MITSUBISHI 1992
OPTOELECTRONICS

OPTICAL SEMICONDUCTOR DEVICES and OPTICAL-FIBER COMMUNICATION SYSTEMS

DATA BOOK

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OPTICAL SEMICONDUCTORS COMPONENTS GUIDANCE

1

Ordering Information

ML 7 76B 1 F

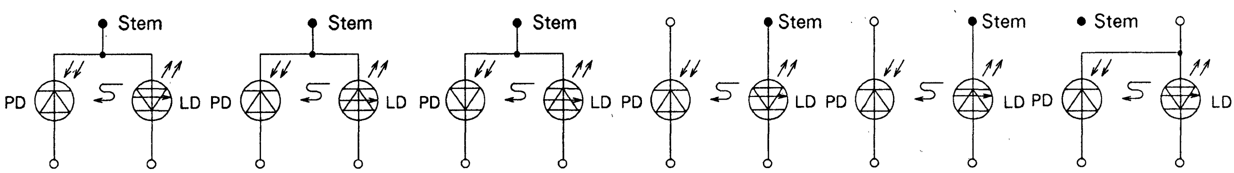
- ML — Device type (ML : Laser diode; ME : Light emitting diode; PD : Photodiode)
- 7 — Wavelength code*2
- 76B — Package type (old = 2digits, new = 3digits)*1
- 1 — Chip series No.
- F — Pin connection*3 (fixed only to the monitor PD incorporated laser diode)

*1 Applicable from Jan. 1991.
*2 Wavelength code classification

Device type	Wavelength code	Wavelength range (nm)
ML	2 3 5	800 < λ ≦ 900
	4 6	700 < λ ≦ 800
	7	1250 < λ ≦ 1400
	8	900 < λ ≦ 1250
	9	1400 < λ

Device type	Wavelength code	Wavelength range (nm)
ME	1	700 < λ ≦ 900
	7	1250 < λ ≦ 1400
PD	1 2	500 < λ ≦ 900
	7 8	1000 < λ ≦ 1600

*3 Pin connection (for Laser)

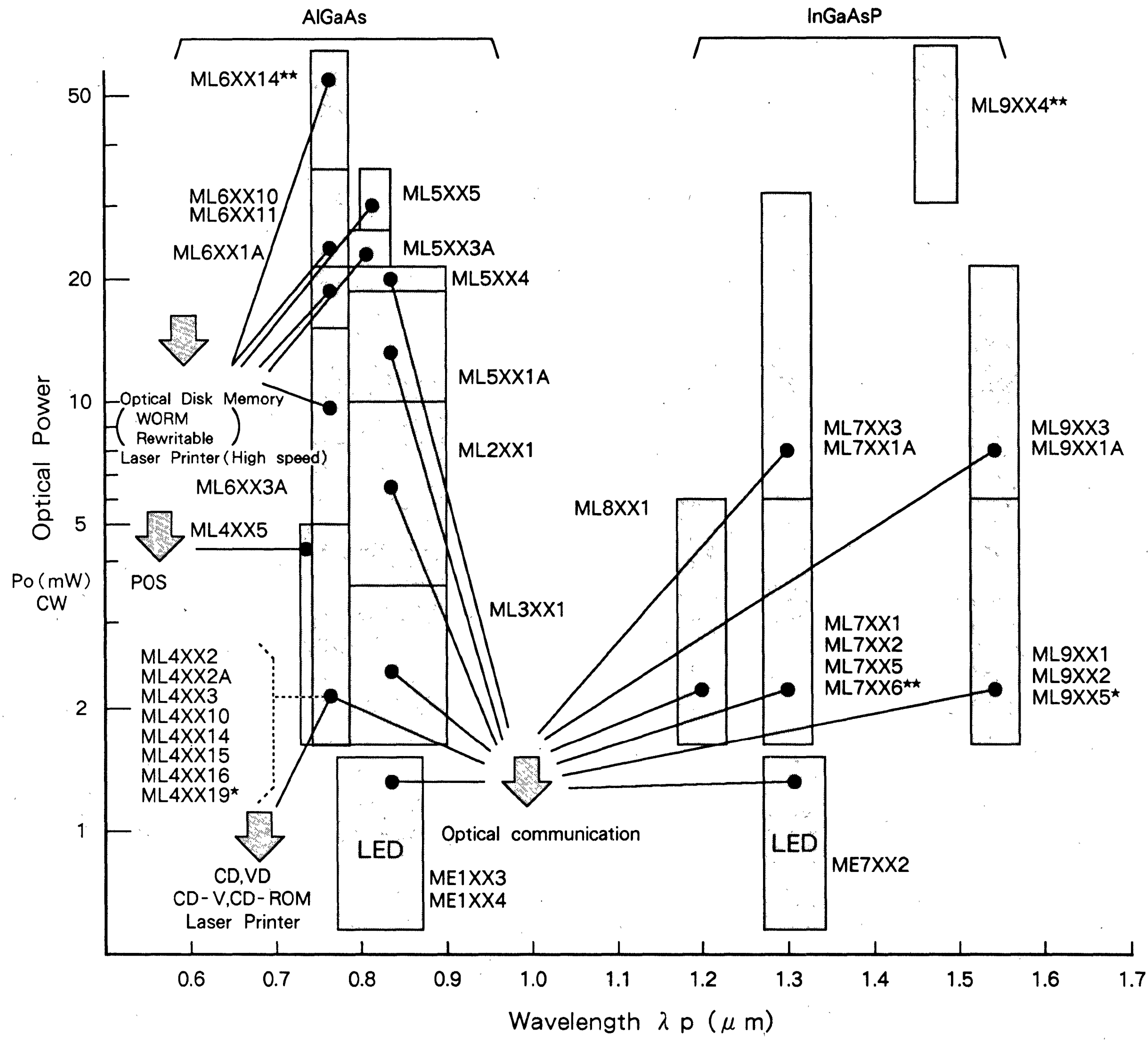


N type (LD : Anode Common, PD : Cathode Common)
C type (LD : Cathode Common, PD : Cathode Common)
R type (LD : Cathode Common, PD : Anode Common)
F type (LD : Anode Common, PD : Floating)
E type (LD : Cathode Common, PD : Floating)
S type (LD : Floating, PD : Floating)

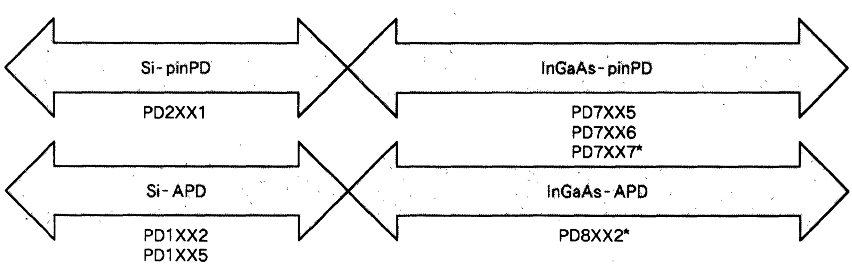
Application Diagram

(★New product ★★Under development)

Laser Diode (LD)
Light Emitting Diode (LED)

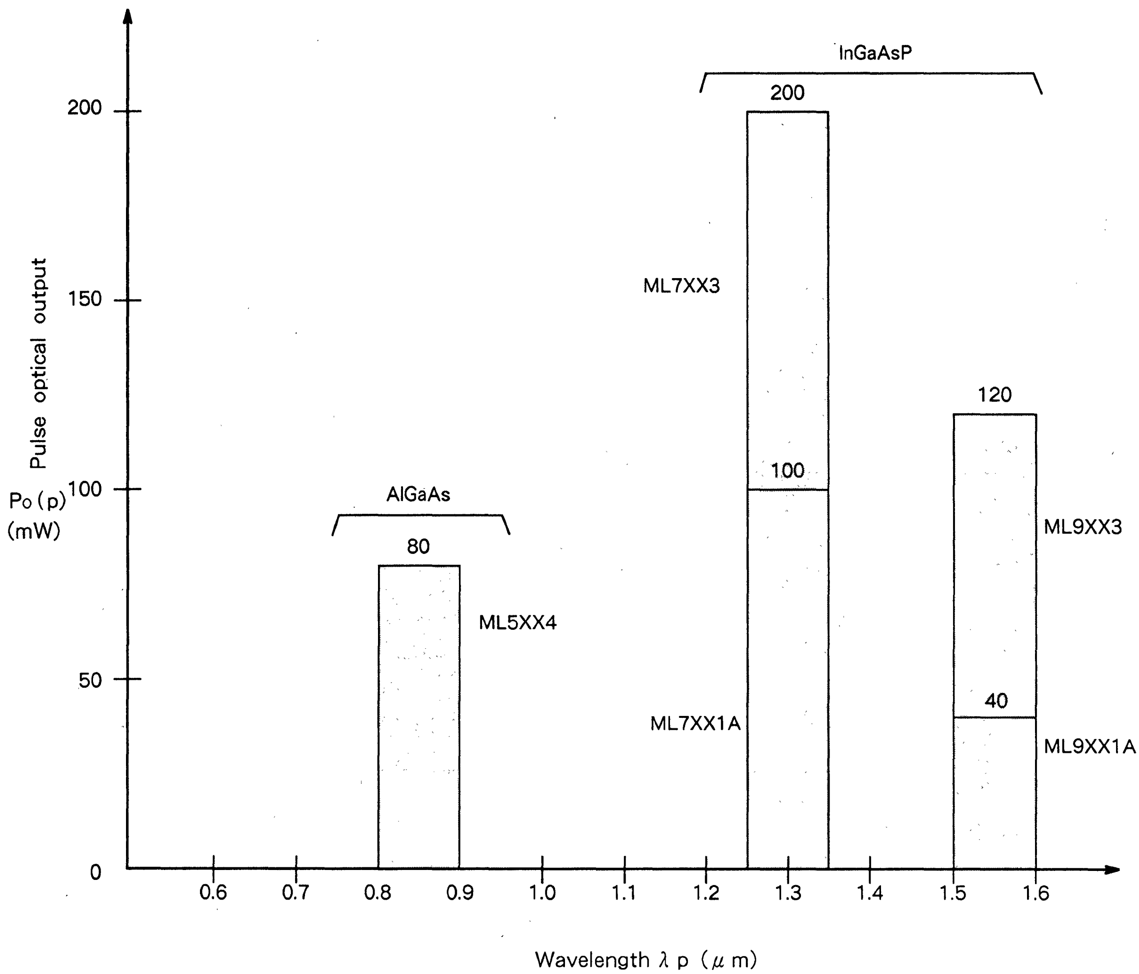


High Responsivity Photodiode (pinPD, APD)



Application Diagram

Laser diodes for OTDR applications



ML5XX4 .... Pulse width 2 μ s, duty 0.2 %

ML7XX1A, ML7XX3, ML9XX1A, ML9XX3 } .... Pulse width less than 1 μ s, duty less than 1 %

Index by Application

[Application]	[Main use]	[Wavelength typ. (nm)]	[Rated optical output (Forward current)]	[Series name (Features・Structure)]
Information processing & instrumentation	Laser beam printer	780	P_O = 5mW	ML4XX3 (low droop)
				ML4XX14 (low droop, small dispersion)
			P_O = 8mW	ML4XX19* (medium output, small dispersion)
			P_O = 15mW	ML6XX3A (higher output, for high-speed machine)
	OTDR	850	$P_{O(p)}$ = 80mW	ML5XX4 (pulse high output operation)
		1310	$P_{O(p)}$ = 100mW	ML7XX1A (pulse high output operation)
			$P_{O(p)}$ = 200mW	ML7XX3 (pulse high output operation)
		1550	$P_{O(p)}$ = 40mW	ML9XX1A (pulse high output operation)
			$P_{O(p)}$ = 120mW	ML9XX3 (pulse high output operation)
	POS	750	P_O = 5mW	ML4XX5 (shortwave length)
	ODD	780	P_O = 5mW	ML4XX15 (read only)
			P_O = 20mW	ML6XX1A (for mass-produced machine)
			P_O = 35mW	ML6XX10 (small dispersion)
				ML6XX11 (low Iop, small dispersion)
			P_O = 60mW	ML6XX14** (low Iop)
		830	P_O = 25mW	ML5XX3A (for mass-produced machine)
			P_O = 35mW	ML5XX5 (small dispersion)

★ : New product
★★ : Under development

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Index by Application

[Application]	[Main use]	[Wavelength typ.(nm)]	[Rated optical output (Forward current)]	[Series name (Features • Structure)]
Communication	Transmitter	780	Po = 5mW	ML4XX10 (higher reliability, multi-mode)
				ML4XX16 (higher reliability, pulsation)
		850	Po = 3.5mW	ML3XX1 (higher reliability)
			Po = 10mW	ML2XX1 (higher reliability)
			(If = 75mA)	ME1XX3 (AlGaAs-LED, φ 100 μm lens)
				ME1XX4 (AlGaAs-LED, φ 200 μm lens)
		1200	Po = 6mW	ML8XX1 (high-temperature operation, FP-LD)
		1310	Po = 6mW	ML7XX1, ML7XX6** (high-temperature operation, FP-LD)
				ML7XX2 (for digital use, DFB-LD)
			Po = 12mW	ML7XX5 (for analog use, DFB-LD)
			(If = 120mA)	ME7XX2 (InGaAsP LED)
		1550	Po = 6mW	ML9XX1 (high-temperature use, FP-LD)
				ML9XX2 (for digital use, DFB-LD)
			Po = 12mW	ML9XX5* (for analog use, DFB-LD)
	Receiver	600~900		PD1XX2 (φ 200 μm Si-APD)
				PD1XX5 (φ 500 μm Si-APD)
				PD2XX1 (□500 μm Si-pinPD)
		1000~1600		PD7XX5 (φ 80 μm InGaAs-pinPD)
				PD7XX6 (φ 300 μm InGaAs-pinPD)
				PD7XX7* (φ 40 μm InGaAs-pinPD)
				PD8XX2* (φ 50 μm InGaAs-APD)
	Fiber Amplifier	1480		ML9XX4** (high power, high reliability)

★ : New product
★★ : Under development

■ AlGaAs Laser Diodes :

Mitsubishi laser diodes are high-performance light sources that offer extremely stable single-mode oscillation with a low threshold current. High reliability and long-service life make these devices suitable for use in a broad range of applications, including such areas as optical communications and optical data processing.

Type	Material	Max. Ratings				@Po (mW)	Ith (mA)		Iop (mA)		Vop (V)		λp (nm)			θ// (deg)	θ⊥ (deg)	Im ※3 (mA)		
		Po CW (mW)	Po※1 Pulse (mW)	Tc (℃)	Tstg (℃)		Typ.	Max.	Typ.	Max.	Typ.	Max.	Min.	Typ.	Max.	Typ.	Typ.	Min.	Typ.	Max.
ML2XX1	AlGaAs	10	15	−40 ~ +70	−55 ~ +100	8	30	50	55	90	1.8	2.5	830	850	870	12	35	0.3	0.8	2.0
ML3XX1	AlGaAs	3.5	6	−40 ~ +60	−55 ~ +100	3	20	40	30	50	1.8	2.5	830	850	870	11	30	0.1	0.3	0.7
ML4XX2	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	30	60	40	70	1.8	2.5	765	780	795	11	33	0.15	0.35	0.7
ML4XX2A	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	40	60	50	70	1.8	2.5	765	780	795	11	33	0.15	0.4	0.7
ML4XX3	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	35	60	50	85	1.8	2.5	765	780	795	11	33	0.4	1.0	2.0
ML4XX5	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	35	70	45	80	2.0	3.0	735	750	765	11	33	0.15	0.35	0.7
ML4XX10	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	45	60	53	70	1.8	2.5	765	780	800	11	33	0.15	0.4	0.7
ML4XX14	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	30	50	50	70	2.0	2.5	765	780	795	11	33	0.25	1.0	2.0
ML4XX15	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	45	60	58	70	1.8	2.5	765	780	795	11	38	0.15	0.35	0.7
ML4XX16	AlGaAs	5	6	−40 ~ +60	−55 ~ +100	3	45	70	55	80	1.8	2.5	765	780	800	11	38	0.15	0.4	0.7
ML4XX19★	AlGaAs	8	−	−40 ~ +60	−55 ~ +100	5	30	50	45	70	2.0	2.5	765	780	795	11	33	0.3	0.7	1.7
ML5XX1A	AlGaAs	18	30	−40 ~ +50	−55 ~ +100	15	30	50	60	90	1.8	2.5	830	850	870	11	30	0.5	1.0	3.0
ML5XX3A	AlGaAs	25	−	−40 ~ +60	−55 ~ +100	10	40	60	65	100	2.0	2.5	800	820	840	12	30	0.3	0.8	1.7
ML5XX4	AlGaAs	20	※2 450	−40 ~ +50	−55 ~ +100	15	25	50	50	90	1.8	2.5	830	850	870	11	30	0.04	0.12	1.0
ML5XX5	AlGaAs	35	45	−40 ~ +60	−55 ~ +100	30	50	70	125	150	2.0	2.5	810	825	840	11	26	2.0	4.0	6.0
ML6XX1A	AlGaAs	20	25	−40 ~ +60	−55 ~ +100	10	40	60	65	100	2.0	2.5	765	780	795	12	30	0.3	0.8	1.7
ML6XX3A	AlGaAs	15	−	−40 ~ +60	−55 ~ +100	10	40	60	65	100	2.0	2.5	765	780	795	12	30	0.3	0.8	1.7
ML6XX10	AlGaAs	35	45	−40 ~ +60	−55 ~ +100	30	70	85	140	160	2.0	2.5	770	785	800	10.5	26.5	1.0	3.0	6.0
ML6XX11	AlGaAs	35	45	−40 ~ +60	−55 ~ +100	30	60	75	120	135	2.0	2.5	770	785	800	10.5	26.5	−	0.9	−
ML6XX14★★	AlGaAs	60	70	−40 ~ +60	−55 ~ +100	50	55	−	135	−	2.0	2.5	770	785	800	9.5	25	−	0.3	−

※1 : Duty less than 50 %, pulse width less than 1 μs. ※2 : Forward current max. rating, duty = 1 %, pulse width less than 4 μs.
※3 : Im value depends on package type.

★ : New Product ★★ : Under development

■ InGaAsP Laser Diodes

Type	Material	Max. Ratings Po CW (mW)	Po※1 Pulse (mW)	Tc (°C)	Tstg (°C)	@Po (mW)	Ith (mA)		Iop (mA)		Vop (V)		λp (nm)			θ// (deg)	θ⊥ (deg)	Im ※3 (mA)			SMSR @Po (dB)	
							Typ.	Max.	Typ.	Max.	Typ.	Max.	Min.	Typ.	Max.	Typ.	Typ.	Min.	Typ.	Max.	Min.	Typ.
ML7XX1	InGaAsP	10	10	−20 ~ +70	−40 ~ +100	5	10	30	25	50	1.2	1.6	1280	1300	1330	25	30	0.2	0.5	−	−	−
ML7XX1A	InGaAsP	30	※2 400mA	−20 ~ +50	−40 ~ +100	25	10	30	70	130	1.5	2.0	1280	1310	1330	25	30	0.2	0.5	−	−	−
ML7XX2	InGaAsP (DFB laser)	6	−	0 ~ +60	−40 ~ +100	5	15	40	30	80	1.2	1.8	−	1310	−	25	30	0.1	0.25	−	30	40
ML7XX3	InGaAsP	30	※2 900mA	+20 ~ +30	−40 ~ +100	25	20	50	80	150	1.5	2.0	1280	1310	1330	25	30	0.1	0.2	−	−	−
ML7XX5	InGaAsP (DFB laser)	20	−	+20 ~ +30	−40 ~ +100	10	15	40	45	80	1.2	1.8	−	1310	−	25	30	−	−	−	30	40
ML7XX6**	InGaAsP	Not specified (under development)																				
ML8XX1	InGaAsP	6	10	−20 ~ +70	−40 ~ +100	5	15	30	30	60	1.2	1.6	1180	1200	1230	25	30	0.2	0.5	−	−	−
ML9XX1	InGaAsP	6	10	−20 ~ +60	−40 ~ +100	5	15	35	40	60	1.3	1.7	1520	1550	1580	30	35	0.2	0.5	−	−	−
ML9XX1A	InGaAsP	20	※2 400mA	−20 ~ +50	−40 ~ +100	15	15	35	75	120	1.5	2.0	1520	1550	1580	30	35	0.1	0.3	−	−	−
ML9XX2	InGaAsP (DFB laser)	6	−	0 ~ +60	−40 ~ +100	5	20	40	45	90	1.2	1.8	−	1550	−	30	35	0.1	0.25	−	30	40
ML9XX3	InGaAsP	30	※2 900mA	+20 ~ +30	−40 ~ +100	25	25	50	120	180	1.5	2.0	1520	1550	1580	30	35	0.1	0.3	−	−	−
ML9XX4**	InGaAsP	Not specified (under development)																				
ML9XX5*	InGaAsP (DFB laser)	20	−	+20 ~ +30	−40 ~ +100	10	20	40	45	90	1.2	1.8	−	1550	−	30	35	−	−	−	30	40

※1 : Duty less than 50 %, pulse width less than 1 μs
※2 : Forward current max. rating, duty = 1 %, pulse width less than 1 μs ※3 : Im value depends on package type

★ : New product ★★ : Under development

■ LEDs :

The Mitsubishi communication LEDs are high−performance optical sources which provide wide modulation band width, optical output with excellent linearity, high coupling efficiency, high reliability, and long service life.

