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General rules 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 5940:1989 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.

This Standard contains Annexes stated as follows:

- Annex 1 (informative) Form of detail specification of laser diodes for fiber optic transmission
- Annex 2 (informative) Form of detail specification for environmental test and endurance test of laser diodes for optic transmission
- Annex 3 (informative) Marking on electrostatic sensitive device

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General rules 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 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, IEC 747-5 Amendment 1 issued in 1994 and IEC 747-5 Amendment 2 issued in 1995, without any modification in technical contents.

1 Scope This Japanese Industrial Standard specifies such general common matters as terms, classification, maximum ratings and performances for laser diodes for fiber optic transmission (excluding ones accommodated in electronic circuits; hereafter referred to as “laser diodes”) used as the light source.

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

JIS C 0301 *Graphical symbols for electrical apparatus*

JIS C 5941 *Test methods of laser diodes for fiber optic transmission*

JIS Z 8202 *Quantity symbols, unit symbols and chemical symbols*

JIS Z 8203 *SI units and the use of their multiples and of certain other units*

2 The International Standard corresponding to this Standard is shown below:

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

IEC 747-5 : 1994 Amendment 1

IEC 747-5 : 1995 Amendment 2

2 Definitions For the purpose of this Standard, the following principal definitions apply:

- (1) **absolute maximum rating** The limit value which shall not be exceeded even for an instant. Any one of the specified values shall not be exceeded.
- (2) **storage temperature (T_{stg})** The allowable range of ambient temperature at which laser diodes are stored without the supply voltage and input signal applied.
- (3) **ambient temperature (T_a)** The temperature of the atmosphere on which laser diodes are located.

- (4) **operating temperature** (T_{op}) The ambient temperature ($T_{op(a)}$) or the case temperature ($T_{op(c)}$) at which the operation of diodes is ensured under the specified voltage or current.
- (5) **threshold current** (I_{th}) The current at which a diode starts laser oscillation through stimulated emission.
- (6) **radiant power** (P_o) The optical power which can be taken out from the optical output end. In some cases NA for measurement is specified.
- (7) **operating current** (I_{op}) The forward current at which the specified radiant power is available.
- (8) **operating voltage** (V_{op}) The forward voltage at which the specified radiant power is available.
- (9) **radiant power at threshold** (P_{th}) The radiant power at the threshold current.
- (10) **differential efficiency** (η_d) Regarding to the radiant power from fiber end at the operating current, and that at the threshold current or a current higher than the threshold current but sufficiently lower than the operating current, this term means the quotient of the difference in radiant power by the difference in current.
- (11) **longitudinal mode** The individual oscillation spectrum when spectra of oscillation modes which propagate along an optical axis exist discretely. When the oscillation is performed in one longitudinal mode, such case is especially called single longitudinal mode oscillation.
- (12) **mode spacing** The difference in wavelength for two neighboring longitudinal modes.
- (13) **number of longitudinal modes** The total number of longitudinal modes. In general, a certain ratio to the peak is determined and the modes which have a strength not less than the ratio are counted.
- (14) **peak emission wavelength** (λ_p) The wavelength at which the laser emission is the maximum.
- (15) **central emission wavelength** (λ_c) The central wavelength in an emission spectrum, which is obtained by one of the following measuring methods:
 - (a) **Envelope method** The average wavelength of the longest wavelength and the shortest wavelength at cross points when the peaks of individual longitudinal mode are connected by an envelope and the envelope crosses a value having a specified ratio to the maximum peak.
 - (b) **N-dB method** The average wavelength of the longest emission wavelength of longitudinal mode and the shortest emission wavelength of longitudinal mode at two points on both sides of the peak-emission wavelength where the radiant power shows the specified ratio to the peak.
 - (c) **RMS method** The wavelength obtained from the optical level of n -th longitudinal mode (A_n) and the emission wavelength (λ_n) by means of the following equation:

