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Measuring methods of laser diodes for fiber optic transmission

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently, JIS C 5941:1989 has been revised and replaced with this Standard.

In this revision, conformance of provisions between JIS and International Standard was taken into consideration.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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Measuring methods of laser diodes for fiber optic transmission

Introduction Users should note that at application of this Standard, the normative references to this Standard shall be referred to at the same time.

Further, it is often necessary to carry out comparison with and study on the similar standard(s), if any.

This is a Japanese Industrial Standard prepared based on IEC 747-5, *Semiconductor devices. Discrete devices and integrated circuits – Part 5 : Optoelectronic devices* issued in 1992, and IEC 747-5 Amendment 1 issued in 1994, without any modification in technical contents.

1 Scope This Japanese Industrial Standard specifies measuring methods of laser diodes for fiber optic transmission as the light source. (Diodes accommodated in electronic circuit are excluded. However, monitor photodiodes are included if necessary. Hereafter referred to as “laser diodes”.)

Remarks 1 The normative references to this Standard are as follows.

JIS C 1102 *Electrical indicating instruments*

JIS C 5001 *General rules for electronic components*

JIS C 5940 *General rules of laser diodes for fiber optic transmission*

2 The International Standards corresponding to this Standard are shown below.

IEC 747-5 : 1992 *Semiconductor devices. Discrete devices and integrated circuits – Part 5 : Optoelectronic devices*

IEC 747-5 : Amendment 1 : 1994

2 Definitions For the purpose of this Standard, the principal definitions given in JIS C 5940 apply.

3 Atmospheric conditions for measurement

3.1 Standard conditions Unless otherwise specified, the measurement shall be carried out under the standard conditions (temperature 15 °C to 35 °C, relative humidity 25 % to 85 % and air pressure 860 hPa to 1 060 hPa) specified in 4.1 of JIS C 5001. If any doubt arises on the decision of the measured values under the standard conditions or if required especially the conditions of 3.3 shall be employed.

If it is necessary to convert the measured data to that under the reference conditions, the conditions of 3.2 shall be employed as the basis.

When it is difficult to carry out the measurement under this standard conditions, the measurement may be carried out under the conditions other than the standard conditions if there is no dispute on the decision.

3.2 Reference Conditions The reference conditions shall be that specified in 4.2 of JIS C 5001 (temperature 25 °C, relative humidity 45 % and air pressure 860 hPa to 1 060 hPa). However, only the temperature may be employed as the reference condition.

3.3 Referee Conditions The referee conditions shall be the referee condition I, temperature grade 2 and relative humidity grade 2 (temperature 25 ± 2 °C, relative humidity 45 % to 55 % and air pressure 860 hPa to 1 060 hPa) specified in 4.3 of JIS C 5001.

4. Measuring apparatus and equipment

4.1 Measuring power supply The d.c. power supply shall be of a ripple content not exceeding 3 %, and the a.c. power supply shall be of a higher harmonic content not exceeding 5 %. However, in the case of power frequency, the higher harmonic content shall be not more than 10 %.

Especially in the test in which the a.c. output is measured, the ripple content of d.c. power supply, higher harmonic content of a.c. power supply and the a.c. impedance of the d.c. circuit through which a.c. current flows shall be made small to avoid the influence on the measurements.

Further, enough protective means shall be provided against entry of surges.

4.2 Instrument and measuring apparatus Unless otherwise specified, the instrument shall be that of class index 0.5 specified in JIS C 1102, and the measuring apparatus shall have at least the equivalent accuracy, and their impedances shall be such that the influence on the measuring system is negligible.

Remarks : If there is no instrument of class index 0.5 or better or measuring apparatus of equivalent accuracy as the standard product, the provision of 4.2 does not apply.

4.3 Optical power meter The optical power meter shall be calibrated at the appropriate wavelength and shall have sufficiently flat sensitivity profile on its photo-receptive plane.

4.4 Optical spectrum analyzer The optical spectrum analyzer to be used for the measurements shall have, at the appropriate wavelength, enough dynamic range (enough low stray light), accuracy on abscissa (wavelength) and ordinate (level) and enough resolving power to separate emission spectrum.

5. Measuring methods

5.1 Forward current (I_f)

5.1.1 Purpose The purpose is to measure forward currents of laser diodes under specified conditions.

5.1.2 Measuring circuit Carry out the measurement of forward currents of laser diodes in the circuit of Fig.1 in accordance with the method stated below.