Type	Material	Max. Ratings IF(DC) @Tc≤50°C (mA)	IF※1 (pulse) @Tc≤50°C (mA)	Tc (°C)	Tstg (°C)	@IF (mA)	λp (nm)		Δλ (nm)	Po(DC) (mW)		Po(pulse)※1 (mW)		fc (MHz) IRF = 4mAP-P	
							Min.	Max.	Typ.	Min.	Typ.	Min.	Max.	Min.	Typ.
ME1XX3	AlGaAs	75	120	−40 ~ +100	−55 ~ +125	50	820	880	45	1.0	1.5	2.0	3.0	15	30
ME1XX4	AlGaAs	75	120	−40 ~ +100	−55 ~ +125	50	820	880	45	0.5	1.5	1.0	3.0	10	30
ME7XX2	InGaAsP	120	−	−30 ~ +80	−40 ~ +100	100	1280	1340	130	※2 15	※2 20	−	−	−	150

※1 : Duty = 50 %, f = 100kHz ※2 : Pf (μW, GI 50/125 Optical Fiber)

■ Si pin Photodiodes : Mitsubishi Si pin photodiodes are high-performance optical detectors for standard short-waveband applications offering high-speed response

Type	Material	Max. Ratings				As (μm)	I_D (nA) @V_R = 10V		C_t (pF) @V_R = 5V Typ.	t_r (ns) @V_R = 5V Typ.	λ (nm)	R (A/W) @V_R = 5V λ = 850nm	
		V_R (V) @Tc≤80°C	I_F (mA) @Tc≤80°C	Tc (°C)	Tstg (°C)		Typ.	Max.				Min.	Typ.
PD2XX1	Si	30	10	−40 ~ +110	−55 ~ +150	□ 500	0.5	4	5	2	600~900	0.4	0.45

■ Si Avalanche Photodiodes : Mitsubishi Si avalanche photodiodes are high-performance optical detectors for short-waveband applications offering high-speed response, wide band width and low noise

Type	Material	Max. Ratings				As (μm)	$V_{(BR)R}$ (V) @I_R = 100μA			β (%/°C) Typ.	C_t (PF) @V_R = 0.9 × $V_{(BR)R}$		I_D (nA) V_R = 50V		R (A/W) V_R = 50V λ = 800nm		Mmax @I_{PO} = 10nA R_L = 1kΩ Typ.	fc (GHz) @M = 100 R_L = 50Ω −3dB Typ.
		I_R (μA) @Tc≤80°C	I_F (mA) @Tc≤80°C	Tc (°C)	Tstg (°C)		Min.	Typ.	Max.		Typ.	Max.	Typ.	Max.	Min.	Typ.		
PD1XX2	Si	200	10	−40 ~ +110	−55 ~ +150	φ 200	100	150	200	0.12	1.5	2.0	0.3	1.0	0.4	0.45	1000	2
PD1XX5	Si	200	10	−40 ~ +110	−55 ~ +150	φ 500	100	150	200	0.12	5.0	7.0	0.3	1.0	0.4	0.45	1000	0.4

■ InGaAs pin Photodiodes : Mitsubishi InGaAs photodiodes are high-performance optical detectors for long-waveband applications offering high-speed response

Type	Material	Max. Ratings				As (μm)	I_D (nA) @V_R = 10V Max.	C_t (pF) @V_R = 10V Max.	fc (MHz) @V_R = 10V R_L = 50Ω −3dB Min.	λ (nm)	R (A/W) @λ = 1300nm V_R = 10V Min.
		I_R (μA)	I_F (mA)	Tc (°C)	Tstg (°C)						
PD7XX5	InGaAs	500	2	−30 ~ +80	−40 ~ +100	φ 80	1	2	1000	1000~1600	0.6
PD7XX6	InGaAs	3000	2	−30 ~ +80	−40 ~ +100	φ 300	3	15	200	1000~1600	0.6
PD7XX7★	InGaAs	500	2	−30 ~ +80	−40 ~ +100	φ 40	※1 0.3	※1 1	※1 1500	1000~1600	0.6

※1 : @V_R = 5V

■ InGaAs Avalanche Photodiodes : Mitsubishi InGaAs avalanche photodiodes are high-performance optical detectors for long-waveband applications offering high-speed response, wide bandwidth and low noise

Type	Material	Max. Ratings				As (μm)	$V_{(BR)R}$ (V) @I_R = 10μA Typ.	I_D (nA) @V_R=0.9$V_{(BR)R}$ Max.	η (%) @λ = 1300nm Typ.	C_t (pF) @V_R=0.9$V_{(BR)R}$ Typ.	fc (GHz) @M = 10 R_L = 50Ω −3dB Min.
		I_R (μA)	I_F (mA)	Tc (°C)	Tstg (°C)						
PD8XX2★	InGaAs	500	2	−30 ~ +80	−40 ~ +100	φ 50	70	30	80	0.7	1

★: New product

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Index by Series Type

★ : New product ★★ : Under development

PRINCIPLES OF LASER OSCILLATION

1.PRINCIPLES OF EMITTING DEVICES

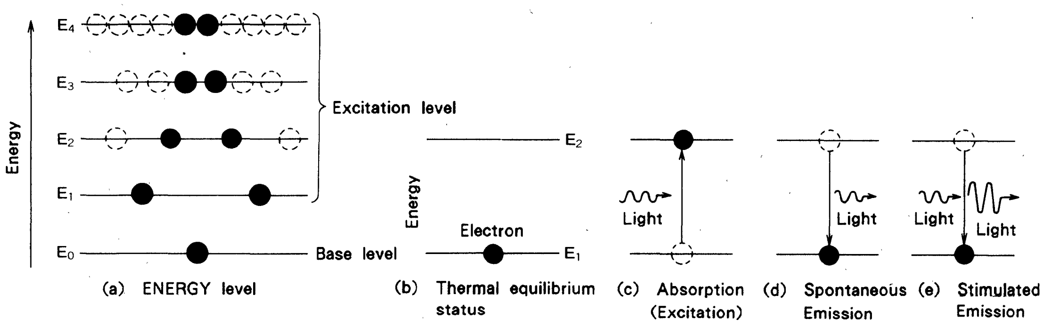


Fig. 1 Energy level and transition processes

Electrons accompanying atoms and molecules have individual energetic values at specific intervals, as shown in Fig.1-(a). This status is called energy level. The lowest energy level is defined as 'base level', and the higher one is called 'excitation level'. When electrons transit from level E_2 to level E_1, electrons absorb or emit light which has a wavelength related as described in the following formula.

$$\lambda = \frac{C}{|E_2 - E_1| / h} = \frac{1.2398}{|E_2 - E_1|} \quad \cdots\cdots\cdots (1)$$

C : Velocity of light (2.998×10^8cm/sec)

h : Planck's constant (6.625×10^{-34}Joule.sec)

E_1: Energy before transition

E_2: Energy after transition

The termal equilibrium status on Fig. 1-(b) considers that excitation is balanced with the spontaneous emission process. The transition process consists of 3 different modes as shown Fig. 1-(c)-(e). The first is defined as 'absorption', where electrons transit from low energy level E_1 to higher level E_2 by absorbing. The second is 'spontaneous emission', in which electrons transit from high energy level E_2 to the stable low level E_1 and emit the energy $|E_2-E_1|$ as light. (Fig. 1-(d)). In this case low energy electrons located at energy level E_2 are moving at random relative to each other. A light that is generated under such conditions is called incoherent (not in phase) and it is a distinctive feature of sponteneous emission. The emitted light of LED's belongs to this category.

The third transition process is defined as 'stimulated emission'. Fig. 1-(e) explains that when photons of ligh with energy almost equal to $|E_2-E_1|$ have incidence on electrons located at E_2 the electrons move by compulsion to the E_1 level.

The light generated in this way is called stimulated emission light, or in other words, coherent light.

Light is emitted in this way on the condition that it is resonant with the incident light, therefore both photon energies (wavelength) are equal and the phase relationship is constant. This phenomena has been applied to laser diodes.

The stimualted emission is only realized when the number of electrons after excitation on E_2 gets larger than those on the low level E_1. Such a state is called 'population inversion'. An electric current should be applied to a laser diode, in order to create this condition. Once stimulated emission occurs, the strength of the incident light should be increased and thereby achieve optical amplification. Then, it becomes be possible to cause the optical oscillation by making an optical resonator. 'LASER' is an acronym of Light Amplification by Stimulated Emission of Radiation.

2.STRUCTURE OF AlGaAs LASER

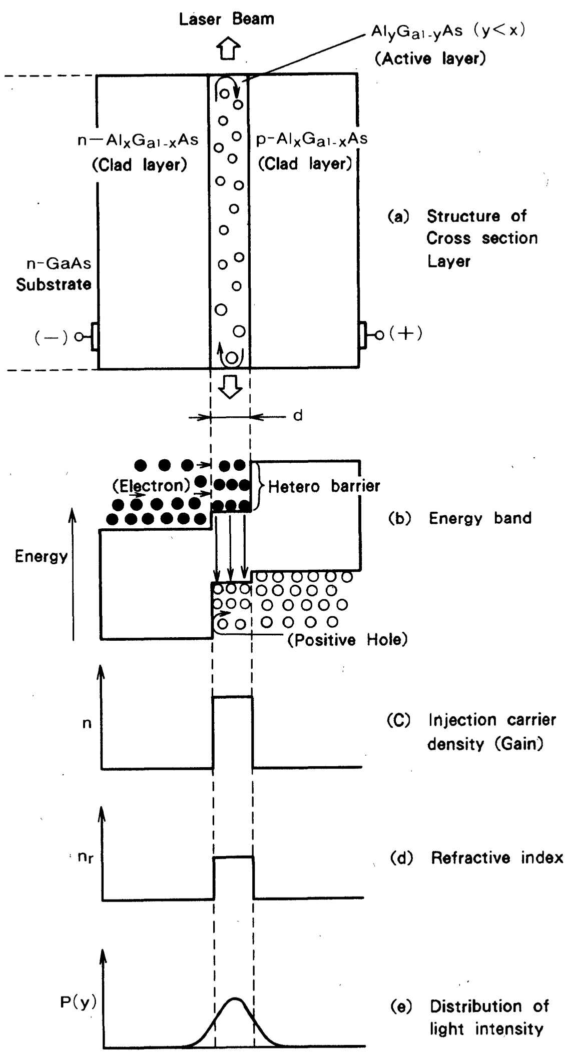


Fig. 2 Operational principle of double hetero junction laser

A laser diode can't oscillate if amplication has occured. Laser oscillation never happens unless it has feedback. In order to achieve this a "Fabry-Perot" oscillator is often used. (See Fig. 2-(a)).

The operation principles are : use the two cleaved facets as reflection mirrors. At first the beams go in every direction within the active layer. However, only selected beams that correspond to the Fabry - Perot oscillator's direction would be confined between these mirrors and the result that optical oscillation occurs.

AlGaAs laser diode for example, has a double hetero junction structure, where an AlyGa1 - As active layer is sandwiched between n and p-AlxGa1 -xAs cladding layers (y < x). (See Fig. 2-(a)). The amplifying media is a double hetero junction narrow band gap layer ($AlyGa_{1-y}As$ active layer). By making the p-clad layer ⊕ and the n-clad layer ⊖, and adding forward directed bias, electrons and holes will be injected from the n and p-cladding layers. Carriers will be confined to the active layer and create 'population inversion'. The result is that a high gain will be obtained, because the band-gap of the cladding layer is larger than that of active layer and a barrier will be produced in the junction. (Fig. 2-(b), (c)). Light has a characteristic that it gathers to the area of high refractive index. The refractive index of the activation layer is higher than that of cladding layer, in an AlGaAs LASER. (Fig. 2-(d)).

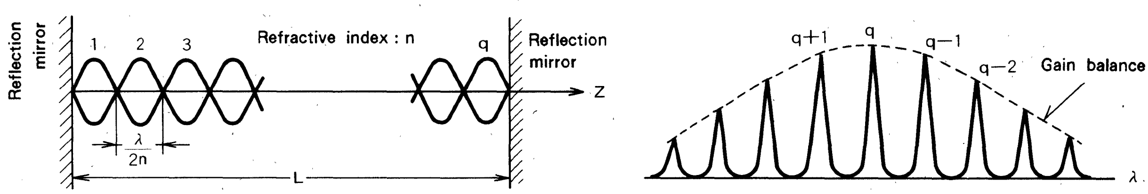
The light will therefore remain in the active layer. This is called 'optical confinement'. In this way, stimulated emission will be performed effectively, because carriers and light are confined in the active layer.

3.Longitudinal mode

On the condition that laser oscillation occurs, beams run both ways in the optical resonator and there is an optical standing wave produced whose phase front is parallel to the reflection mirrors. Power output will be obtained by the wave's penetration from the reflection mirrors. This standing wave is shown in Fig. 3-(a). Letting the vertical length of optical resonator equal L, the equivalent refractive index of the wave in the wave guide equal n, and the wave length of the standing wave in the wave guide equal λ, then it will be clear that the total length L equals a multiple whole number of half wavelengths for the media $\lambda/2n$, and the following formula will be derived :

$$\frac{\lambda}{2n} q = L \ (q : \text{Integer}) \qquad \cdots\cdots\cdots (2)$$

In the case of $\lambda = 780$nm, $n = 3.5$ and $L = 250\,\mu$m, the integer q becomes 2.244 resulting in a very large number. Even if q changes by up to ± 1, the resonant wavelength changes by only a small fraction, and in the above case the wavelength balance $\Delta\lambda$ will be $|\Delta\lambda| = 3.5$Å. A laser resonator having resonator length L which is far longer than the wavelength allows the resonating of many waves having slightly different lengths.



(a) Standing waves of longitudinal mode

(b) Resonance spectrum for longitudinal mode

Fig. 3 Longitudinal mode generating mechanism

4.Transverse mode

The standing waves at laser oscillation consists of a wave generated between both reflection surfaces shown earlier (the longitudinal mode), a wave generated in the direction perpendicular to the active layer (the vertical transverse mode), and a wave generated in the direction in parallel to the active layer (the horizontal transverse mode). Normally the transverse mode of a laser diode is required to be a basic mode where just one luminous point exists. The perpendicular transverse mode will be a basic mode on the normal double hetero structure laser which has a thin active layer. In order to achieve stable oscillation on a basic parallel transverse mode, the expanding electromagnetic fields will be restained by inclucing optical waveguide using the existing refractive index. Stripe structure, that makes the width of optical waveguide as oscillation other than a basic mode is insulated, is fully worked out. These modes have a grat influence on the optical longitudinal mode, linearity of current-light output power characteristics, modulation speed, threshold current, aberration of laser beam, and so on.

TECHNICAL TERMS AND SYMBOLS FOR LASER DIODES

TERM	SYMBOL	DESCRIPTION
Threshold current	I_{th}	Current at which laser oscillation begins (Fig. 1)
Operating current	I_{OP}	Forward current to obtain specified light output (Fig. 1)
Operating voltage	V_{OP}	Forward voltage to obtain specified light output (Fig. 1)
Slope efficiency	η	Change of light output per unit of applied forward current $\Delta P_O / \Delta I_{OP} = \eta$ (mW/mA)
Light output power	P_O	Output power from the front facet of the LD (Fig. 1)
Pulse light output power	$P_{O(P)}$	Pulsed output power from the front facet of the LD
Droop	ΔP	Characteristic of dropping of light output caused by heat generated when a constant current in pulse is applied to semiconductor laser. It is expressed as follows : PA : Light output initial value of 600Hz, 10% duty; PB : Light output final value of 600Hz, 90% duty, $\Delta P = \frac{PA - PB}{PA} \times 100(\%)$ (ref. 1-31)
Monitoring light output power	P_m	Output power from the rear facet of the LD (Fig. 2)
Monitoring output current	I_m	Output current of monitor photodiode (Fig. 1)
Peak wavelength	λ_P	Wavelength of peak longitudinal mode in emission spectra (Fig. 2)
Spectral half width	$\Delta\lambda$	Full width at a half maximum of enveloped profile of emission spectra (Fig. 2)
Beam divergence angle Parallel Perpendicular	 $\theta_{//}$ $\theta_{\perp}$	The beam from semiconductor laser spreads as shown in Fig. 2. This angle refers to the width (full angle) at the point which is 1/2 of peak intensity in intensity distributions parallel and perpendicular to junction. Parallel direction is expressed in $\theta_{//}$ and vertical direction in $\theta_{\perp}$. The intensity distribution concerned is called far field pattern (FFP).
Near field pattern	NFP	This pattern refers to the intensity distributions parallel and perpendicular to junction at the front facet of semiconductor laser chip (Fig. 2).
Rise time	t_r	Time taken for the optical output to increase from 10% to 90% of max output. Max optical output means the steady state value attained after relaxation oscillation.
Fall time	t_f	Time taken for the optical output to decrease from 90% to 10% of max output.
Cutoff frequency	f_c	The frequency in which the sine wave amplitude of the modulated light output obtained by intensity-modulating small signals with a sine wave at the specified light output bias point drops to 1/2 of the low frequency amplitude.
Astigmatic distance	A_s	There is a difference of the focal point in the parallel and perpendicular direction to junction when the laser beam is focused. This distance is called astigmatic distance (Fig. 3)
Polarization ratio	$P_{//}/P_{\perp}$	The laser beam consists mainly of parallel polarized light output. This is the retio between parallel polarized light and perpendicular polarized light.
Relative intensity noise	RIN	The parameter to indicate, like S/N, the intensity fluctuation of laser beam. Let the average light output of semiconductor laser by DC drive be P_O, the intensity fluctuation of light output be δP, and the band width under test be Δf, then, $RIN = 10\log\ [\langle \delta P \rangle^2 / P_O^2 \cdot 1/\Delta f]$ [dB/Hz]
Composite Second Order Composite Triple Beat	CSO CTB	CSO(Composite Second Order) refers to the intensity difference between the secondary harmonic distortion component and the signal component generated when a semiconductor laser is driven by current modulation(analog modulation) with a multi-channel sine wave signal. CTB(Composite Triple Beat) refers to the intensity difference between the tertiary harmonic distortion component and the signal component.
Signal to Noise ratio	S/N	Intensity fluctuation of laser beam. If the average light output power is defined as P_O and the intensity fluctuation is defined as δP_O, the signal to noise is defined as. $S/N = 20\log(P_O/\delta P_O)$ [dB] Mainly, a semiconductor laser has (1) mode hopping noise in which the mode jumps at the temperature change in the junction and (2) the returen beam noise in which the laser beam reflects from the externalresonator (a composite resonator).
Side mode suppression ratio	SMSR	Ratio of spectrum intensity of maximum mode (main mode) to side mode. The parameter to indicate the singularity of the longitudinal mode of DFB (Distribution Feedback) laser. (Fig. 4)
Interferogram	α, β	The damping pattern of the interferogram obtained when the laser beam is made the interference beam through the Michelson interferometer. For details, see "Measuring Oscillating Wavelengths" on page 1-24.