$$\lambda_c = \Sigma(A_n \times \lambda_n) / \Sigma A_n$$

- (16) **spectrum bandwidth** ($\Delta\lambda_w$) The spread of emission spectrum, which is obtained by one of the following methods:
- (a) **Envelope method** The difference between the wavelength on longer side and the wavelength on shorter side at the cross points when the peaks of individual longitudinal mode are connected by an envelope and the envelope crosses a value having a specified ratio to the maximum peak.
 - (b) **N-dB method** The width between two cross points of a spectrum when the spectrum crosses a radiant power having a specified ratio to the maximum peak of a longitudinal mode (for single-mode emission) ; or the difference between the longest wavelength and the shortest wavelength from among the longitudinal modes emitted at a radiant power having a specified ratio or more to the maximum peak of longitudinal modes (for multimode emission). The width obtained relating with the emission spectrum equal to 50 % of the maximum peak is called spectral half width ($\Delta\lambda$).
 - (c) **RMS method** The width of wavelength obtained from the optical level of n -th longitudinal mode (A_n) and the emission wavelength (λ_n) by means of the equation stated below.

The K is a constat which shall be selected according to the purpose (from 1, 2, 2.35 and 3) and clearly stated (if 2.35 is selected the bandwidth corresponds the spectral half-width when the shape of spectrum is considered as Gaussian distribution).

$$\Delta\lambda_w = K \times \sqrt{\frac{\Sigma[A_n \times (\lambda_n - \lambda_c)^2]}{\Sigma A_n}}$$

- (17) **emission source seize width and height** ($W_{\perp}$, $W_{//}$) The distance between two points (full width half maximum) where the distribution of optical power is 50 % of the peak value in the direction perpendicular to ($\perp$) or parallel to ($//$) the pn junction plane at the optical output end of laser diode.
- (18) **half-intensity angle in two specified planes** ($\theta_{\perp}$, $\theta_{//}$) The angular difference between two points (full angle half maximum) where the angular distribution of optical power is 50 % of the peak value in a plane perpendicular to ($\perp$) or parallel to ($//$) the pn junction plane in an optical power distribution emitted from a laser diode (called field pattern sometimes).
- (19) **polarization ratio** (P_1) The ratio of the optical power of linearly polarized light component parallel to the pn junction plane to that perpendicular to the said face.
- (20) **side-mode suppression ratio (SMSR)** This is the parameter which shows the uniqueness of longitudinal mode of the laser emitted mainly in longitudinal mode such as DFB laser, and expressed by the ratio in spectral intensity of the largest mode (main mode) to the second large mode (side mode).
- (21) **spectral linewidth** ($\Delta\lambda_L$) The width of wavelength spread in a spectral line at single longitudinal mode emission. This means the width between two points in a

spectral line at which the optical power is a value equal to a specified ratio to the maximum value of the spectrum, and usually expressed by the frequency.

- (22) **rise time (t_r)** The time necessary for an optical output pulse to increase from 10 % to 90 % of the maximum value ⁽¹⁾.
- (23) **fall time (t_f)** The time necessary for an optical output pulse to decrease from 90 % to 10 % of the maximum value ⁽¹⁾.
- (24) **turn-on time (t_{on})** The necessary time interval for increasing from 10 % of the maximum value of applied current pulse to 90 % of the maximum value ⁽¹⁾ of output optical pulse.
- (25) **turn-off time (t_{off})** The necessary time interval for decreasing from 90 % of the maximum value of applied current pulse to 10 % of the maximum value ⁽¹⁾ of output optical pulse.
- (26) **turn-on delay time ($t_{d(on)}$)** The necessary time interval for increasing from 90 % of the maximum value of applied current pulse to 90 % of the maximum value ⁽¹⁾ of output optical pulse.
- (27) **turn-off delay time ($t_{d(off)}$)** The necessary time interval for decreasing from 90 % of the maximum value of applied current pulse to 90 % of the maximum value ⁽¹⁾ of output optical pulse.

Note⁽¹⁾ The maximum value means the stationary value after transition oscillations.