5.1.3 Measuring method Let the laser diode emit the specified radiant power P_0 and measure the forward current I_f at that time.

5.1.4 Precaution for measurement When the laser diode consumes fairly large power and the temperature rise of the junction due to this power consumption largely affects the measured values, carry out the measurement by either one of the methods given below and clearly state the method.

- (1) Use a d.c. power supply and carry out the measurements after the thermal equilibrium has been achieved. If the thermal equilibrium is not achieved, carry out the measurement after a prescribed time from initiation of application of the specified voltage.
- (2) Use pulses, or carry out the measurements in a short time so that the temperature rise of the junction is negligible.

When pulses are used, clearly state the pulse width and duty cycle.

5.1.5 Items to be specified in detail specifications

- (1) Operating temperature T_{op}
- (2) Radiant power P_0

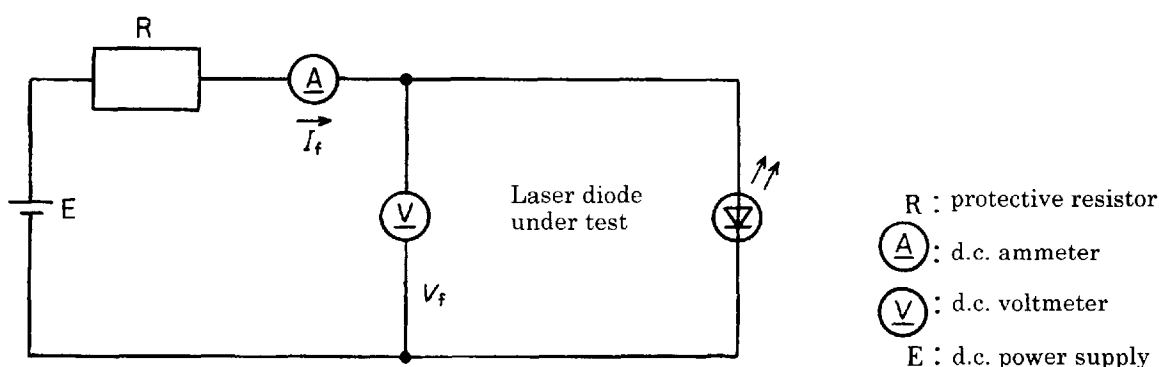


Fig.1 Measurements of forward current and forward voltage

5.2 Forward voltage (V_f)

5.2.1 Purpose The purpose is to measure forward voltages of laser diodes under the specified conditions.

5.2.2 Measuring circuit Carry out the measurement of forward voltages of laser di-

odes in the circuit of Fig. 1, in accordance with the method stated below.

5.2.3 Measuring method Pass the specified forward current I_f through the laser diode, and measure the forward voltage V_f at that time.

5.2.4 Precaution for measurement When the laser diode consumes fairly large power and the temperature rise of the junction due to this power consumption largely affects the measured values, carry out the measurement by either of the methods given below and clearly state the method.

- (1) Use a d.c. power supply and carry out the measurement after the thermal equilibrium has been achieved. If the thermal equilibrium is not achieved, carry out the measurement after a prescribed time from initiation of passing the specified current.
- (2) Use pulses, or carry out the measurement in a short time so that the temperature rise of the junction is negligible.

When pulses are used, clearly state the pulse width and duty cycle.

5.2.5 Items to be specified in detail specifications

- (1) Operating temperature T_{op}
- (2) Forward current I_f or radiant power P_o

5.3 Reverse voltage (V_r)

5.3.1 Purpose The purpose is to measure reverse voltages of laser diodes under the specified conditions.

5.3.2 Measuring circuit Carry out the measurement of reverse voltages of laser diodes in the circuit of, Fig. 2 in accordance with the method stated below.

5.3.3 Measuring method Pass the specified reverse current I_r through the laser diode, and measure the reverse voltage V_r at that time.

5.3.4 Precaution for measurement When the laser diode consumes fairly large power and the temperature rise of the junction due to the power consumption largely affects the measured values, carry out the measurement by either of the methods given below and clearly state the method.

- (1) Use a d.c. power supply and carry out the measurement after the thermal equilibrium has been achieved. If the thermal equilibrium is not achieved, carry out the measurement after a prescribed time from initiation of passing the specified current.
- (2) Use pulses or carry out the measurement in a short time so that the temperature rise of the junction is negligible.