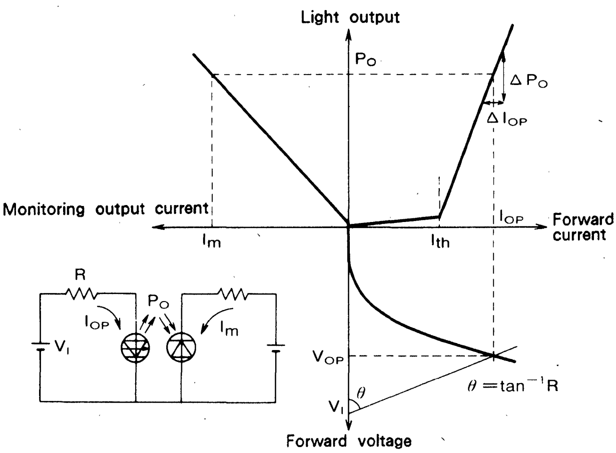


Fig. 1 Electrical and optical characteristics of laser diode (with a Monitor photodiode)

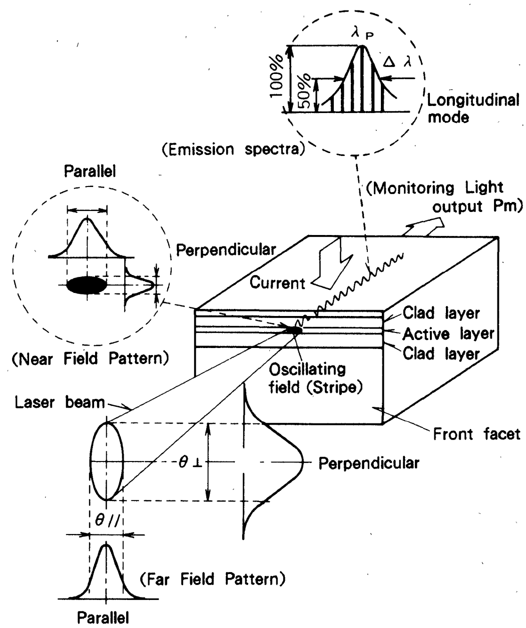


Fig. 2 Optical characteristics of laser diode

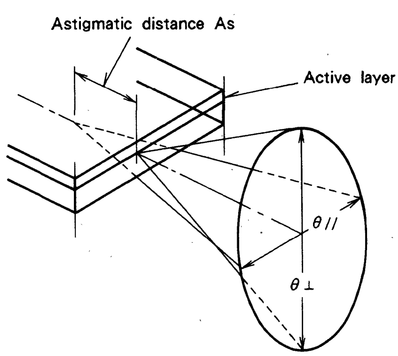


Fig. 3 Astigmatic distance

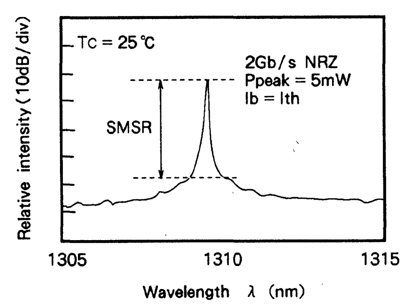


Fig. 4 Spectral Side Mode Suppression Ratio

TECHNICAL TERMS AND SYMBOLS FOR LEDs

TERM	SYMBOL	DESCRIPTION
Forward current	I_F	Standard operating current (Fig. 5)
Forward voltage	V_F	Forward voltage when IF is supplied (Fig. 5)
Rise time	t_r	Time taken for the optical output to increase from 10 % to 90 % of max output
Fall time	t_f	Time taken for the optical output to decrease from 90 % to 10 % of max output
Cutoff frequency	f_c	The frequency (Hz) in which the sine wave amplitude of the modulated light output obtained by intensity-modulating small signals with a sine wave at the specified operating point drops to 1/2 of the low frequency amplitude.
Beam divergence angle	θ	Full angle at a half maximum of far field radiation patterns.
Optical output	P_O	The total optical output value to be obtained when the specified forward current is applied. (Fig. 5)
Fiber coupled power	P_f	The optical output value which can be coupled with optical fiber when the specified forward current is applied. (Fig. 5)

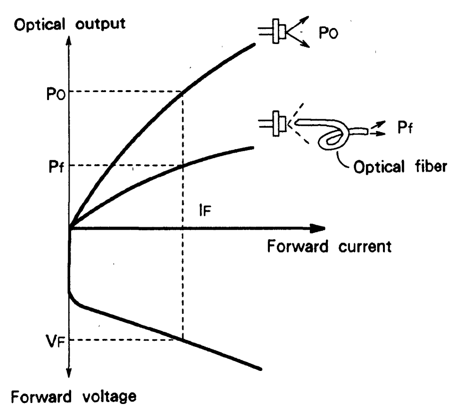


Fig. 5 Electrical and optical charactristics of LED

TECHNICAL TERMS AND SYMBOLS FOR PHOTODIODES

TERMS	SYMBOL	DESCRIPTION
Dark current	I_D	The current which flows when the specified reverse voltage is applied without light incidence.(Fig. 6)
Responsivity	R	Output current per unit of input optical power of a specified wavelength
Quantum efficiency	η	Percentage of number output of electrons per number of input photons
Rise time	t_r	Time taken for the incident light to increase from 10% to 90% of max power
Fall time	t_f	Time taken for the incident light to decrease from 90% to 10% of max power
Cutoff frequency	f_c	The frequency in which the sine wave amplitude of the signal output obtained when the intensity modulated light of small signal by sine wave is introduced at the specified operating point drops to 1/2 of the low frequency amplitude.
Total capacitance	C_t	The capacitance between the anode and cathode lead terminals, which is obtained at the specified reverse voltage and frequency
Breakdown voltage	$V_{(BR)R}$	Breakdown voltage refers to the voltage to be obtained when the specified reverse current is flown in the area.(Fig. 6)
Multiplication rate	M	Ratio of the output current multiplied by avalanche multiplication to the output current without any multiplication
Excess noise factor	F	Indicates the scale of noise produced in the avalanche multiplication process. Excees noise factor may be represented in excess noise index X shown in the following relation : $F = M^x$
Breakdown voltage temperature coefficient	β	The change rate of breakdown voltage to the temperature with the breakdown voltage at $T_C = 25$℃ as standard

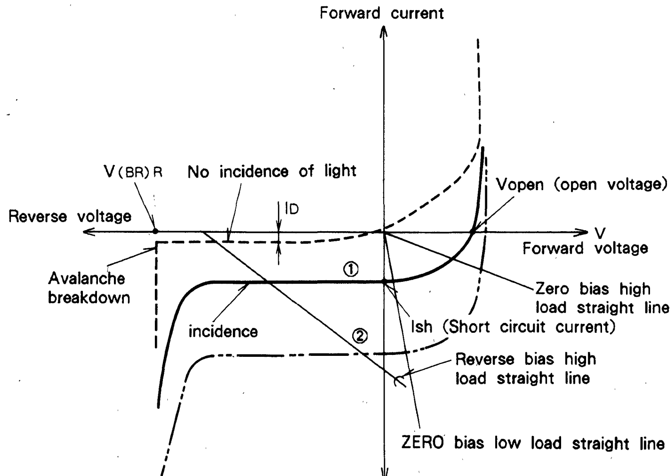


Fig. 6 Operating figure of Photodiode

<Measuring Methods>

1 Optical output vs. forward and monitoring current

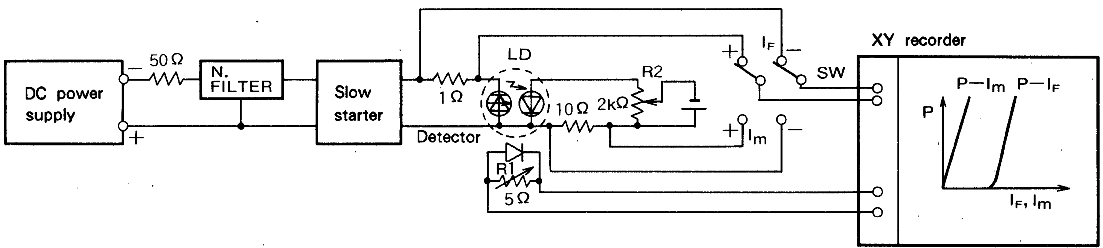


Fig. 1 P-I_F and P-Im characteristics measuring system

Fig. 1 is an example of a measuring system that traces P-I_F and P-I_m characteristics on an XY recorder. A noise filter and the slow starter are implemented in order to avoid degradation of LD by surge current. A silicon or germanium photodiode is used as a detector, and the output is previously adjusted by the load resistance R1.

(i) P-I_F.

Turn SW to "I_F"connect the LD to the power supply at minimum volatge switch the power supply on and gradually increase current from DC power supply. The P-I_F curve will be traced. Then before disconnecting, set the power supply to the minimum voltage, disconnedct the LD then turn the power supply switch OFF.

(ii) P-I_m

The load resistance R2 is adjusted to the PD bias voltage to get an object scaling. SW is turned to "I_m" and operated as above P-I_m characteristic will be traced on the XY recoder. Please take care not to operate the LD over the maximum optical power rating of the LD.

2 Impedance

1. Reference (SHORT)

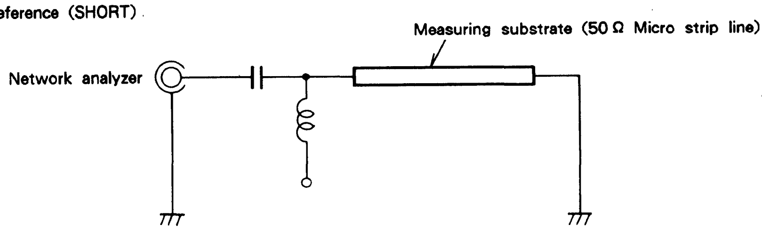


Fig. 2 Reference measuring system

2. Measurement

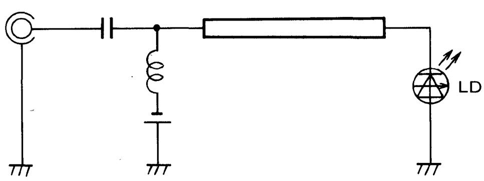


Fig. 3 Impedance characteristic measuring system

Fig. 2 and 3 are examples of circuits used to measure the input impedance characteristics. At first the network analyser should be referenced by placing at the output a SHORT (0 point on Smith chart), as shown on Fig. 2. Next, connect the circuit, measure the return-loss and phase at this time and plot these on a Smith chart. By repeating this operation at every frequency, the input impedance will be calculated.

Typical impedance characteristics of the ML40110R, with lead lengths of 2mm, are shown in Fig. 4 with the bias currents as the parameter.
Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance can be approximated by a series connection of a resistance of 3.5ohm and an inductance of 2.3nH.

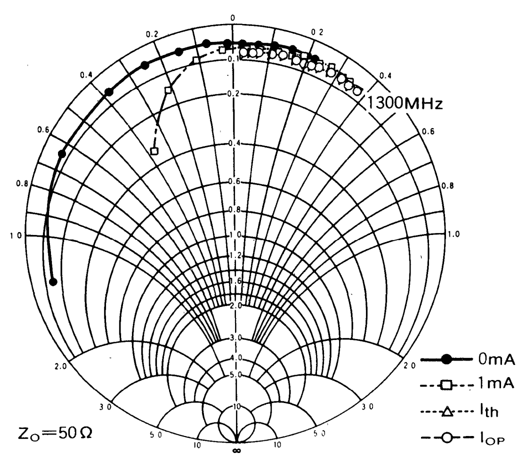


Fig. 4 Example of impedance characteristic

3 Measurement of thermal resistance

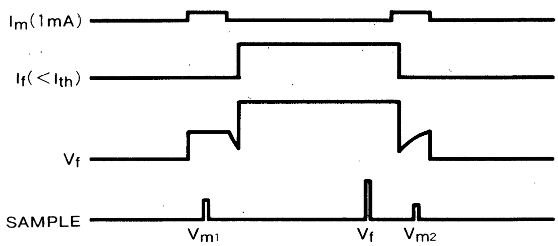


Fig. 5 Timing chart

Thermal resistance is measured by measuring the temperature change in the junction surface by using the temperature dependence of the forward voltage drop of the PN junction of LD.

At first let a small current (I_m = 1mA) with a negligible temperature rise to flow in the forward direction of the LD, and then measure the forward voltage drop (V_{m1}) at that time.

Next, introduce a forward current ($I_f < I_{th}$) for electric power application for 50msec, and measure the forward voltage drop (V_f).

Repeat the first step and measure V_{m2}. (Fig. 5)

Using the voltage values (V_{m1}, V_{m2}, and V_f) thus obtained, the thermal resistance (R_{th}) is calculated as follows :

$$R_{th} = \frac{\left(\frac{V_{m1} - V_{m2}}{m}\right)}{I_f \cdot V_f} \ (^\circ C/W)$$

, where m means previously measured temperature coefficient of junction voltage

$$m = \left(\frac{dV_f}{dT}\right) (V/^\circ C)$$

An example (ML40116R, ML44114R) of thermal resistance is shown in Fig. 6.

Please use a heatsink of good thermal radiation because the junction temperature of a laser influences its life time.

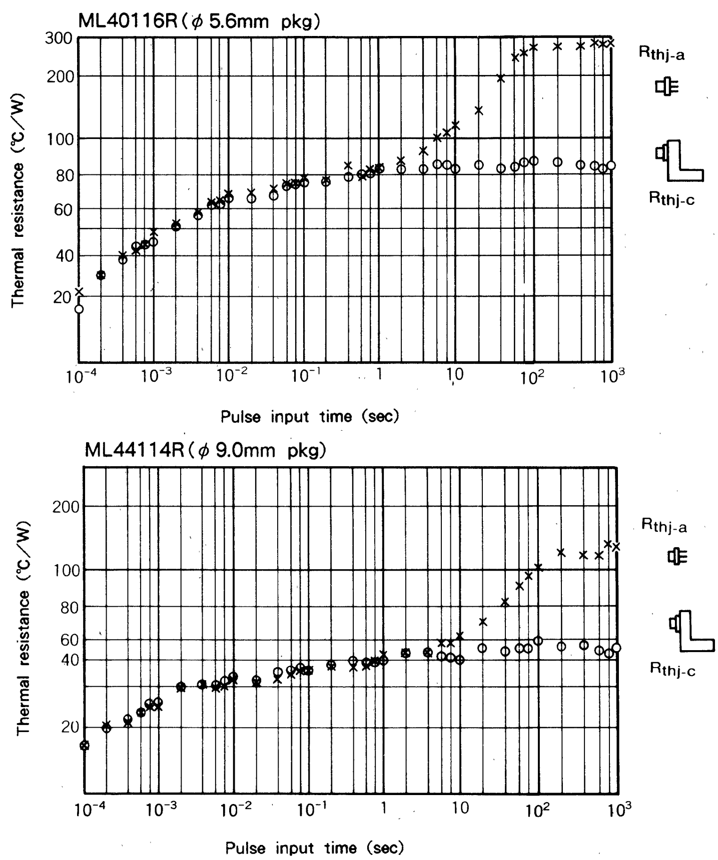


Fig. 6

4 Far Field Pattern(FFP)

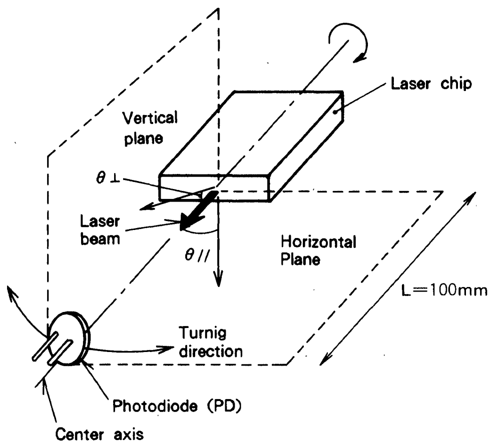


Fig. 7 FFP measuring system

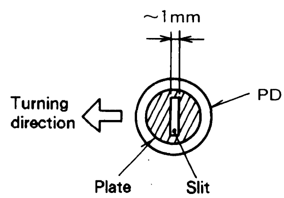


Fig. 8 FFP measuring photodiode

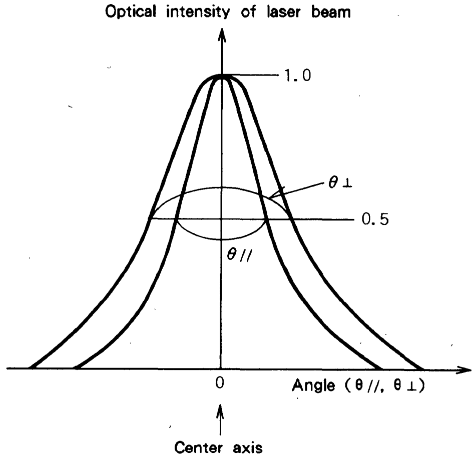


Fig. 9

Direct the PD in a horizontal plane (parallel to the laser junction surface) toward the luminous surface of laser chip and turn it along with circumference (Length ; 100mm) of which center is luminous surface, and can be measured. (Fig. 7) At this time, the PD receiver surface is larger than the luminous surface of the laser chip, so it is necessary to fully enlarge the length from the laser chip and settle a slit on PD, in order to improve resolution (Fig. 8). To measure the $\theta_\perp$ direction, turn the laser chip 90° from the center axis and measure in the same way as $\theta_{//}$.

The measured result is shown in Fig. 9 . Figures of $\theta_{//}$ and $\theta_\perp$ are hanging-bell type symmetrical to the center axis, as angles from the center axis, get larger. This is called Gauss distribution, and the sharpness of beam direction depends on the width of this distribution. Generally the width of angle (full angle at half maximum) in the parallel ($\theta_{//}$) and in the perpendicular ($\theta_\perp$) direction of which the intensity gets down to 0.5 of the maximun optical intensity is specified as the beam spreading angle. Resolution by this measurement is 0.10° .

The angle of gap between the center axis of $\theta_{//}$and $\theta_\perp$ in FFP is defined as the angle gap, $\Delta\theta_{//}$ $\Delta\theta_\perp$respectively.

5 Emission Spectra

1. Measurement by diffraction grating

The measurement of the Emission spectra with a spectrometer , in which the light from the device under measurement is scattered by diffraction grating is shown in Fig. 10.

The light comes through the slit into a photomultiplier. The oscilloscope indicates the spectra which can be measured.

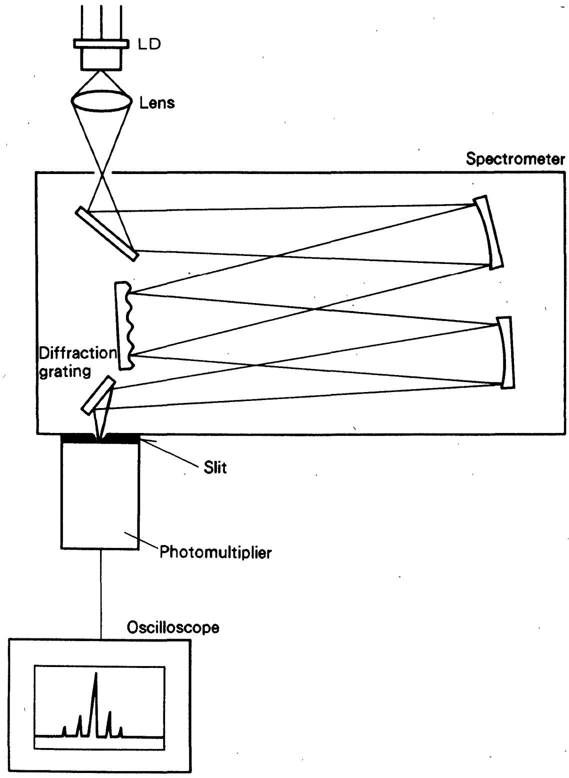


Fig. 10 Emission spectra measuring principle by diffraction grating

2. Measurement by Interferogram

To measure the Emission spectra with interferogram, the light from the device under measurement is represented as interference light with a Michelson interferometer (Fig. 11).

Performing an inverted Fourier transformation on this interferogram yields the spectra.

If the peak value corresponding to the zero position of movable mirror is defined as 1 in Fig. 12, the first peak ratio is defined as interferogram damping ratio α.

The minimum value between the peak value of optical path difference 0 and the primary peak value is defind as β.

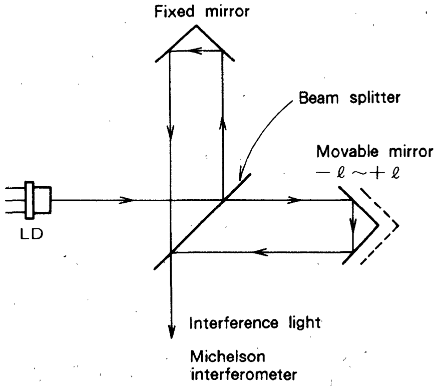


Fig. 11 Michelson interferometer

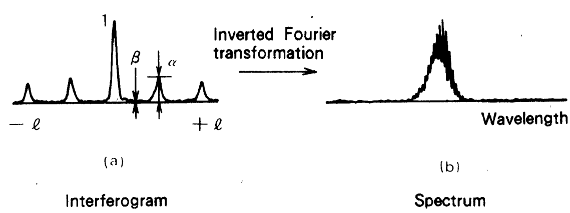


Fig. 12 Measuring by interferogram

6 Pulse response

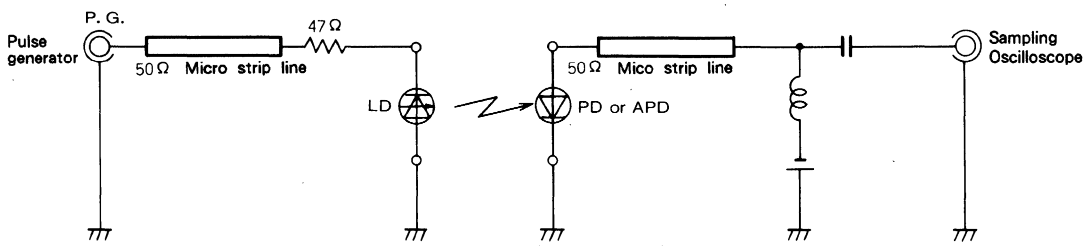


Fig. 13 Pulse response characteristic measuring system

Fig. 13 indicates an example for measuring seriesPulse response characteristics.

Let the time required for the pulse rising (10%-90%) from the sampling oscilloscope output waveform be tr, and the time for falling be tf.