- (28) **cut-off frequency (f_c)** The frequency at which the amplitude of a sinusoidal modulated radiant power produced by modulation with small sinusoidal signal at the specified bias point decreases by 3 dB, from that in low frequency region where the characteristic curve is sufficiently flat.
- (29) **relative intensity noise (RIN)** The ratio of the intensity of optical noise to the average radiant power per unit frequency. The fluctuation of light can be measured and calculated using such photo-receptive element as photodiode and an amplifier, therefore this is practically obtained in such a manner that the Shotky noise of photo-receptive element and the thermal noise of amplifier are eliminated from the noise measured at a specified frequency and the quotient of the remainder so obtained by the average output of laser diode (detected by photoelectric current of photo-receiver in general) and the measurement frequency bandwidth is calculated.
- (30) **higher harmonic distortion (D_n)** This means the electric power of n-th higher harmonic which appears when a laser diode is directly modulated (analog modulation) by a sinusoidal signal expressed in the ratio to the electric power of the sinusoidal signal.
- (31) **composite second-order distortion (CSO)** When a laser diode is directly modulated (analog modulation) by multi-channel sinusoidal signals of the same electric power and frequencies arranged systematically, second-order intermodulation distortions appear. This term means the ratio of total electric power of such distortions to the electric power of the sinusoidal signals.

tions appearing on the same frequency to the electric power of the sinusoidal signal of the neighboring one channel. However, this term often designates the maximum value of distortion for one channel within its image band.

- (32) **composite tripple-beat distortion (CTB)** When a laser diode is directly modulated (analog modulation) by multi-channel sinusoidal signals of the same electric power and frequencies arranged systematically, tripple-beat intermodulation distortions appear. This term means the ratio of total electric power of such distortions appearing on the same frequency to the electric power of the sinusoidal signal of the neighboring one channel. However, this term often designates the maximum value of distortion for one channel within its image band.
- (33) **carrier to noise ratio (C/N)** The ratio of average value of a radiant power to the magnitude of fluctuation of the radiant power.
- (34) **monitor current (I_m)** The current which is obtained by carrying out photo-electric transfer of a monitor radiant power.
- (35) **dark current of monitor photodiode (I_d)** The current which flows through output part of optical monitor when the laser diode is not emitted.
- (36) **monitor photodiode capacitance (C_i)** The capacitance between terminals of a photodiode.
- (37) **rise time of monitor photodiode (t_{rpd})** The time necessary for the output pulse current of photodiode to increase from 10% to 90 % of the maximum value.
- (38) **fall time of monitor photodiode (t_{fpd})** The time necessary for the output pulse current of monitor photodiode to decrease from 90 % to 10 % of the maximum value.
- (39) **tracking error (E_r)** Under operating state of APC (automatic power control) utilizing monitor photodiode accommodated in a laser diode system, the radiant power at a specific temperature is denoted as P_{01} and the radiant power with maximum deviation which appears when the temperature is varied through a specified case or ambient temperature range is denoted as P_{02} . This term means the ratio of P_{01} and P_{02} . Otherwise, the ratio of the maximum radiant power and the minimum radiant power when the temperature is varied through a specified case or ambient temperature range under the said operating state of APC.

3 Detail specifications When the ratings, performances, outline, etc. of individual laser diode are specified based on this Standard, they shall be specified in the detail specification.

4 Graphical symbols The graphical symbols for use in this Standard shall be as specified in JIS C 0301.

The unit symbols shall be as specified in JIS Z 8202 and JIS Z 8203.

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5 **Classification** Laser diodes are classified as given in Table 1.

Table 1 Classification of laser diodes

Classification item		Kinds
Major item	Minor item	
Crystal material	—	Aluminum gallium arsenic/gallium arsenic (AlGaAs/GaAs), Indium gallium arsenic phosphorus/indium phosphorus (InGaAsP/Inp), etc.
Wavelength band	—	800 nm band, 1 300 nm band, 1 550 nm band, etc.
Element construction	Junction construction	Double hetero(DH) junction, separate confinement hetero junction, quantum well structure, etc.
	Stripe construction	Gain waveguide type, refraction waveguide type, etc.
	Feedback construction	Cleavage plane reflection type, distributed feedback type, distributed Bragg reflection type, etc.
Package construction	Optical output construction	Optical output window type, open type, etc.
	Monitor output construction	Without monitor, back beam type, accommodated photodiode type, etc.
	Terminal construction	TO type, chip carrier type, etc.
Use for	—	Low speed, high speed, long distance communication, medium and short communication, digital, analog, etc.