When pulses are used, clearly state the pulse width and duty cycle.

5.3.5 Items to be specified in detail specifications

- (1) Operating temperature T_{op}
- (2) Reverse current I_r

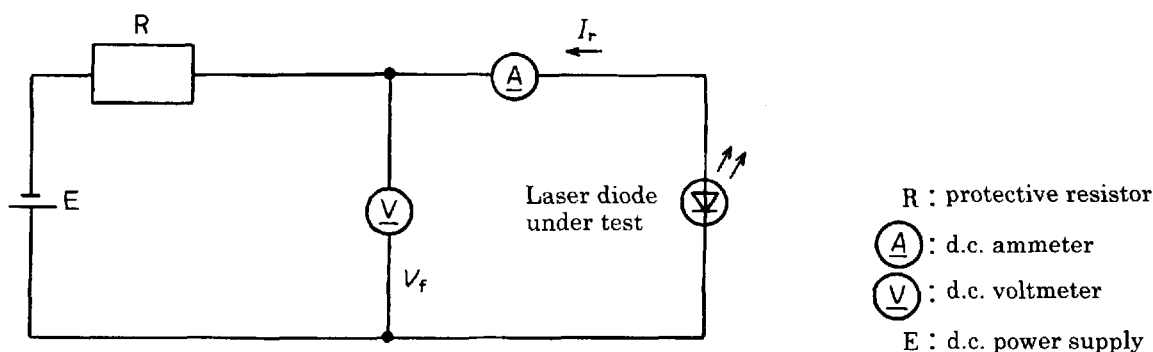


Fig. 2 Measurement of reverse voltage

5.4 Radiant power (P_o)

5.4.1 Purpose The purpose is to measure radiant powers of laser diodes under the specified conditions.

5.4.2 Measuring circuit Carry out the measurement of radiant powers of laser diodes in the circuit of Fig. 3, or Fig. 4, in accordance with the method stated below.

5.4.3 Measuring method Pass the specified forward current I_f through the laser diode and measure the radiant power P_o . The radiant power means that outputs from one end face.

5.4.4 Precaution for measurement The photo-receptive plane of the optical power meter shall be large enough so that the total quantity of light radiated from the laser diode can be received. Minimize the quantity of light returning from the photo-receptive part of optical power meter to the laser diode. An integrating sphere may be used instead of direct receiving of the output light from laser diode by the photo-receptive part. When an integrating sphere is used, the measuring device and the aperture shall be sufficiently small as compared with the surface of the integrating sphere. Further, the inside surface of integrating sphere and the screen shall be coated with a paint with a constant diffuse reflectivity (0.8 at the minimum).