7 Polarization ratio

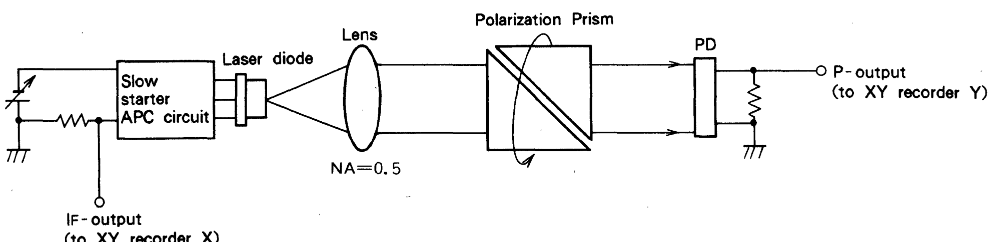


Fig. 14 Polarization ratio measuring system

A laser beam is oscillated almost in TE mode (Beam polarized horizontally to hetero junction). The beam strength is shown as $P_{//}$. TM mode (Beam polarized vertically to hetero junction) is just as strong as natural light (beam). This beam strength is shown as $P_{\perp}$. The Polarization ratio is the ratio between the optical strength of the TM mode and the TE mode ($P_{//}/P_{\perp}$). Fig. 14 shows an example of the measurement set-up required to measure the Polarization ratio. Turn the laser beam to a collimated one by using a lens with NA = 0.5 and resolve the polarization prism, to measure the maximum power ($P_{//}$) and minimum power ($P_{\perp}$).

Obtain the ratio of $P_{//}$ to $P_{\perp}$ at each optical output from the curves of $P_{//}$-I_F and $P_{\perp}$-I_F. The ratio thus obtained is the polarization ratio.

8 Astigmatic distance

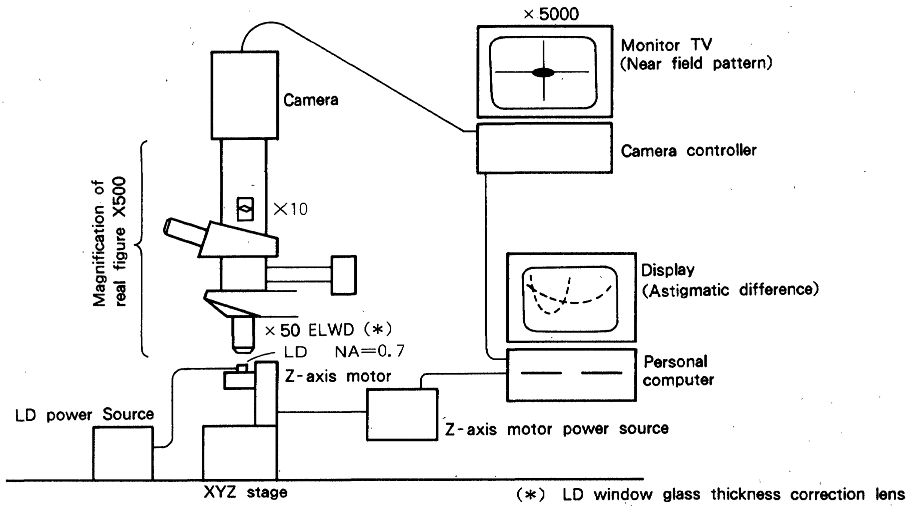


Fig. 15 Astigmatic distance measuring system

Figure 15 shows a sample measuring system. Move the LD in the optical axis direction in steps of 2 μm by driving the Z-axis motor. Read the spots parallel and perpendicular to hetero junction surface in the intensity diameter of $1/e^2$ of the peak value. Plot the spot diameters (parallel and perpendicular) in the direction of LD movement as shown in Fig. 16. Then, approximate this data with a curve to obtain the LD position at which the spot diameters in parallel and perpendicular directions are smallest. The difference in the distance of the movement is the astigmatic distance. A measurement example (ML4403) is shown in Fig. 16.

9 Near Field Pattern

In Fig. 15 please observe the near field pattern of LD by a real image of 500 magnification and camera of 5000 magnification.

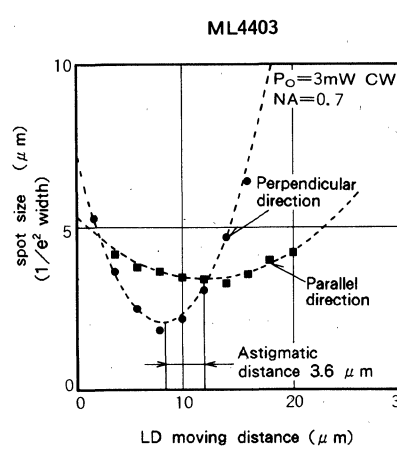


Fig. 16 Example of astigmatic distance measurement

10 Wave front distortion

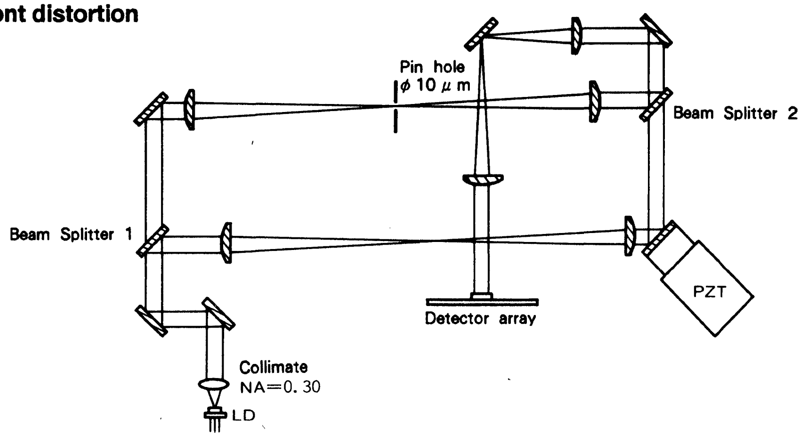


Fig. 17 Wave front distortion measuring system

Equiphase surface of a laser beam without any aberration is spherical. However, in general, the wave front has a distortion. Most of this distortion consists of an astigmatism. The astigmatism for parallel direction to the hetero junction has a different value from that for perpendicular direction to the hetero junction, because the curvatures of wave front for the two directions are different to each other.

The wave front distortion is measured by the equal-path Mach-Zehnder interferometer shown in Fig. 17. Various aberrations are calculated by Zernike's polynomial approximation for the interference fringes observed by the Mach-Zehnder interferometer. The relationship between the astigmatism ($\Delta\phi$) and the astigmatic distance (see page 1-26) (ΔZ) is shown in Fig. 18.

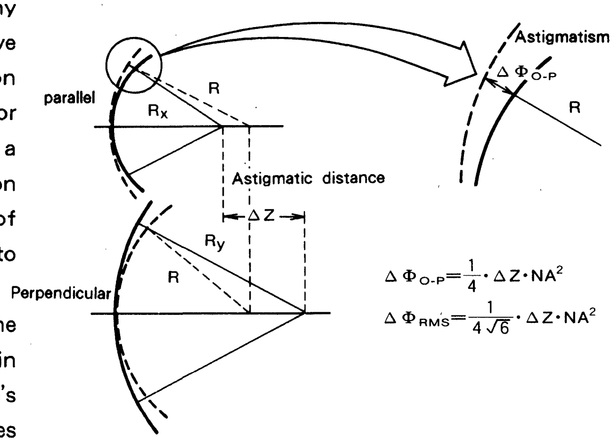


Fig. 18 Relationship between astigmatic distance ΔZ and astigmatism $\Delta\phi$

The sample measurement (ML5415N) is shown in Figures 19 and 20.

Fig. 19 shows wave front (phase front) of ML5415N when the laser beam is collimated.

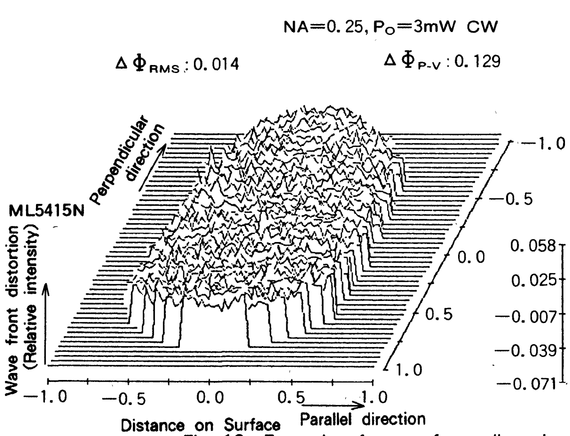


Fig. 19 Example of wave front distortion

NA=0. 25, P_O=3mW, CW

Type of aberration	ΔΦ Aberration (Note)	
	RMS	P-V
Spherical aberration	0. 011*	0. 130
Coma aberration	0. 011*	0. 128
Astigmatism	0. 014	0. 129
Curvature of field	0. 011*	0. 128
Distortion	0. 014	0. 129

(*0.011 is a measuring limit value)

Fig. 20 Example of wave front distortion

11 Harmonic distortion characteristic

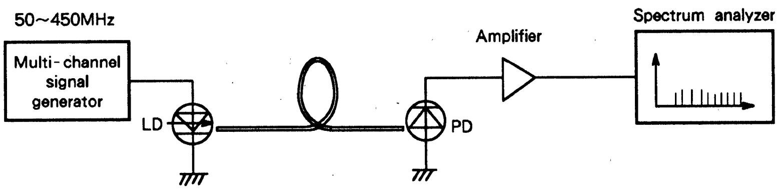


Fig. 21 Harmonic distortion measuring system

Figure 21 shows a harmonic distortion measuring system. When a semiconductor laser is directly modified with a multi-channel sine wave signal fn (n = 1~) of 6MHz intervals, the secondary harmonic distortion component is generated on the frequencies of fn ± 1.25 and fn ± 0.75 against signal frequency fn. The tertiary harmonic distortion component is generated on the frequency same as signal frequency fn (see Fig. 22). The intensity difference between the signal component and the secondary harmonic distortion component is defined as CSO, and that between the signal component and the tertiary harmonic distortion component as CTB.

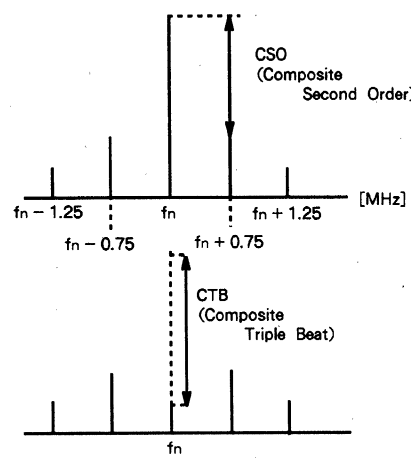


Fig. 22 Example of spectrum at 40ch modulation

MITSUBISHI ELECTRIC

12 S/N characteristic

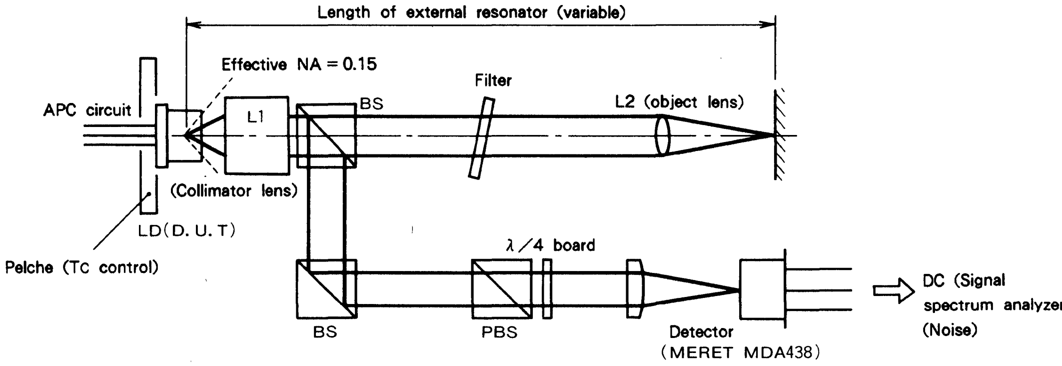


Fig. 23 S/N ratio characteristic evaluating system

The noise of a laser produced in Optical Disk Systems is mainly optical feedback noise. The optical feedback noise is generated when the beam from a semiconductor laser is reflected from a disk surface or the like and gets in the laser again. Let the mean optical power by CW drive be Po and fluctuation be δ Po, then the S/N value is as follows :

$$S/N = 20 \log \frac{Po}{\delta Po} \text{ [dB]}$$

Optical feedback noise is measured by the set-up as shown in Fig. 23. Optical feedback ratio will be changed from 0 to 5% by using filters.

For the noise at each optical feedback ratio, measure the worst value to be obtained when the case temperature has been changed. Make this measure by specifying the measuring frequency and the measuring band width. Figure 24 shows a measuring example with a measuring frequency of 20kHz and a measuring band width of 300Hz.

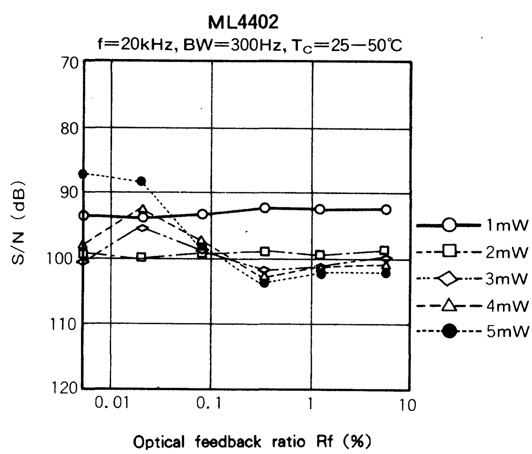


Fig. 24 Example of S/N characteristic

13 Relative Intensity Noise (RIN) characteristic

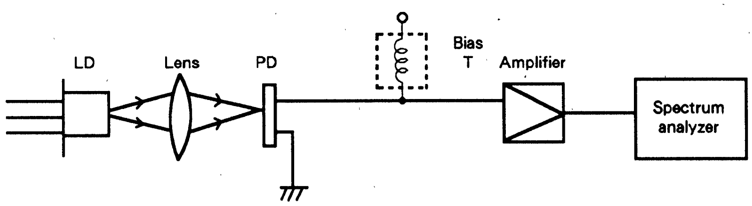


Fig. 25 RIN evaluating system

The analog communication light sources such as the cable TV (CATV) require the low noise characterisric up to several 100MHz. RIN can be obtained as follows with laser's mean optical output being Po, the optical output fluctuation being δ Po, and the band width under measurement being Δf :

$$RIN = 10\log\left(\frac{<\delta P>^2}{Po^2} \cdot \frac{1}{\Delta f}\right) \; [dB/Hz]$$

For measuring the RIN characteristic, the optical system shown in Fig. 25 is used. Figure 26 shows a sample measurement with Tc = 25℃, the band width under measurement = 3MHz, and the optical feedback ratio Rf = 0%.

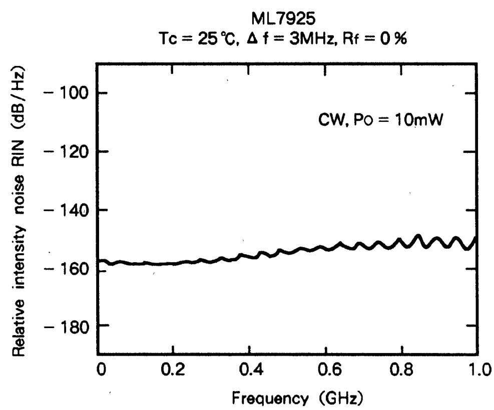


Fig. 26 Example of RIN measurement

14 Droop characteristic (Thermal characteristic)

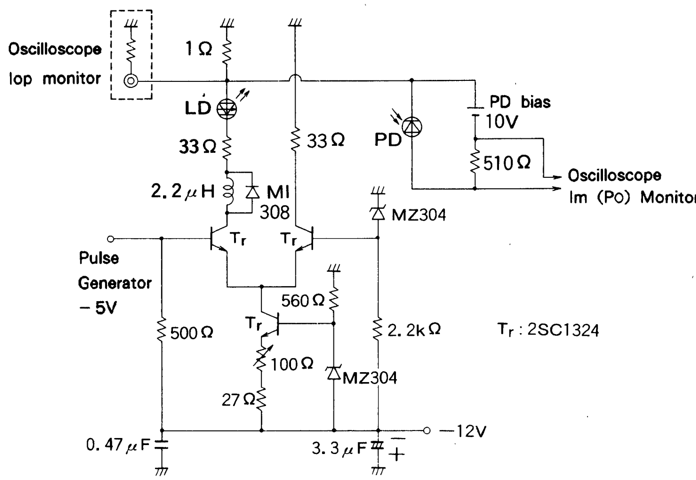


Fig. 27 Droop characteristic evaluating system

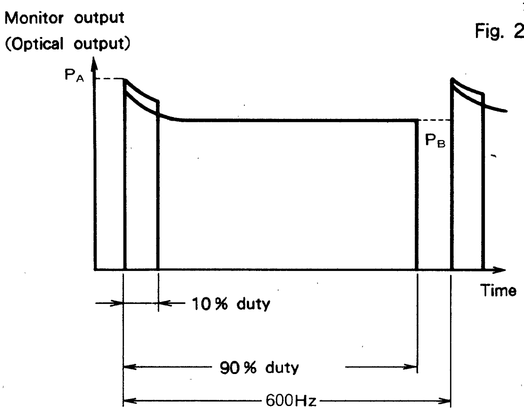


Fig. 28 Definition of droop

The droop characteristic indicates the dependance of the optical output power with temperature.

Fig. 27 is and example of the measuring circuit. The measuring condition which shows in Fig. 28 should be at a frequency of 600Hz, duty 10% and duty 90%.

When P_A is the initial light output at a 10% duty pulse and P_B is the final light output at a 90% duty pulse, droop (ΔP) is defined as following formula.

$$\Delta P\ (\%) = \frac{P_A - P_B}{P_B} \times 100$$

Example (ML4403) of droop characteristic is shown in Fig. 29.

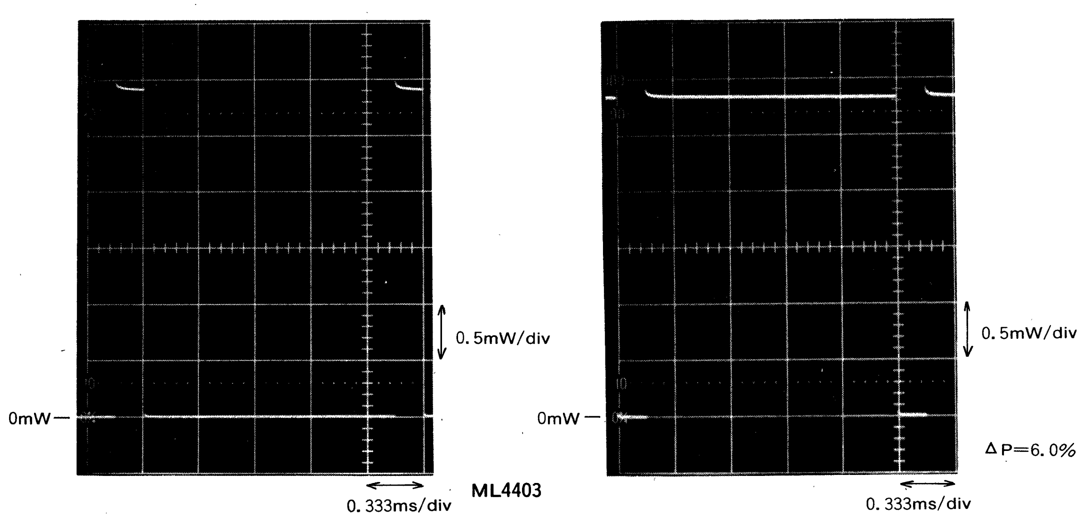


Fig. 29 Example of droop characteristic evaluation

15 Cutoff frequency

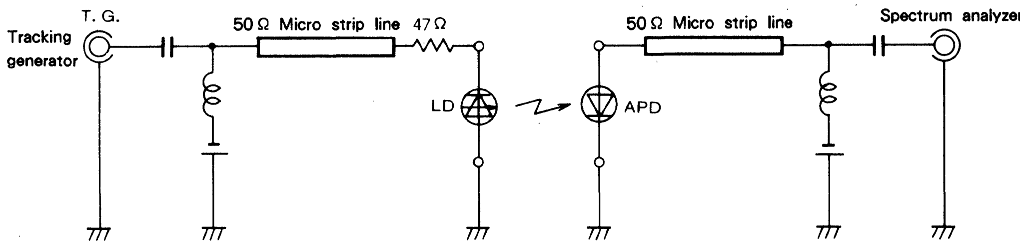


Fig. 30 Cutoff frequency evaluating system

Fig. 30 is an example of the measuring set-up for frequency characteristics.

The Cutoff frequency fc (MHz) is the frequency at which the signal level falls by 3dB.

