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General rules of photodiodes 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 5990 : 1988 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 photodiodes for fiber optic transmission (other than APD)
- Annex 2 (informative) Form of detail specification of photodiodes for fiber optic transmission (APD)
- Annex 3 (informative) Form of detail specifications for environmental test and endurance test of photodiodes for fiber optic transmission

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General rules of photodiodes 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, and **IEC 747-5 Amendment 1** issued in 1994 without any modification in technical contents.

1 Scope This Japanese Industrial Standard specifies such general common matters as terms, symbols, classification, maximum ratings and performances for photodiodes for fiber optic transmission (excluding ones accommodated in an electronic circuit; hereafter referred to as “photodiodes”).

Remarks : The International Standard corresponding to this Standard is given below.

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

IEC 747-5 : 1994 Amendment 1

2 Normative references The following normative references contain provisions which, through reference in this Standard constitute provisions of this Standard. The most recent editions of the normative references shall apply.

JIS C 0301 *Graphical symbols for electrical apparatus*

JIS C 5991 *Test methods of photodiodes for fiber optic transmission*

3 Definitions For the purpose of this Standard, the following principal definitions (symbols) apply:

- a) **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.
- b) **storage temperature** (T_{stg}) The allowable ambient temperature at which photodiodes are stored without the supply voltage and input signal applied.
- c) **ambient temperature** (T_{a}) The temperature of the atmosphere in which photodiodes are located.
- d) **case temperature** (T_{c}) The temperature of the case at a specified position.
- e) **operating temperature** (T_{op}) The ambient temperature ($T_{\text{op(a)}}$) or the case temperature ($T_{\text{op(c)}}$) at which the operation of diodes is ensured under the specified voltage or current.
- f) **reverse dark current** (I_{d}) The current which flows when the specified reverse voltage is applied to photodiodes without incident light.

- g) **breakdown voltage** ($V_{(BR)}$) When a reverse voltage is applied to a photodiode and then increased, the current increases rapidly due to avalanche cumulative multiplication. This term means the voltage when a specified reverse current is passed in such a region.

Remarks : The avalanche cumulative multiplication means a phenomenon of rapid current increase due to rapid repetition of such a process that electrons or positive holes, as a carrier, are inversely biased, catches large energy when they pass through the space-charge layer of very strong electric field and produces positive-hole pairs due to ionization by collision with atoms which compose the crystal.

- h) **responsivity** (S) The output current per unit input optical power at a specified wavelength.
- i) **rise time** (t_r) The time necessary for the electrical output signal to rise from 10 % to 90 % of its maximum value when the optical input pulse is applied.
- j) **fall time** (t_f) The time necessary for the electrical output signal to fall from 90 % to 10 % of its maximum value when the optical input pulse is removed.
- k) **turn-on time** (t_{on}) The necessary time interval for increasing from 10 % of the maximum value of input optical pulse to 90 % of the maximum value of output electrical signal.
- l) **turn-off time** (t_{off}) The necessary time interval for decreasing from 90 % of the maximum value of input optical pulse to 10 % of the maximum value of output electrical signal.
- m) **turn-on delay time** ($t_{d(on)}$) The time necessary for the output electrical signal corresponding to the optical input pulse to increase up to 10 % of the maximum value from the instant when the optical input pulse is 10 % of its maximum value.
- n) **turn-off delay time** ($t_{d(off)}$) The time necessary for the output electrical signal corresponding to the optical input pulse to decrease down to 90 % of the maximum value from the instant when the optical input pulse is 90 % of its maximum value.
- o) **total capacitance** (C_{tot}) The capacitance between anode and cathode under the specified reverse voltage and frequency.
- p) **multiplication factor** (M) The ratio of the output photocurrent resulted from avalanche cumulative multiplication, to the output photocurrent at a voltage region where the avalanche cumulative multiplication is negligible.
- q) **excess noise factor** (F_e) The factor which expresses the magnitude of the noise due to the fluctuation of ionization that appears during avalanche cumulative multiplication process.

Remarks : The excess noise factor is sometimes expressed by the excess noise index x which is expressed by the following formula:

$$F_e = M^x$$

where, F_e : excess noise factor
 M : multiplication factor
 x : excess noise index

- r) **cut-off frequency (f_c)** The frequency at which the amplitude of sinusoidal output signal decreases from that in low frequency region where the amplitude is sufficiently flat, by 3 dB, when a small sinusoidal signal of magnitude modulated light is introduced.
- s) **irradiance (E_e)** The input optical power per unit area of photoreceptive plane.
- 4 Detail specification** The detail specification shall specify the absolute maximum ratings, performances, external dimensions, etc. of individual photodiode.
- 5 Graphical symbol** The graphical symbols shall be as specified in JIS C 0301.
- 6 Classification** Photodiodes are classified as shown in Table 1.

Table 1 Classification of photodiodes

Classification item		Classification
Major item	Minor item	
Crystal material	—	Silicon (Si), germanium (Ge), indium-gallium-arsenic (InGaAs), indium-gallium-arsenic-phosphorus (InGaAsP), etc.
Wavelength band	—	600 nm band, 800 nm band, 1 300 nm band, 1 500 nm band, etc.
Element structure	—	PIN type, APD type, Schottky barrier type, PN type
Package structure	Structure of optical input end	Optical input window type, optical-fiber pigtail type, optical connector type, open type, etc.
	Structure of terminal	TO type, pill type, etc.
Usage	—	For low speed, high speed, multi-mode optical fiber, single-mode optical fiber, etc.

- 7 Maximum ratings** The maximum rating of photodiode means the absolute maximum rating. The maximum ratings to be specified shall be as prescribed in the form of detail specification shown in Annex 1 or Annex 2. The values given in Tables 2 to 4 are recommended as the standard values.

Table 2 Storage temperature (T_{stg})

Unit : °C

Lower limit value	-10	-20	-30	-40	-50	-55	-60	-65	
Upper limit value	50	60	70	80	85	90	100	125	150

Table 3 Operating temperature (T_{op})

Unit : °C

Lower limit value	-10	-20	-30	-40	-50	-55	-60	-65		
Upper limit value	40	50	60	70	80	85	90	100	125	150

Table 4 Forward current (I_F), reverse current (I_R), reverse voltage (V_R)

Forward current, reverse current, reverse voltage $\times 10^n$ A, V	1	1.25	1.5	2	2.5	3	4	5	6	7	8	9
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- Remarks 1 The n is an integer.
- 2 Unless otherwise specified, the operating temperature is 25 °C.

8 Performances

8.1 Electrical and optical characteristics Electrical and optical characteristics of photodiodes shall be specified by the items shown in the form of detail specification given in Annex 1 or 2.

The values shown in Tables 5 and 6 are recommended for the voltage, current, input optical power and frequency of repetition to be given as the measuring conditions of characteristics.

Table 5 Voltage, current and optical input power to be given as test conditions used as basis of specifying characteristics

Voltage, current and optical input power $\times 10^n$ A, V, W	1	1.25	1.5	2	2.5	3	4	5	6	7	8	9
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- Remarks : The n is an integer.

Table 6 Frequency of repetition to be given as test conditions used as basis of specifying characteristic

Frequency of repetition $\times 10^n$ Hz	1	1.25	1.5	2	2.5	3	4	5	6	7	8	9
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- Remarks 1 The n is an integer.
- 2 A frequency of repetition other than that mentioned above may be used for operating characteristics.

8.2 Performances referring to environment and endurance The performances referring to environment and endurance shall satisfy the informative reference given in Annex 3.

9 Measurements Unless otherwise specified, the measurements of photodiodes shall be as specified in JIS C 5991.