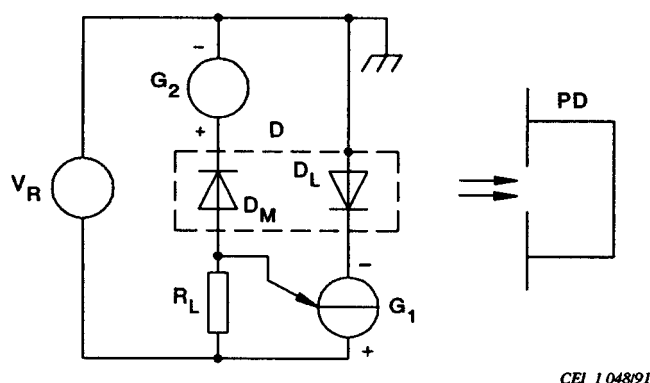


Figure 12b – Laser diode: anode connected to the package