16 Pulse response characteristic of a monitor photodiode

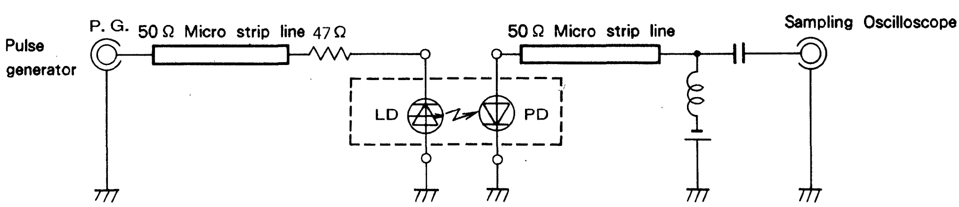


Fig. 31 Monitor PD pulse response characteristic

Fig. 31 an example of a measurement system for monitor PD pulse response characteristic.

To minimize the losses use micro strip lines for the connection on PG/LD and PD/OSC.

17 Measurement of Pf (fiber coupled power of LED)

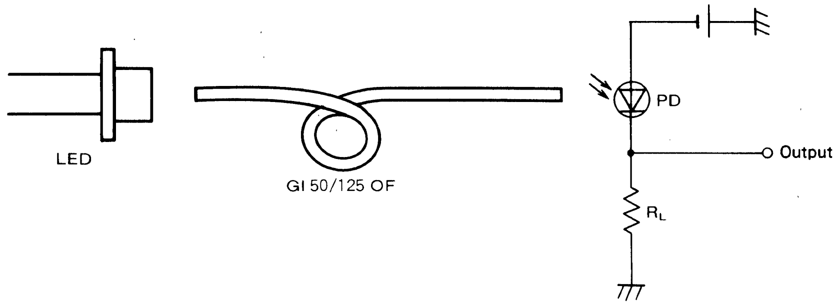


Fig. 32 Pf measuring system

When using optical fiber in communication systems, it is important to know how much of the output light from the LED is efficiency coupled to the fiber. Fig. 32 shows a Pf measuring circuit. Let constant current flow through the LED, and moving the end of fiber to X, Y and Z direction near the emitting point until the measured light is a maximum. Fiber used is normally G150/125 OF.

18 PD spectral response characteristic

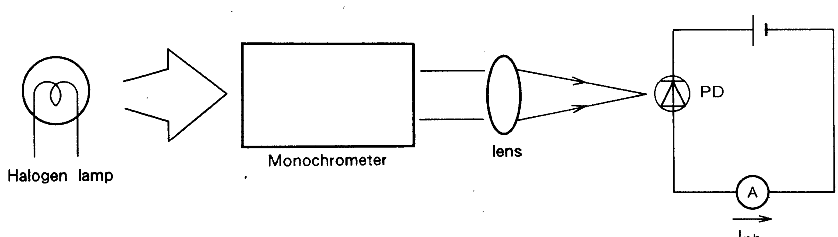


Fig. 33 PD spectral response measuring system

Fig. 33 shows an example of a system used to measure the PD spectral response characteristic.

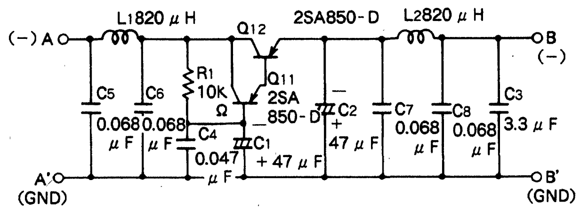
Using a halogen lamp etc. as a light source, and taking only light of a single wavelength by using a monochrometer, focus the light and irradiate the PD.

The responsivity R for that wavelength (λ) will be the calculated as the ratio between I_{ph} (optical current flowing through the PD) and P (the input power) $R = I_{ph}/P$ (A/W)

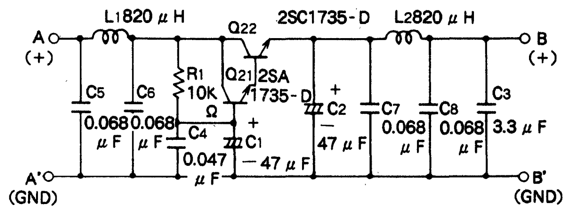
DRIVING CIRCUITS

■ Example of a slow starter circuits

● Common Anode type (− Power drive)

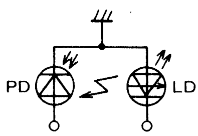


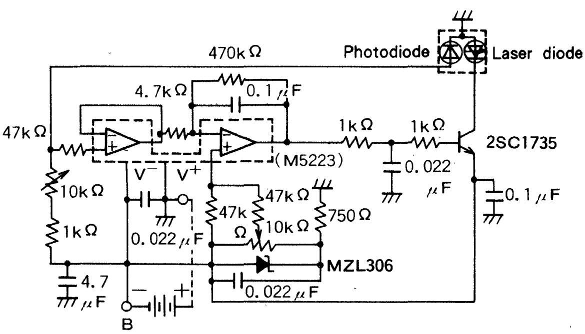
● Common Cathode type (+ Power drive)

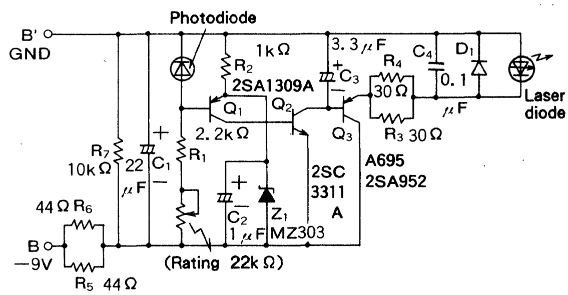


■ Example of an APC circuits

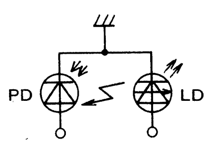
● N type



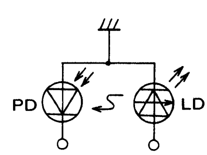


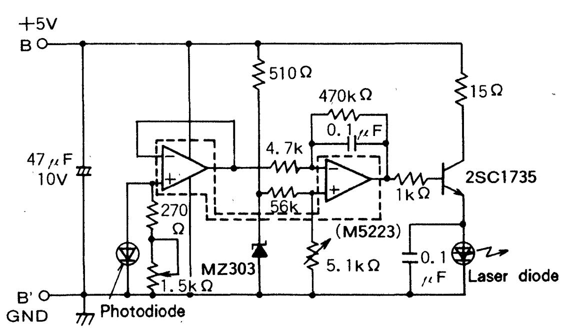


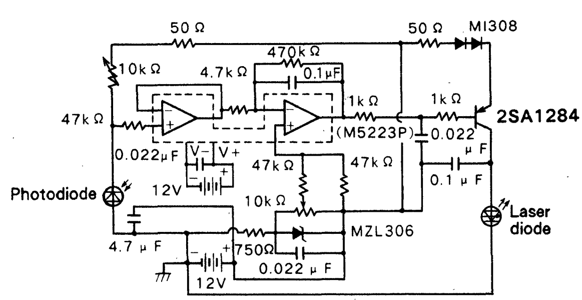
● C type



● R type

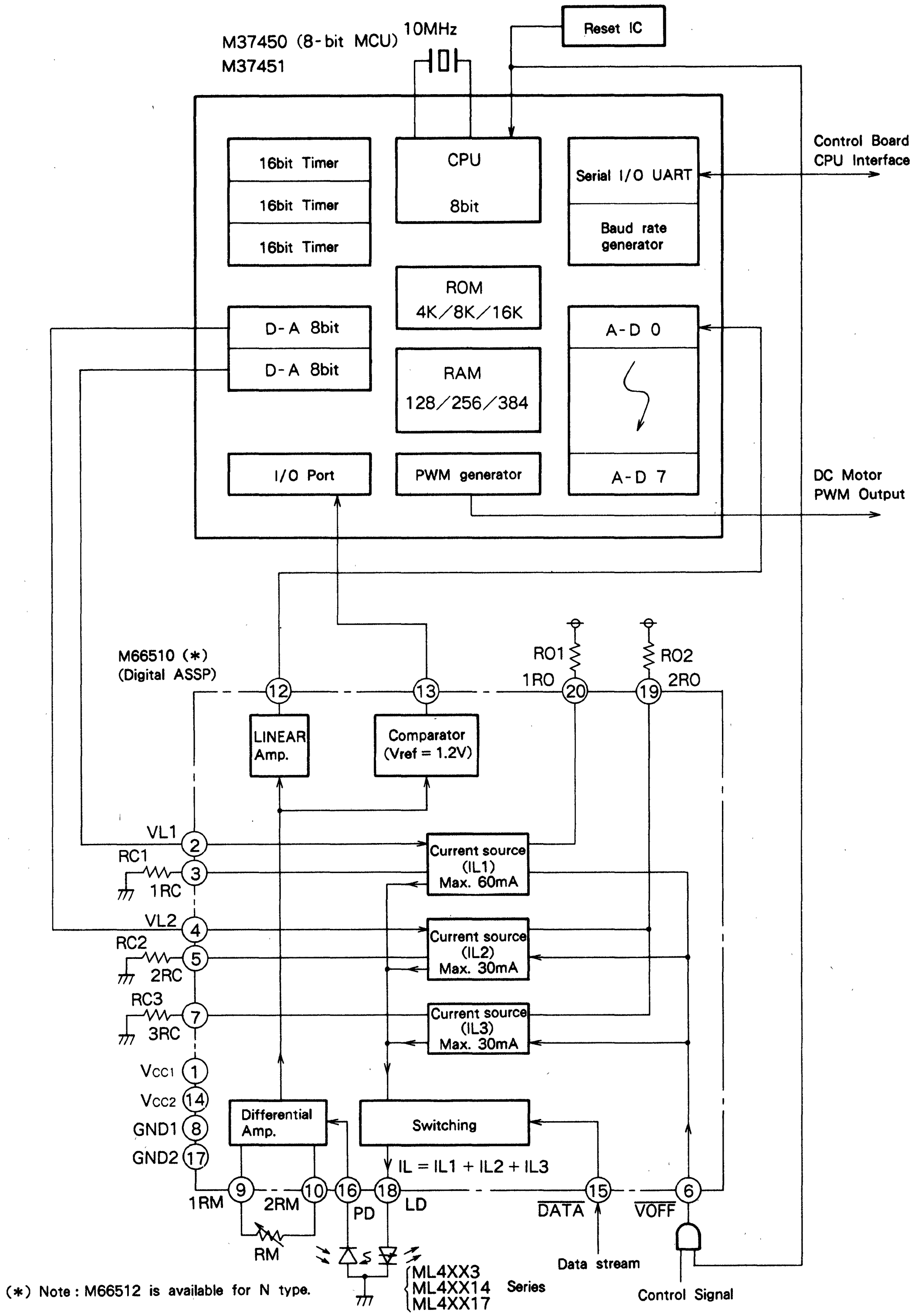






MITSUBISHI ELECTRIC

■ APPLICATION(LASER BEAM PRINTER)



(*) Note : M66512 is available for N type.

As the operating life time of optical devices, especially laser diodes, is important for reliability, it is explained at this page. We sincerely hope that the "Mitsubishi semiconductor reliability handbook" will be of value for basic concepts for quality, quality assurance system, reliability theory and reliability tests of Mitsubishi semiconductor devices.

1. Definition of life time

The life time of laser diodes is defined as the change of the light output power P versus forward current I_F characteristic because the P-I characteristic is the most important factor for laser diodes.

In Fig. 1 (a) shows P-I characteristic under initial condition.

The laser should be operated continuously and its light output power (P_O) should be kept constant by the APC drive.

Operating current $I_{OP(O)}$ at initial condition increases until I_{OP} (to) that is caused by decreasing slope efficiency and increasing threshold current as a result of degradation of the crystal. (Fig. 1 (b)) As degradation increases, a constant light output (P_O) can't be kept. (Fig. 1 (c))

Fig. 2 shows an example of operating current I_{OP} (t) vs. operating time t.

Life time is defined as the time at which the operating current Iop (t) is 1.5times as large as the initial operating current I_{OP} (o).

In Fig. 1, the life time of laser diodes just corresponds to condition (b).

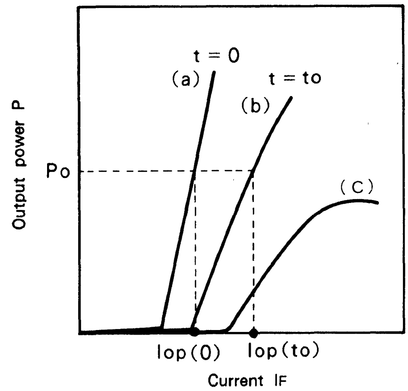


Fig. 1 Light output power vs. forward current characteristic of laser diode

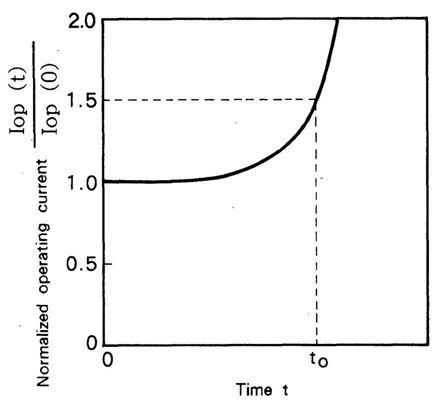


Fig. 2 Change in time of operating current

2. Occasion of influence on lifetime

In the operating condition a large injection current density~kA/c㎡ and a large optical density~MW/c㎡ exist in certain areas of the active region of laser diode, so their permitted quantity is not large for excessive current injection and excessive light output power.

So for practical purposes do not use the absolute maximum rating of the individual laser diodes.

Under the maximum absolute values the case temperature influences the operating lifetime of the laser diode. Increasing case temperature causes the injection current to increase the temperature of the active region, this results in accelerated degradation. Increasing the light output power causes the optical density to increase resulting in accelerated degradation.

Acceleration of degradation caused by temperature and light output power is expressed experimentally as follows.

(1) Accelerated life time due to temperature increase
Arrhenius formula can be applied to the failure rate of a laser diode just like almost any other semiconductor. Life time acceleration factor A_L between case temperature T_0 (K) and T_1 (K) is indicated as follows.

$$A_L = e^{\frac{\Delta E}{k}\left(\frac{1}{T_0}-\frac{1}{T_1}\right)} = e^{11606 \times \Delta E\left(\frac{1}{T_0}-\frac{1}{T_1}\right)}$$

where Δ E (ev) is the activation energy, k is Boltzmann's constant.

For example, in the case where $\Delta E = 1$eV, and the temperature rise is 10℃ from room temperature (300k), the lifetime acceleration factor is 2.8.

Fig. 3 shows the example of mean time to failure (MTTF) vs. case temperature Tc (℃).

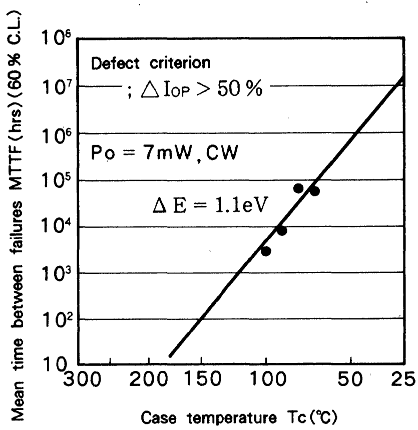


Fig. 3 Life dependency on case temperature Tc

(2) Accelerated lifetime due to increased light output power.

There is no qualitative formula for accelerated lifetime due to increased light output power, but it is expressed experimentally as follows.

$$B_L = \left(\frac{P_2}{P_1}\right)^n$$

where B_L is the lifetime acceleration factor between the light output powers P_1 and P_2.

In the case where n = 2, and the light output power change from 2mW to 4mW, the life time acceleration factor is 4.

Fig. 4 shows the example of mean time to failure (MTTF) vs. light output power (Po).

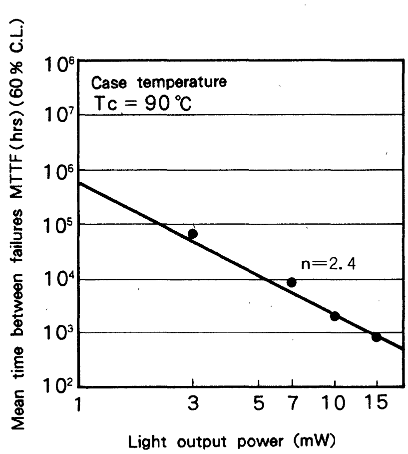


Fig. 4 Life dependency on light output power Po

■ Safety considerations for laser diodes

Mitsubishi laser diodes are all put given operating aging tests at high temperature and have high reliability.

In order to keep this reliability, take care with the following points.

- **Maximum rating**
  Laser is a semiconductor device which has high current density and high optical density of about 2.1 μm × 0.7 μm near field (ML4000 series). Degradation of devices should be considered more carefully than silicon semiconductor devices. Therefore, the absolute maximum ratings should never be exceeded even for a short time.
- **Surge current and heat radiation**
  In operating laser diodes, sufficient surge protection measures are required. Surge current is easily produced during power switching and output adjustment.
  Referring to the example of connections for laser operation, and make sure that sufficient care is taken.

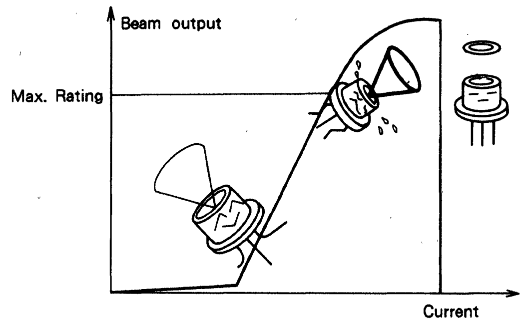


Fig. 1 Light output power vs.
forward current characteristic of laser diode

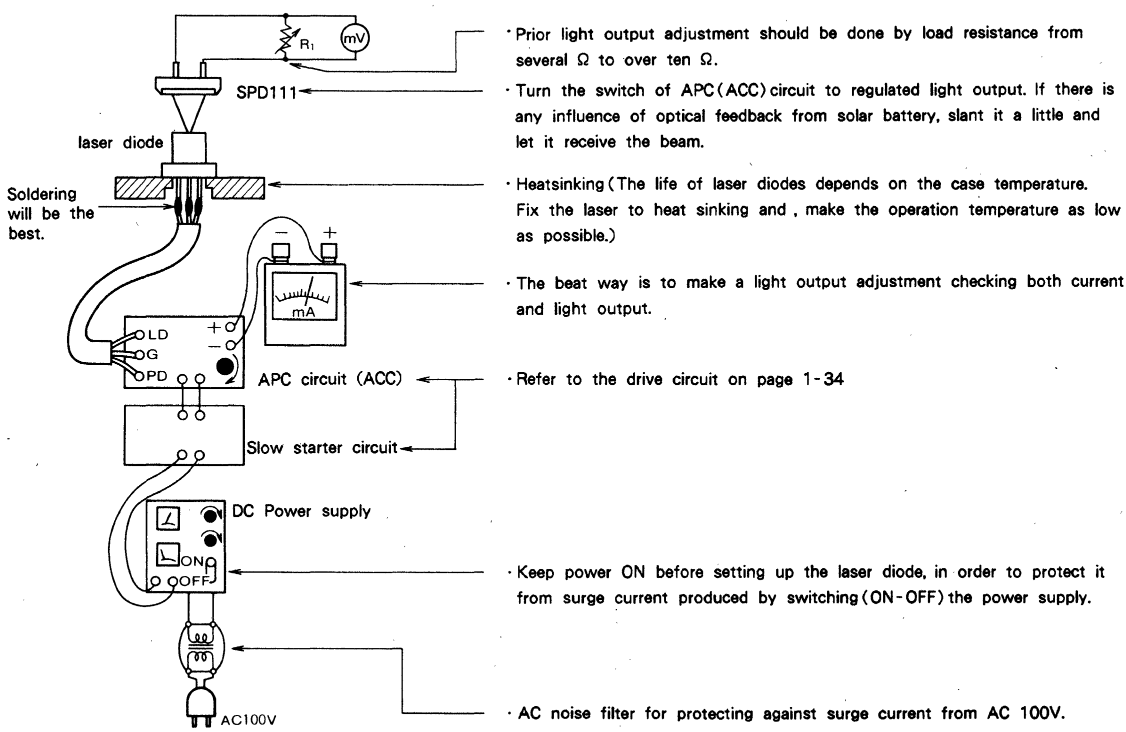
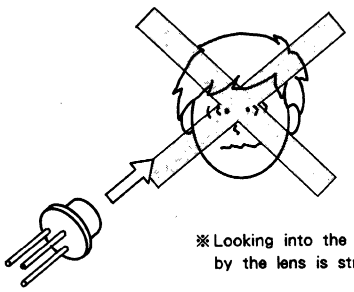


Fig. 2 Example of surge current suppressing and heat releasing circuit

● Safeties

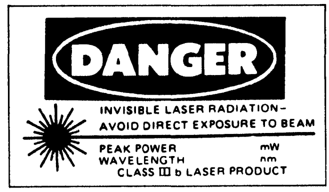
The laser beam from the laser (diode) mainly consists of near infrared rays and is very harmful to the human eyes though it is invisible. Take great care not to look directly into the luminous point when the laser is in operation. The laser beam can be observed by with an IR viewer, ITV camera or a simpler, IR phosphor device (made by KODAK corp.), which can all detect infrared rays.