5.4.5 Items to be specified in detail specifications

- (1) Operating temperature T_{op}
- (2) Forward current I_f

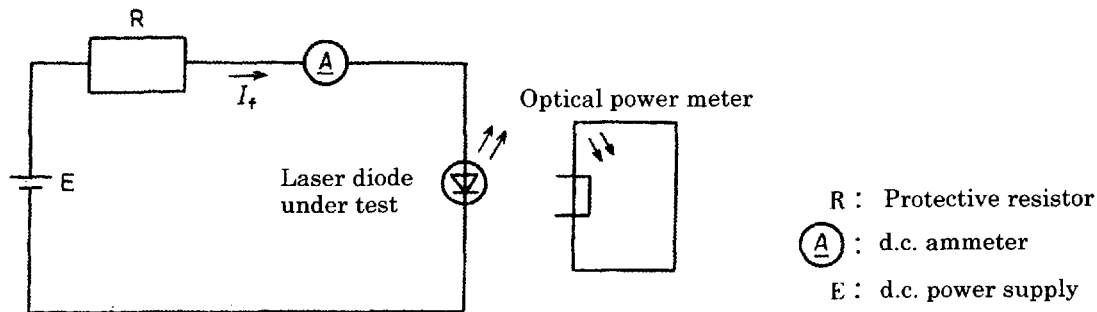


Fig. 3 Measurement of radiant power of laser diode

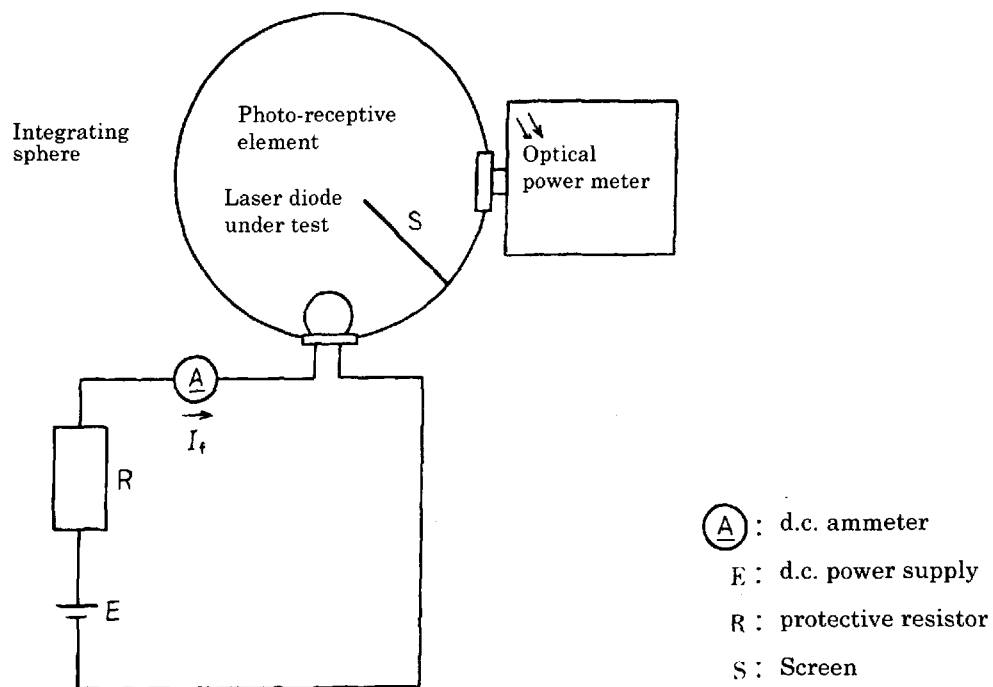


Fig. 4 Measurement of radiant power using integrating sphere

5.5 Threshold current (I_{th})

5.5.1 Purpose The purpose is to measure the threshold current of a laser diode under the specified conditions.

5.5.2 Measuring circuit Carry out the measurement of threshold current of laser diodes in the circuit of Fig. 3, in accordance with the method stated below.

5.5.3 Measuring method Record the forward current I_f and the radiant power P_o on an X-Y recorder, an oscilloscope, etc. while changing the forward current I_f passed through the laser diode. Calculate the threshold current by using one of the methods stated in (1) to (3).

- (1) **Method 1** Extend two straight line portions on the record of I_f - P_o curve as illustrated in Fig. 5, obtain the current at the intersection of the above lines and take it as the threshold current I_{th} .

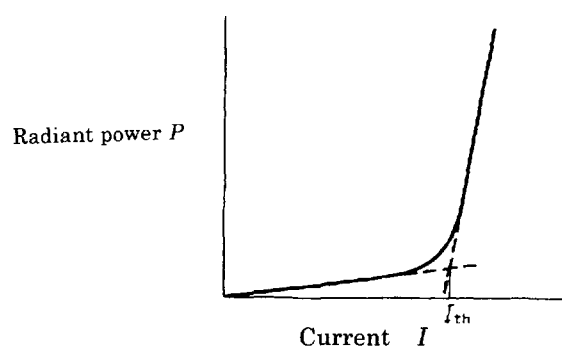


Fig. 5 I - P_o curve (method 1)

- (2) **Method 2** If application of the method (1) is difficult because the change in I_f - P_o characteristic is gradual, extend the straight line corresponding to the laser emission power, obtain the current at the intersection of the above straight line and X axis as illustrated in Fig. 6, and take it as the threshold current I_{th} .