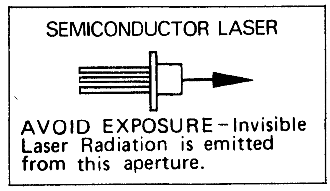
※Looking into the output beam condensed by the lens is strictly prohibited.

For each device, each of the labels shown right are attached to the individual laser container.

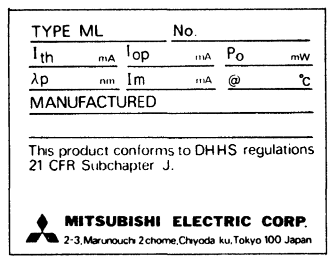
They are illustrated to comply with the requirements of DHHS standards under the Radiation Control for Health and Safety Act of 1968.



Warning Label



Aperture Label



Identification and Certification Label

LASER DIODES

2

TYPE NAME **ML2701**

DESCRIPTION

ML2XX1 is a high-Power AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 830-870nm and standard light output of 8mW.

ML2XX1 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as short-distance optical communications.

FEATURES

- Single longitudinal mode
- Short astigmatic distance
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Optical communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	10	mW
		Pulse (Note 1)	15	
V_{RL}	Reverse voltage (Laser diode)	–	3	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+70	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

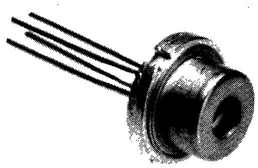
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	30	50	mA
I_{OP}	Operating current	CW, P_O = 8mW	–	55	90	mA
V_{OP}	Operating voltage	CW, P_O = 8mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 8mW	–	0.32	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 8mW	830	850	870	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 8mW	–	12	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 8mW	–	35	–	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 8mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.3	0.8	2.0	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

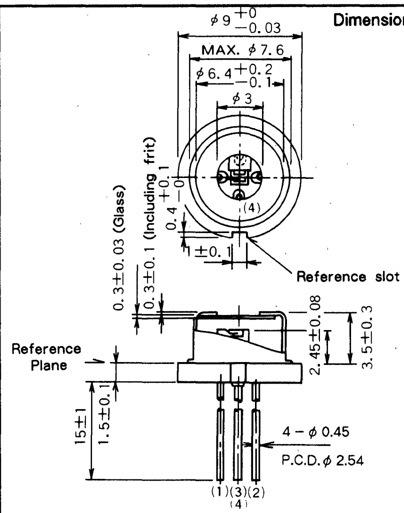
Note 2 : R_L is load resistance of the photodiode.

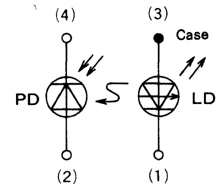
OUTLINE DRAWINGS

ML2701



Dimensions in mm





MITSUBISHI ELECTRIC

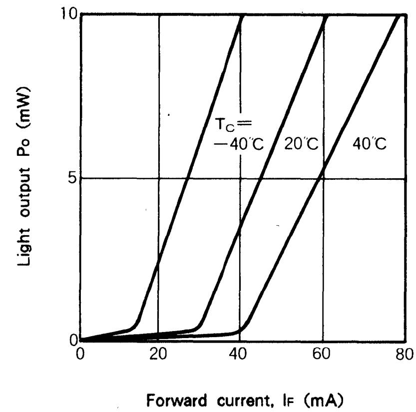
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 30mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 8mW is obtained at I_{th} + 25mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the outputcurrent of the built-in monitor PD becomes constant.)

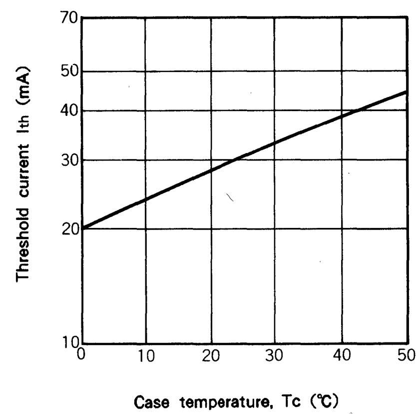
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current typically 65K in $T_C \leqq 50$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

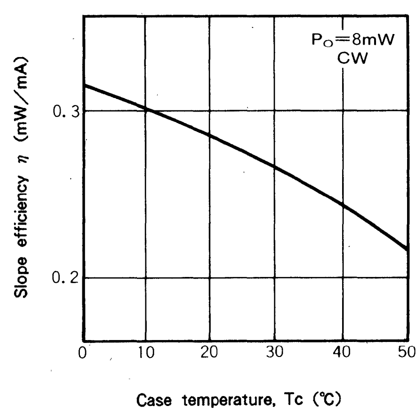
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is − 0.002mW/mA/℃.

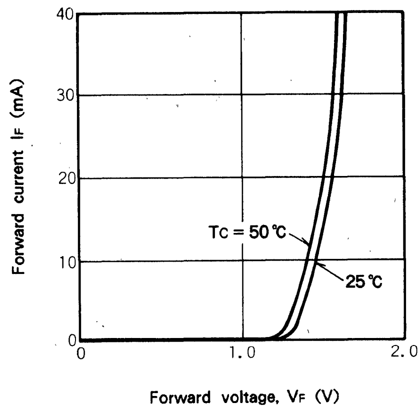
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-2.0mV/°C$ at $I_F = 1mA$.

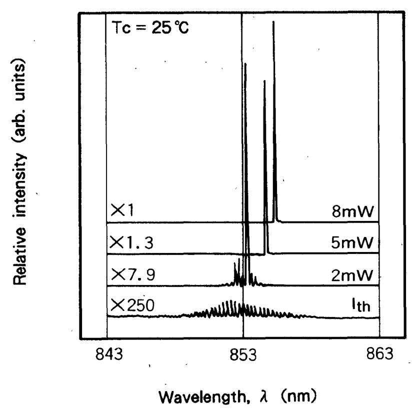
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectrum under CW operation are shown in Fig.5. In general, at an output of 5mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

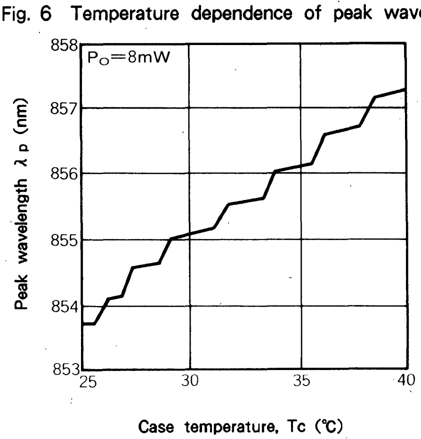


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW 8mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25 nm/°C typical.

Fig. 6 Temperature dependence of peak wavelength



MITSUBISHI ELECTRIC

7 Far-field pattern

ML2XX1 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area(size of near-field pattern) of 2.1 × 0.7 μ m². Fig.7 and Fig.8 show typical farfield radiation patterns in " parallel " and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 12° and 35° .

Fig. 7 Far-field patterns in plane parallel to heterojunctions

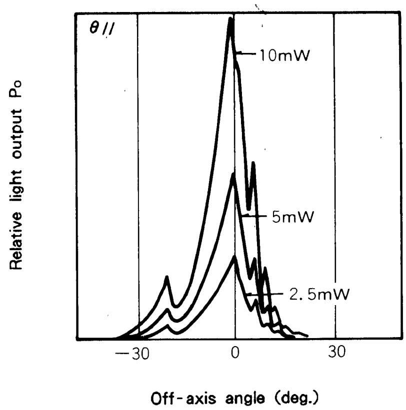
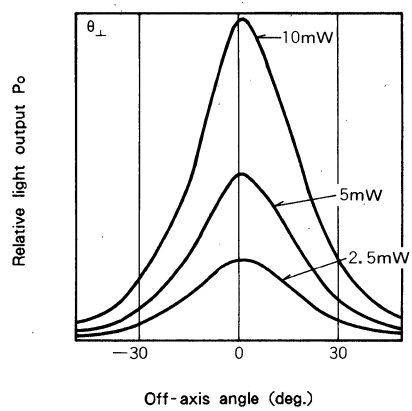


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions

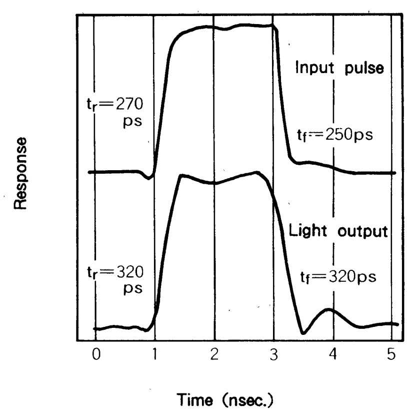


8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Figure 9 shows a standard response waveform obtained by biasing ML2XX1 to Ith and applying a square pulse current (top of Fig.9) up to 8mW.A quick response is obtained with rising and falling times being both 0.3ns typical.

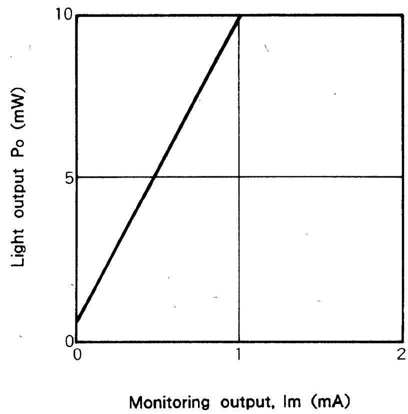
Fig. 9 Pulse response waveform



9 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs. monitoring photocurrent characteristics. The monitored photocurrent linearly increases with the light output.

Fig. 10 Light output vs. monitoring output current

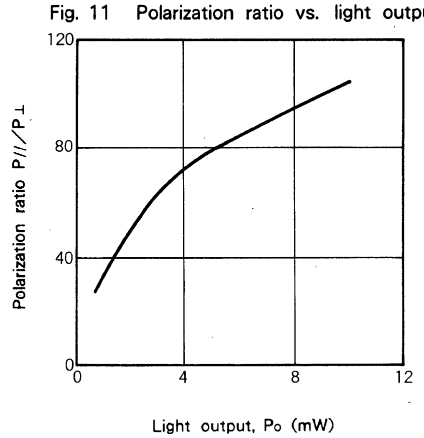


10 Polarization ratio vs. light output characteristic

The main polarization of ML2XX1 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 11 shows the standard polarization ratio vs. Total light output characteristic.

The polarization ratio increases with the light power.

Fig. 11 Polarization ratio vs. light output

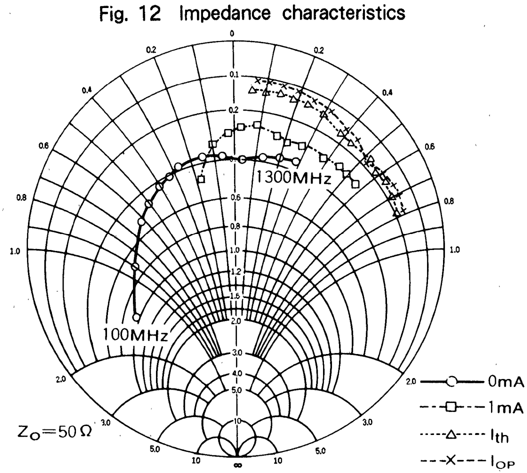


11 Impedance characteristics

Typical impedance characteristics of the ML2XX1, with lead lengths of 2mm, is shown in Fig.12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance of the ML2XX1 is nearly equal to a series connection of a resistance of 5 ohm and an inductance of 5nH.

Fig. 12 Impedance characteristics



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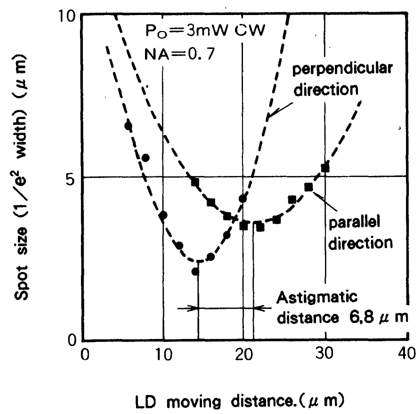
12 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance betweeen the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions.Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML2XX1 is shown in Fig.13.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 13 Astigmatic distance



TYPE NAME

ML3101, ML3411

DESCRIPTION

ML3XX1 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation of a standard light output of 3mW around emission wavelength of 850nm.

ML3XX1 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-perfomance, highly reliable, and long-life semiconductor laser is suitable for such applications as optical information processing and precision telemetry.

FEATURES

- Single longitudinal mode
- Short astigmatic distance (1 μm standard)
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Laser beam printer, telemetry, instrumentation, alignment, and optical communication

ABSOLUTE MAXIMUN RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	3.5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	3	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40~+60	℃
T_{stg}	Storage temperature	–	−55~+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

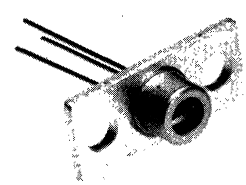
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits Min.	Typ.	Max.	Unit
I_{th}	Threshold current	CW	–	20	40	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	30	50	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.3	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	830	850	870	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	18	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	30	50	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.1	0.3	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

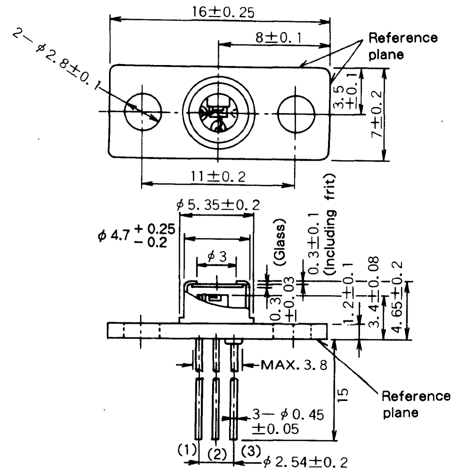
Note 2 : R_L is load resistance of the photodiode.

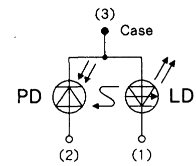
OUTLINE DRAWINGS

ML3101

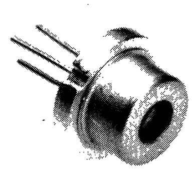


Dimensions in mm

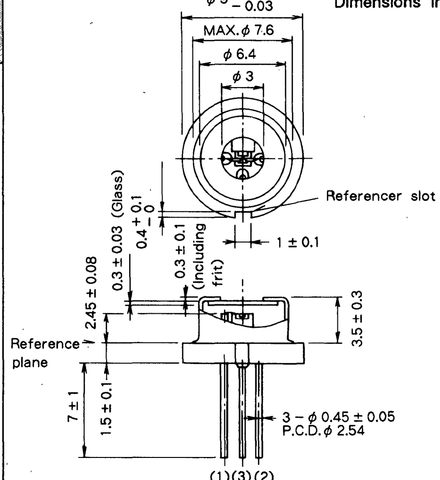


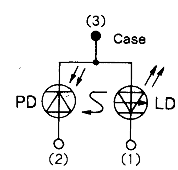


ML3411



Dimensions in mm





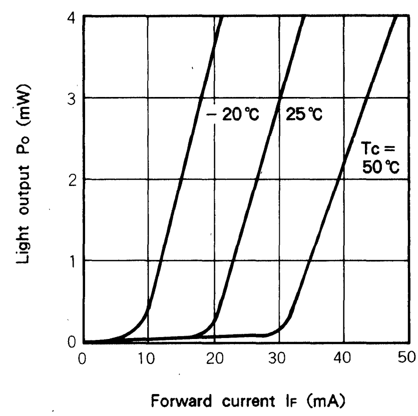
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 20mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 10 mA.

Beacause I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

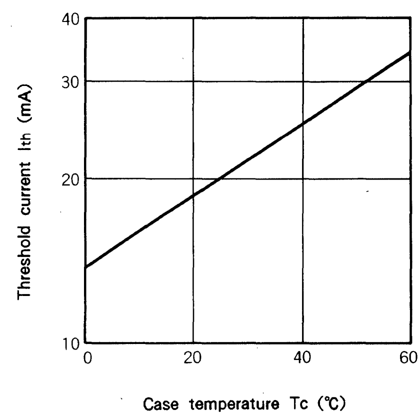
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature. T_O of the threshold current is typically 65K in $T_C \leqq 50$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$

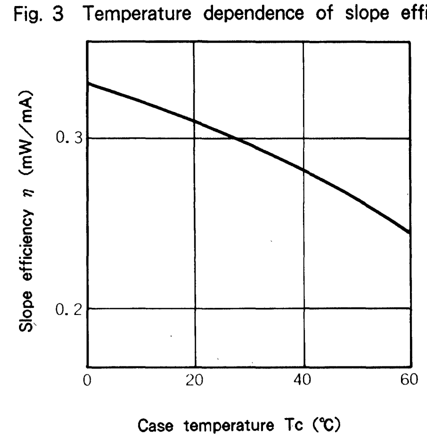
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is −0.0015mW/mA/℃.

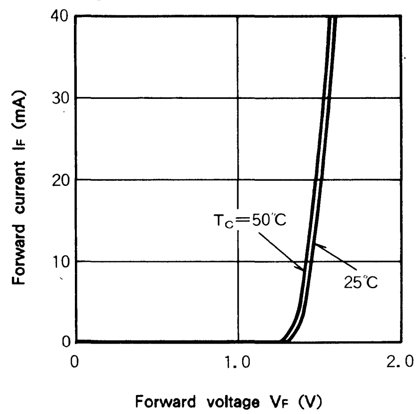
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

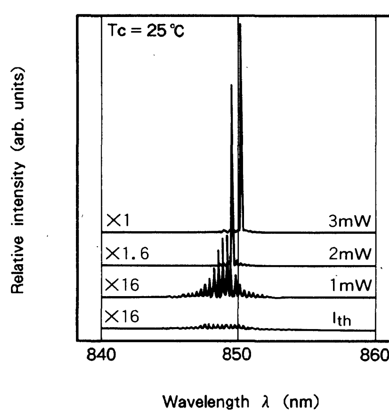
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectrum under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

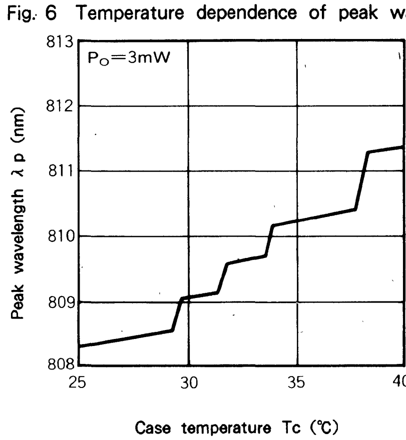


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

ML3XX1 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area (size of near-field pattern) of $2.2 \times 0.8 \mu m^2$. Fig.7 and Fig.8 show typical farfield radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 30°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

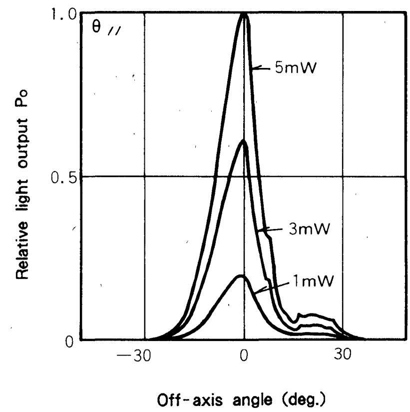
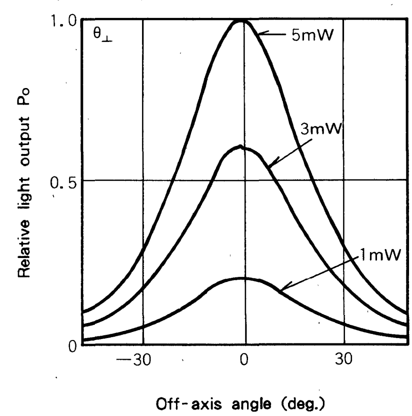


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$

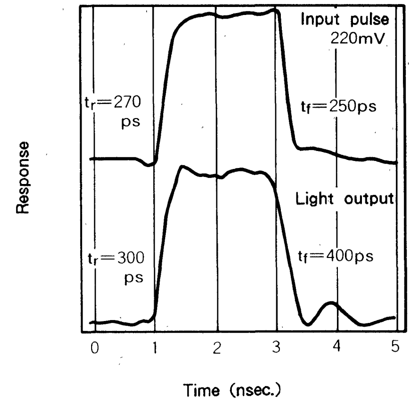


8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Figure 9 shows a standard response waveform obtained by biasing ML3XX1 to Ith and applying a square pulse current (top of Fig. 9) up to 3mW. A quick response is obtained with rising and falling times being 0.3ns and 0.4ns typical respectively.

Fig. 9 Pulse response waveform



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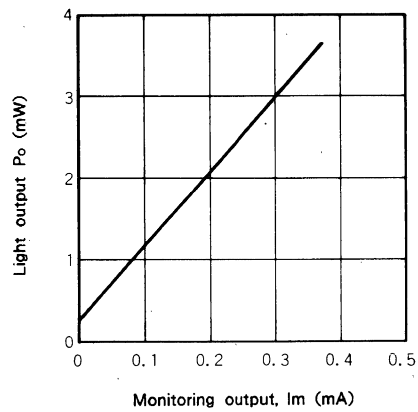
9 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs monitoring photocurrent characteristics. When the front baeam output is 3mW, the monitor output becomes 0.3mA.

Fig. 10 Light output vs. monitoring output current

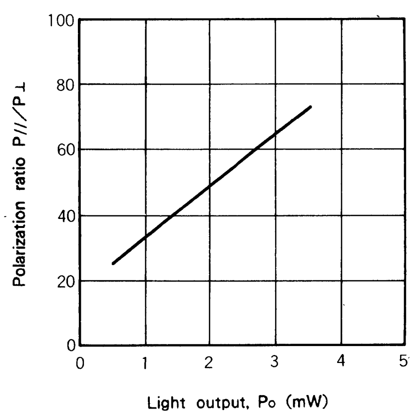


10 Polarization ratio vs. light output characteristic

The main polarization of ML3XX1 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendiculat to it. Figure 11 shows the standard polarization ratio vs. total light output characteristic.

The polarization ratio increases with the light power.

Fig. 11 Polarization ratio vs. light output

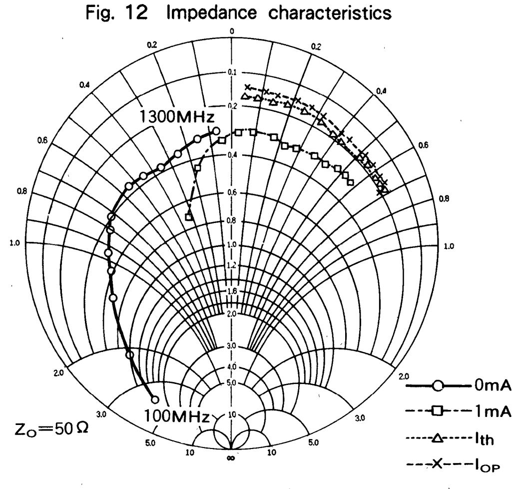


11 Impedance characteristics

Typical impedance characteristics of the ML3XX1, with lead lengths of 2mm, is shown in Fig.12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance of the ML3XX1 is nearly equal to a series connection of a resistance of 5ohm and an inductance of 5nH.

Fig. 12 Impedance characteristics



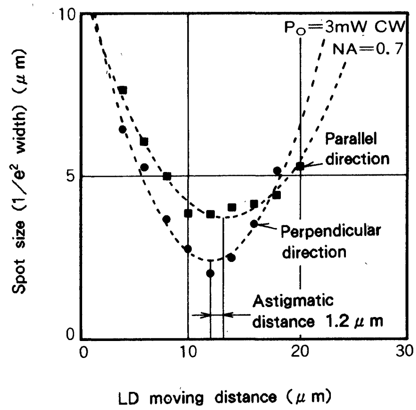
12 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA=0.7 of ML3XX1 is shown in Fig.13.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 13 Astigmatic distance



TYPE NAME **ML4012N, ML4102, ML4402, ML4412N, ML4442N**

DESCRIPTION

ML4XX2 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780 nm and standard light output of 3mW.

ML4XX2 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-perfomance, highly reliable, and long-life semiconductor laser is suitable for such applications as optical disk reading and optical information processing.

FEATURES

- Single longitudinal mode
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Audio compact disk player, laser beam printer, optical distance meter, Bar code reader, optical alignment

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	– 40～+ 60	℃
T_{stg}	Storage temperature	–	– 55～+ 100	℃

Note 1 : Duty less than 50 %, pulse width less than 1 μ s.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25 ℃)

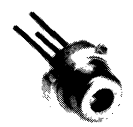
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	30	60	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	40	70	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.3	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	33	45	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.15	0.35	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μ A
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

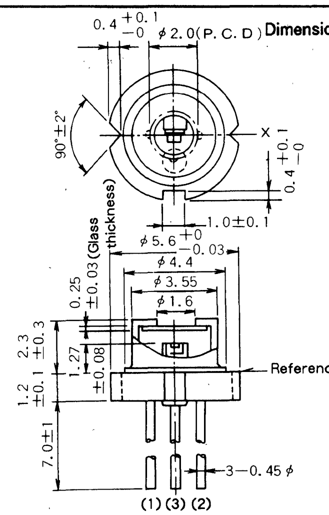
Note 2 : R_L is load resistance of the photodiode.

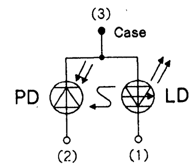
FOR OPTICAL INFORMATION SYSTEMS

OUTLINE DRAWINGS

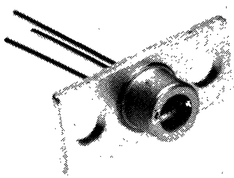
ML4012N

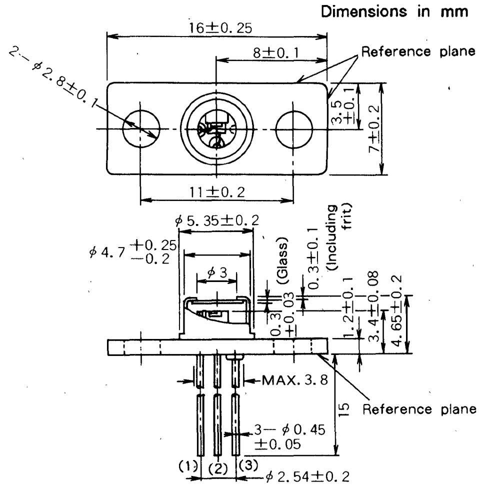


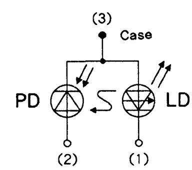




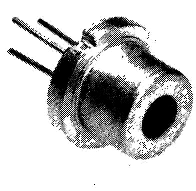
ML4102

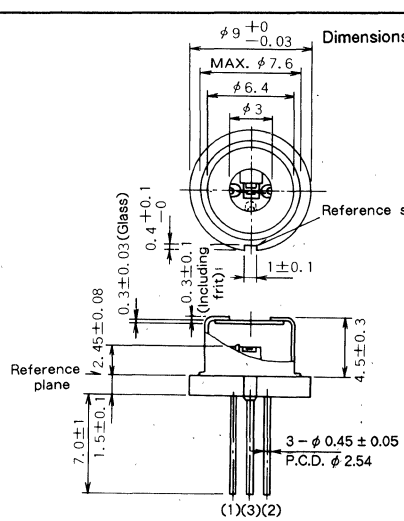


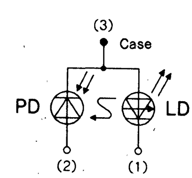




ML4402







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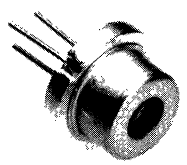
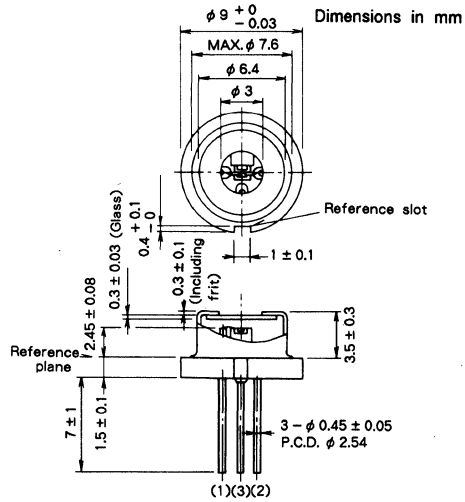
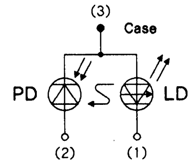
FOR OPTICAL INFORMATION SYSTEMS

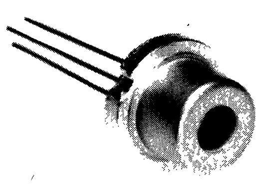
ML4412N

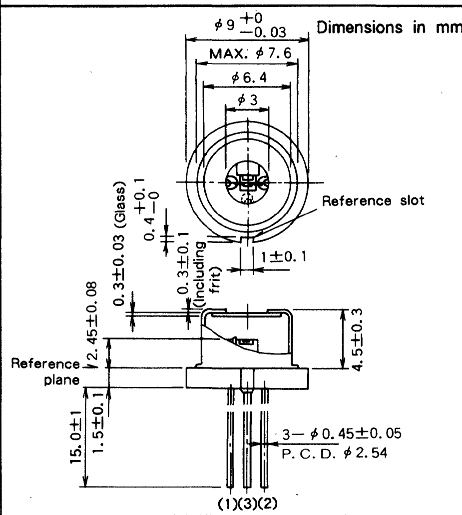


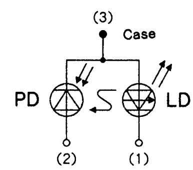




ML4442N







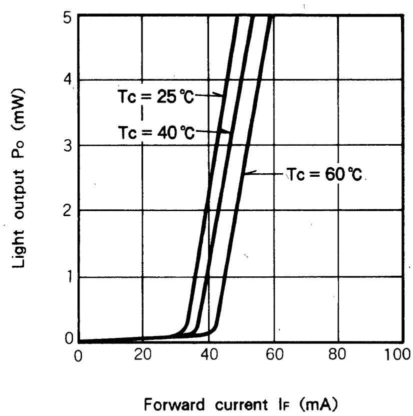
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 30mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 10mA.

Beacause I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

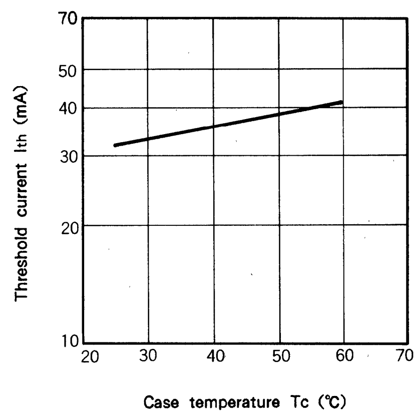
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current is typically 140K in $T_C \leqq 60$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$

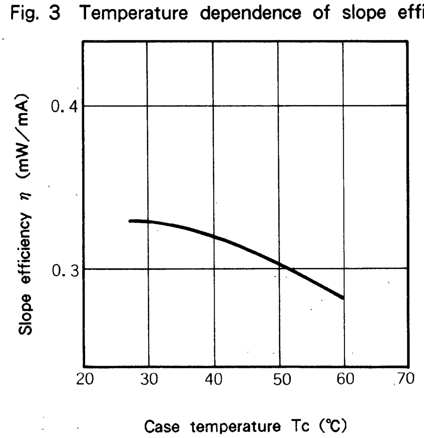
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is −0.0014mW/mA/℃.

Fig. 3 Temperature dependence of slope efficiency



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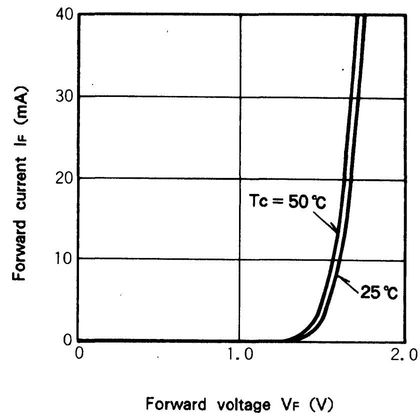
4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-2.0mV/°C$ at $I_F = 1mA$.

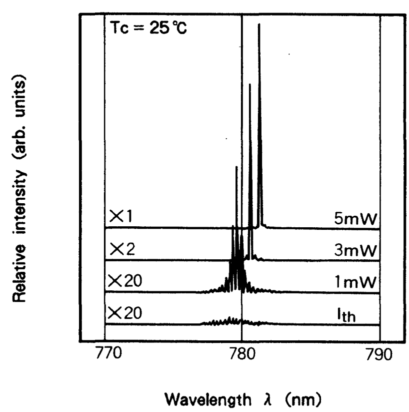
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

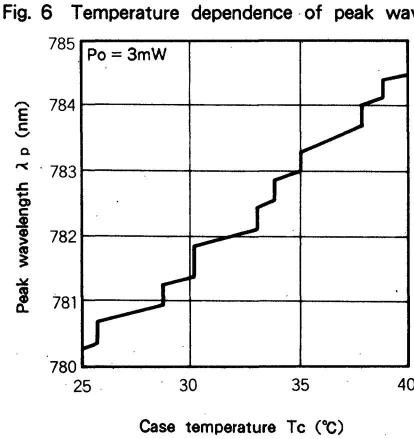


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.26nm/°C typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

ML4XX2 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area (size of near-field pattern) of 2.1 × 0.7 μm². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximun points (FAHM) are typically 11° and 33°

Fig. 7 Far-field patterns in plane parallel to heterojunctions θ//

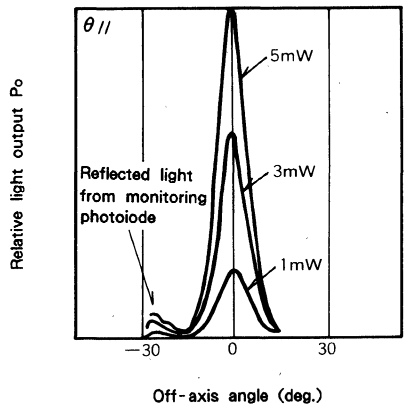
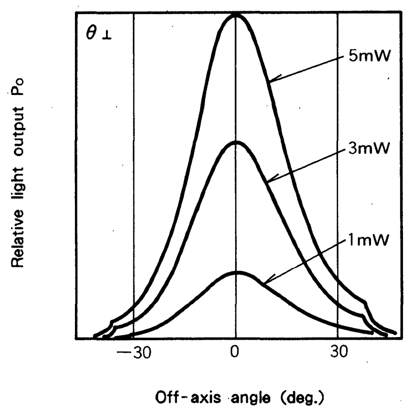


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions θ⊥

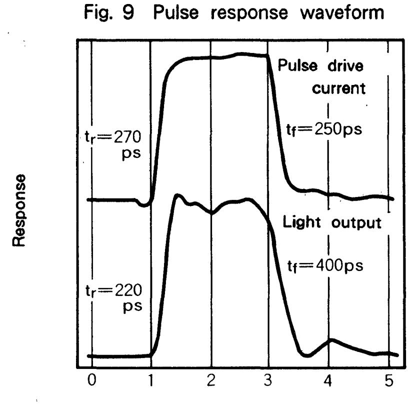


8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current since the delay time is a time for charging the junction up to the threshold current. Figure 9 shows a standard response waveform obtained by biasing ML4XX2 to I_{th} and applying a square pulse current (top of Fig.9) up to 5mW. A quick response is obtained with rising and falling times being 0.3ns and 0.4ns typical respectively.

Fig. 9 Pulse response waveform

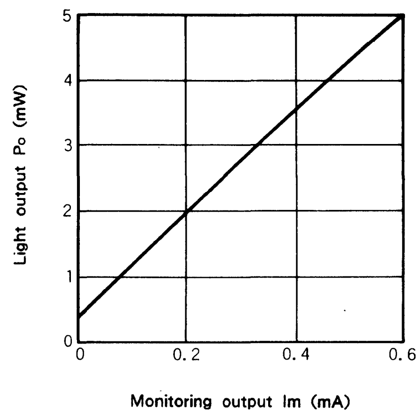


MITSUBISHI ELECTRIC

9 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs. monitoring photocurrent characteristics. When the front beam output is 3mW, the monitor output becomes 0.3 mA.

Fig. 10 Light output vs. monitoring output current

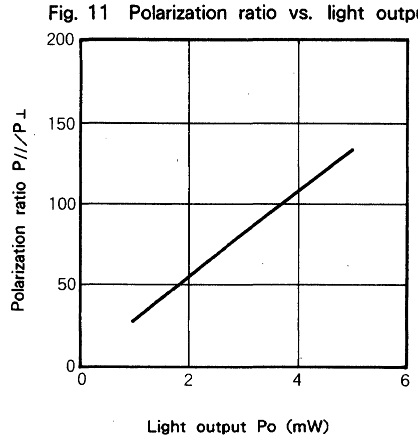


10 Polarization ratio vs. light output characteristic

The main polarization of ML4XX2 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 11 shows the standard polarization ratio vs. total light output characteristic.

The polarization ratio increases with the light power.

Fig. 11 Polarization ratio vs. light output



11 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.12.

That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.13.

The S/N value is the worst value obtained at case temperatures of 25℃ to 50℃.

Fig. 12 S/N vs. optical feedback ratio

f=20kHz, BW=300Hz, T_C=25−50℃

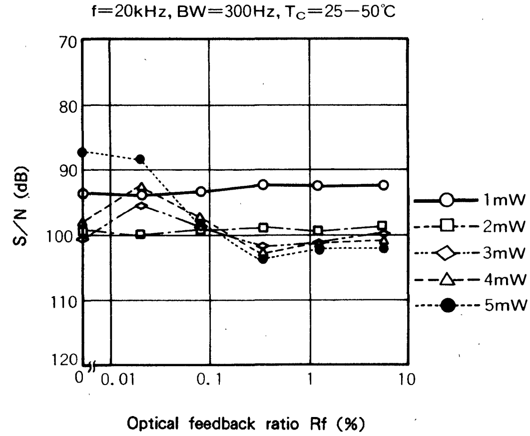
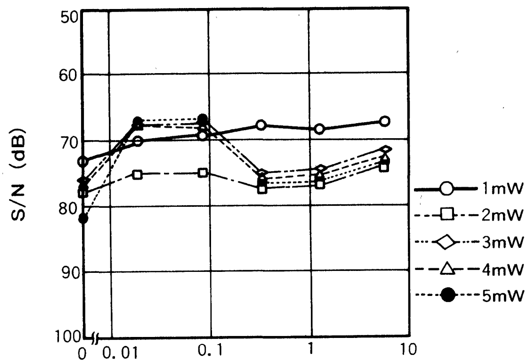


Fig. 13 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz, T_C=25−50°C



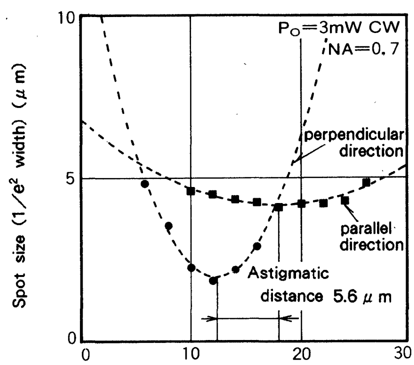
12 Astigmatic focal distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, Terefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX2 is shown in Fig.14.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 14 Astigmatic focal distance



TYPE NAME

ML4102A, ML4402A, ML4412A

DESCRIPTION

ML4XX2A is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX2 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as optical disk reading and optical information processing.

FEATURES

- Low noise
- Built-in monitor photodiode
- High reliability, long operation life
- Multiple longitudinal mode

APPLICATION

Reading memory disk, video disk player, data link

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40~+60	℃
T_{stg}	Storage temperature	–	−55~+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

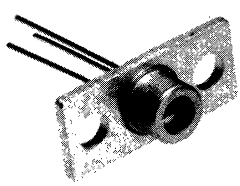
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

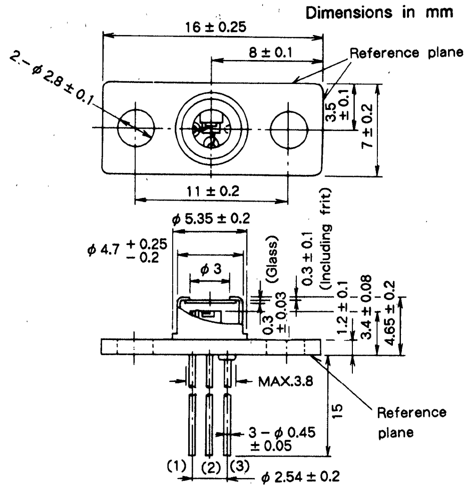
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	40	60	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	50	70	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.32	–	mW/mA
λ_P	Peak oscillation wavelength	CW, P_O = 3mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	33	45	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 1)	0.15	0.4	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

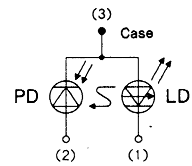
Note 2 : R_L is load resistance of the Photodiode.