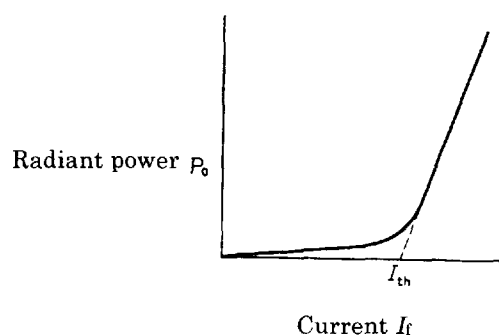
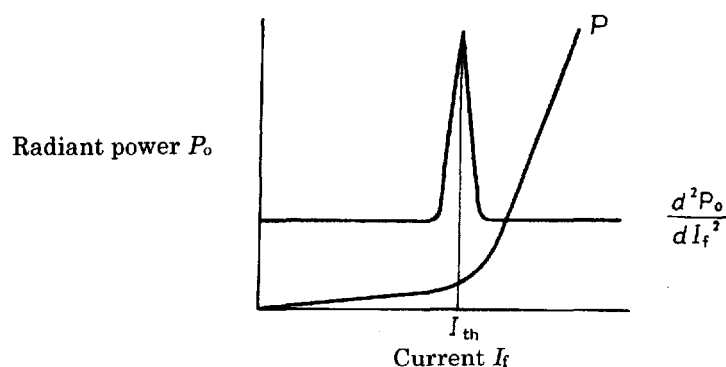


Fig. 6 I_f - P_o curve (method 2)

- (3) **Method 3** Obtain the quadratic differential of I_f - P_o curve, obtain the smallest current corresponding to the peak of the quadratic differential as illustrated in Fig. 7, and take this current as the threshold current I_{th} .

Fig. 7 I_f - P_o curve (method 3)

5.5.4 Precaution for measurement At the measurement, take care so that the quantity of light returning from the measuring system is minimized. Clearly state the method used for calculation of the threshold current.

5.5.5 Items to be specified in detail specifications

(1) Operating temperature T_{op}

5.6 Threshold radiant power (P_{th})

5.6.1 Purpose The purpose is to measure the threshold radiant power of a laser diode under the specified conditions.

5.6.2 Measuring circuit Carry out the measurement of threshold radiant power of laser diodes in the circuit of Fig. 3, in accordance with the method stated below.

5.6.3 Measuring method Pass a forward current I_f equal to the threshold current I_{th} through the laser diode, and measure the threshold radiant power P_{th} .

5.6.4 Precaution for measurement Use the method specified in 5.4 for measurement of radiant power.

5.6.5 Items to be specified in detail specifications

(1) Operating temperature T_{op}

(2) Threshold current I_{th}

5.7 Differential efficiency (η_d)

5.7.1 Purpose The purpose is to measure the differential efficiency of a laser diode under the specified conditions.

5.7.2 Measuring circuit Carry out the measurement of the differential efficiency of a

laser diode in the circuit of Fig. 3, in accordance with the method stated below.

5.7.3 Measuring method Record the forward current I_f and the radiant power P_o on an X-Y recorder, an oscilloscope, etc. while changing the forward current I_f passed through the laser diode, and calculate the efficiency by formula (1).

5.7.4 Precaution for measurement At the measurement, take care so that the quantity of light returning from the measuring system is minimized.

$$\eta_d = \frac{P_o - P_{th}}{I_f - I_{th}} \dots\dots\dots (1)$$

Where, η_d : differential efficiency (W/A)

I_{th} : threshold current (A)

I_f : specified forward current (or forward current to obtain specified radiant power) (A)

P_{th} : radiant power when I_{th} is passed (W)

P_o : radiant power when I_f is passed (or specified radiant power) (W)

Remarks : In the above expression, "a current higher than the threshold current but sufficiently lower than the operating current" may substitute for "threshold current" and "radiant power at a current higher than the threshold current but sufficiently lower than the operating current" may substitute for "radiant power when I_{th} is passed".

5.7.5 Item to be specified in detail specifications

(1) Operating temperature T_{op}

5.8 Mode spacing and number of longitudinal modes

5.8.1 Purpose The purpose is to measure the mode spacing and the number of longitudinal modes in laser diode emission under the specified conditions.

5.8.2 Measuring circuit Carry out the measurement of the mode spacing and the number of longitudinal modes in laser diode emission in the circuit of Fig. 8, in accordance with the method stated below.

5.8.3 Measuring method Pass the specified forward current I_f or a forward current I_f by which the specified radiant power is obtained, through the terminals of a laser diode and obtain the spectrum (see Fig. 9) by using the optical spectrum analyzer.

Obtain the spacing in wavelength for two neighboring modes (mode spacing), and count the number of peaks with a level larger than the specified ratio to the maximum peak (number of longitudinal modes) from the spectrum so obtained.