OUTLINE DRAWINGS

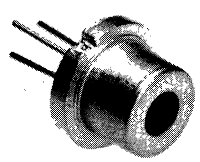
ML4102A

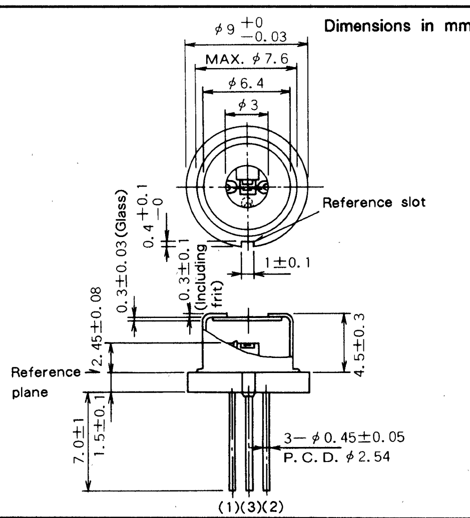


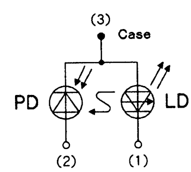




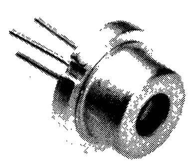
ML4402A

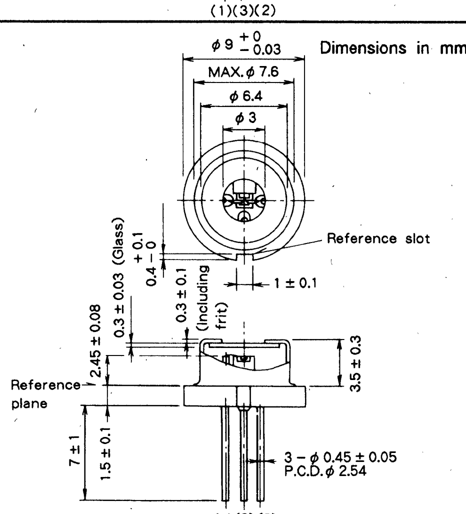


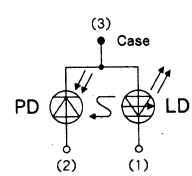




ML4412A







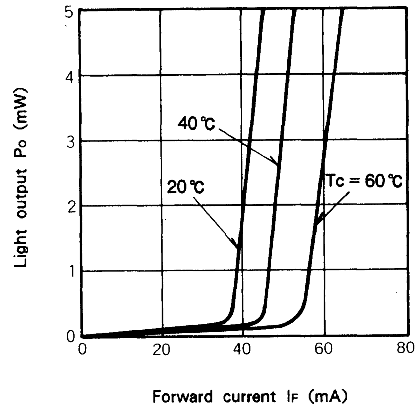
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 40mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 10mA.

Because I_{th} and slope efficiency η (dP_o/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

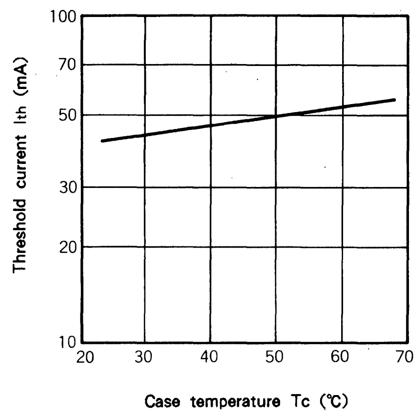
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic T_o of the threshold current is typically 140K in $T_c \leqq 70℃$, where the definition of T_o is $I_{th} \propto \exp(T_c/T_o)$

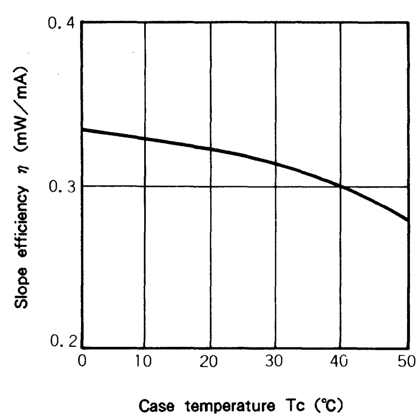
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is $-0.001 mW/mA/℃$

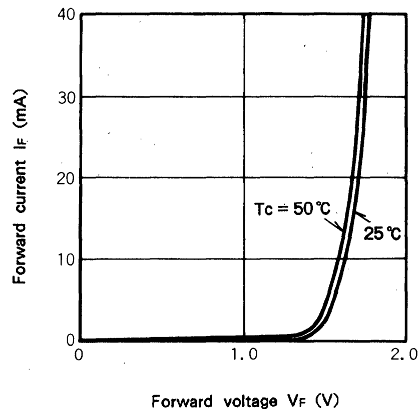
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

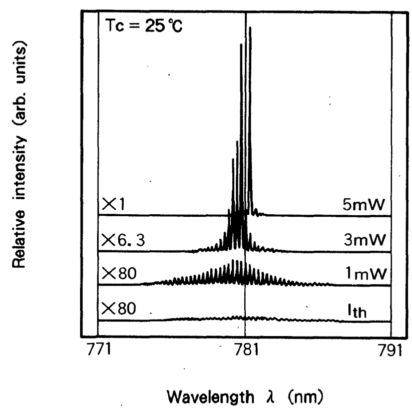
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig.5. Generally, at the output of about 3mW, the laster oscillates in the multi-mode; when the output is raised to about 5mW, it begins oscillating in the single mode. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

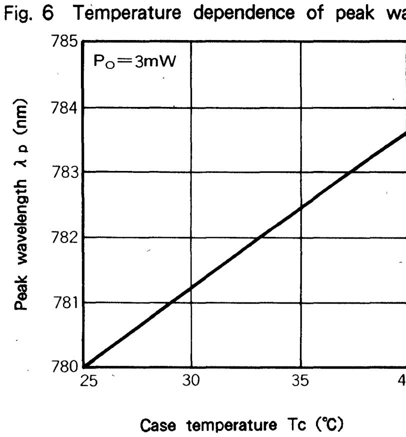


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

ML4XX2A oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area (size of near-field pattern) of 2.1 μm^2. Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 33°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

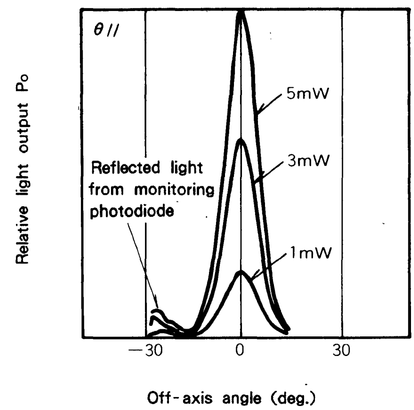
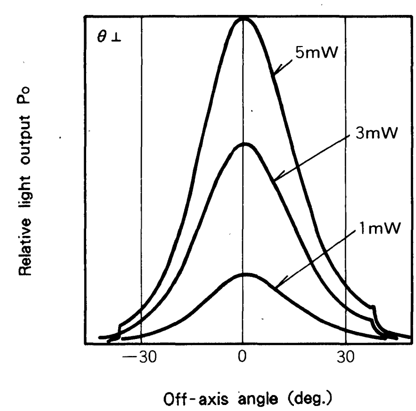


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$

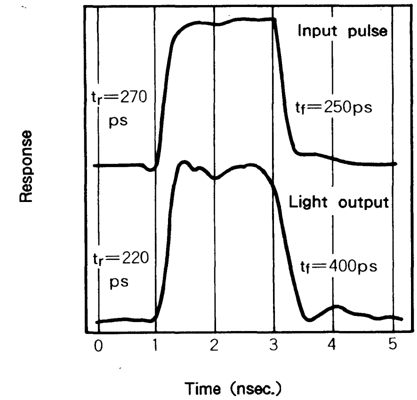


8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

Generally, the laser diode is biased up to near the threshold current to minimize oscillation delay time. Figure 9 shows a standard response waveform obtained by biasing ML4XX2A to Ith and applying a square pulse current (top of Fig.9) up to 3mW. The rise time and the fall time in Fig.9 are typically 0.3ns and 0.4ns. They are limited by response speed of the detecter.

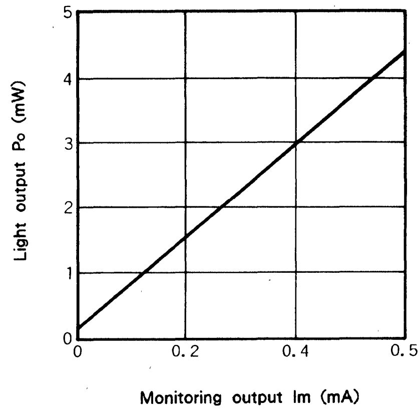
Fig. 9 Pulse response waveform



9 Light output vs. monitoring output characteristic

The laser diodes emit beams form both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs monitoring photocurrent characteristics. When the front beam output is 3mW, the monitor output becomes 0.4mA.

Fig. 10 Light output vs. monitoring output current

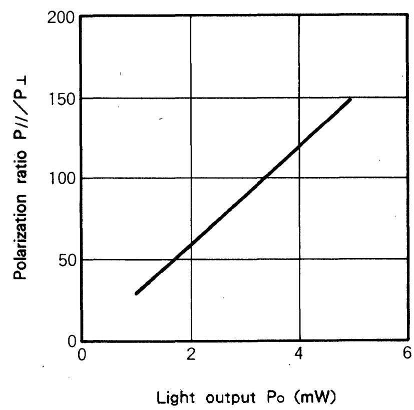


10 Polarization ratio vs. light output characteristic

The main polarization of ML4XX2A is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 11 shows the standard polarization ratio vs. total light output characteristic.

The polarization ratio increases with the light power.

Fig. 11 Polarization ratio vs. light output

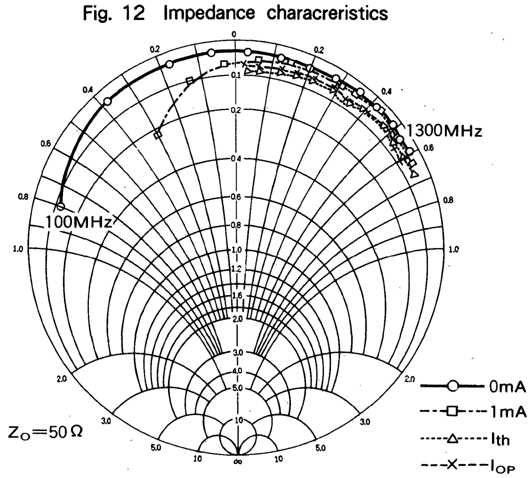


11 Impedance characteristics

Typical impedance characteristics of the ML4XX2A, with lead lengths of 2mm, and shown in Fig.12 with the bias currents as the parameter.

Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Fig. 12 Impedance characreristics



MITSUBISHI ELECTRIC

12 S/N vs. optical feedback ratio

S/N vs optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.13.

That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.14.

The S/N value is the worst value obtained at case temperatures of 25℃ to 50℃.

Fig. 13 S/N vs. optical feedback ratio
f=20kHz, BW=300Hz, T_C=25−50℃

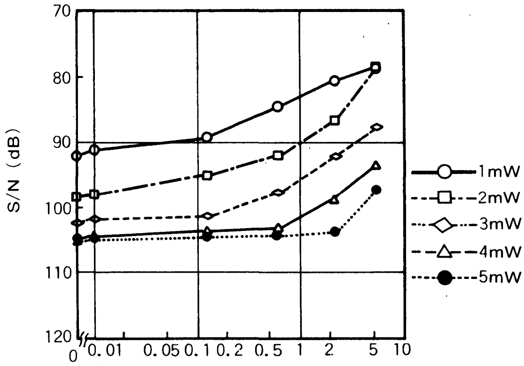
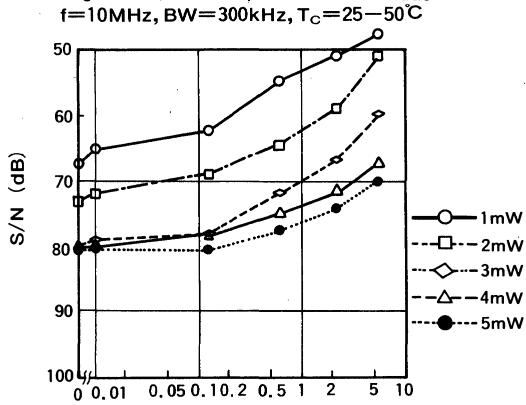


Fig. 14 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz, T_C=25−50℃



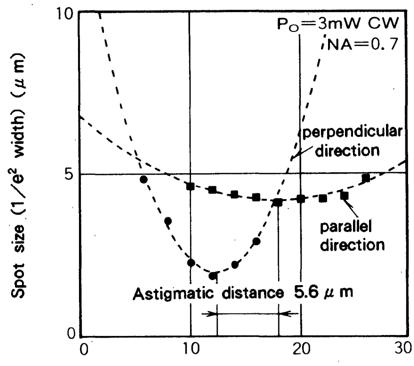
13 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX2A is shown in Fig.15.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 15 Astigmatic distance



TYPE NAME

ML4403, ML4403R, ML4413N, ML4413C

DESCRIPTION

ML4XX3 is an AlGaAs semiconductor laser Which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX3 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as laser beam printers.

FEATURES

- Single longitudinal mode
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life
- Low droop

APPLICATION

Laser beam printer

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case Temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

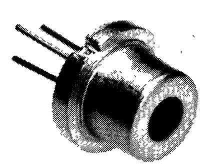
Symbol	Parameter	Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
I_{th}	Threshold current	CW	–	35	60	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	50	85	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.15	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	33	45	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.4	1.0	2.0	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

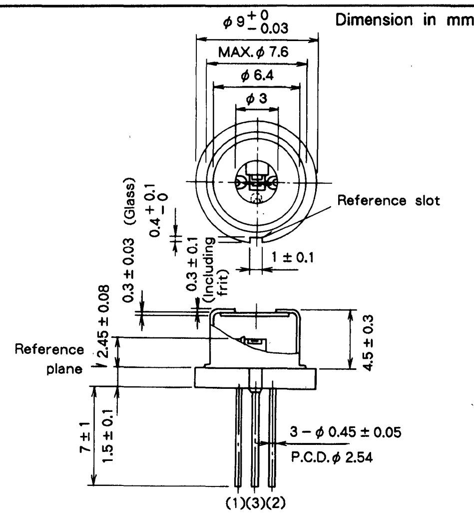
Note 2 : R_L is load resistance of the photodiode.

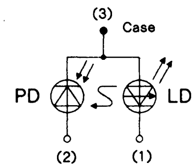
FOR OPTICAL INFORMATION SYSTEMS

OUTLINE DRAWINGS

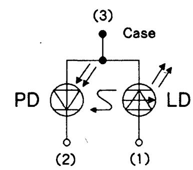
ML4403/ ML4403R





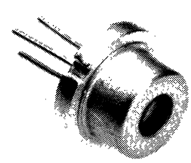


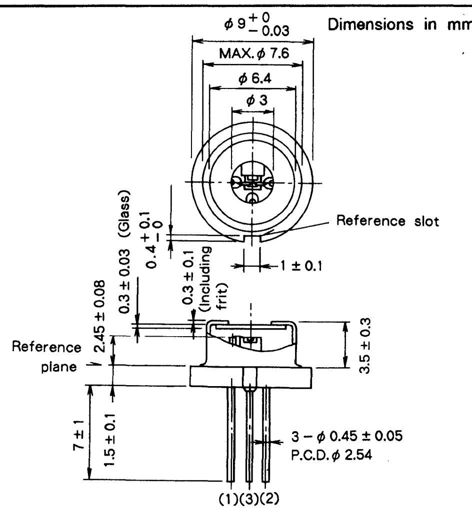
ML4403

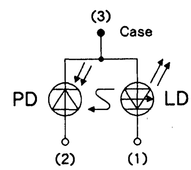


ML4403R

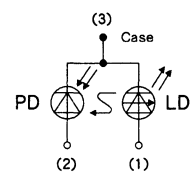
ML4413N/ ML4413C







ML4413N



ML4413C

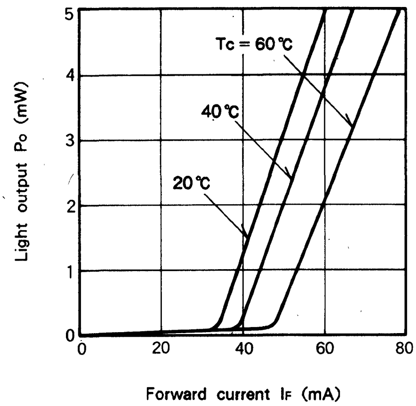
SAMPLE CHARACTERISTICS

1 Light output vs forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 35mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 15mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current.(Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

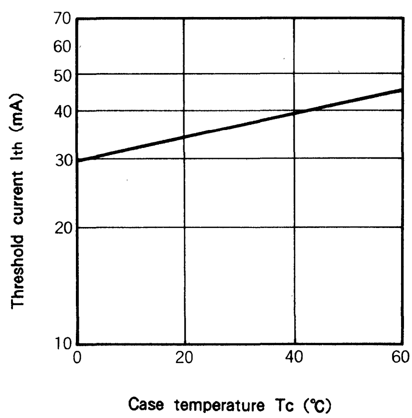
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown Fig.2. The characteristic temperature To of the threshold current is typically 130K in $T_C \leqq 60$℃, where the definition of To is $I_{th} \propto \exp(T_C/T_O)$

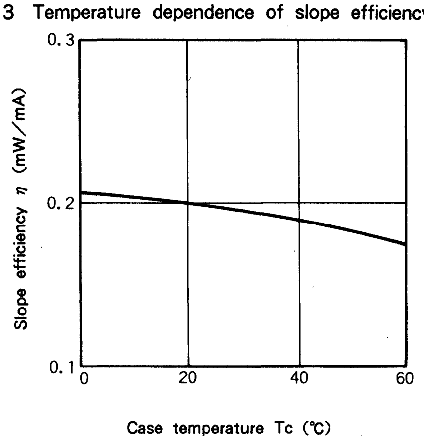
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficienty(η o)

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is −0.0005mW/mA/℃.

Fig. 3 Temperature dependence of slope efficiency

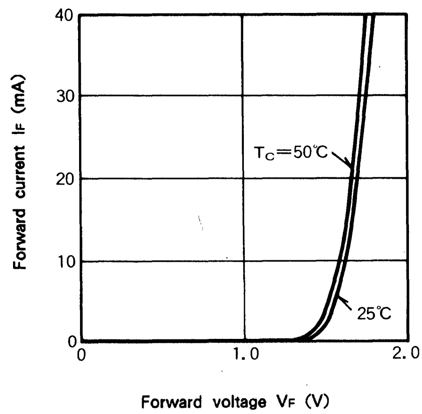


MITSUBISHI ELECTRIC

4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown ing Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F, V_F varies typically at a rate of $-2.0mV/°C$ at $I_F = 1mA$.

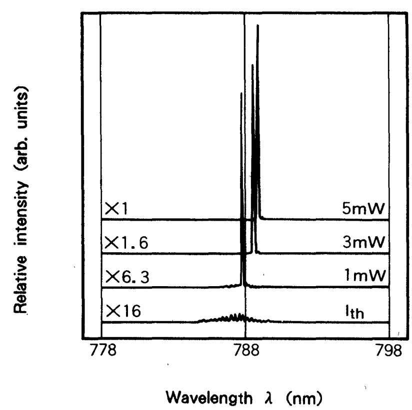
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

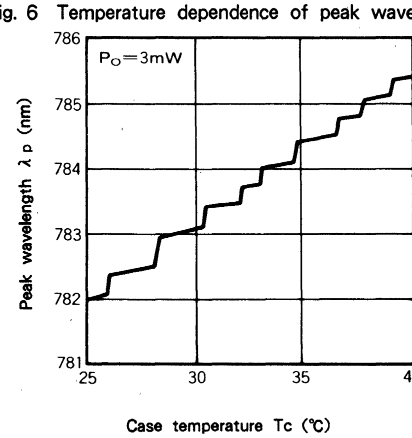


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.26nm/°C typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

ML4XX3 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output levle. They have a typical emitting area (size of near-field pattern) of 2.1 $\mu m^2 \times$ 0.7 μm^2. Fig.7. and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 33°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

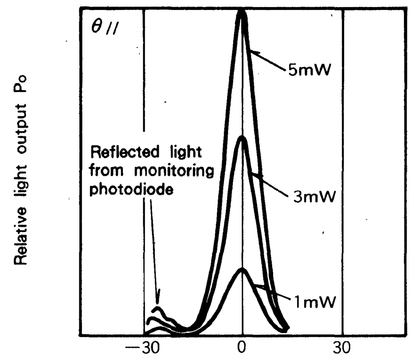
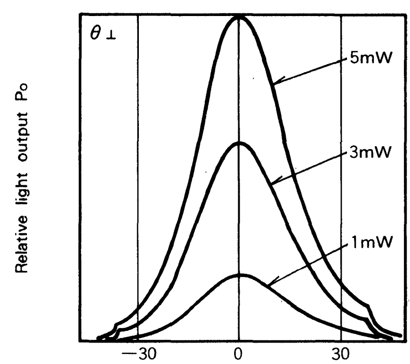


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$

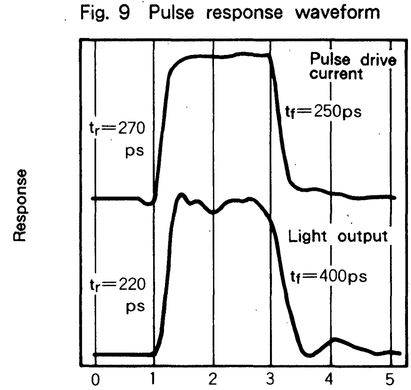


8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current since the delay time is a time for charging the junction up to the threshold. Figure 9 shows a standard response waveform obtained by biasing ML4XX3 to I_{th} and applying a square pulse current (top of Fig.9) up to 3mW. The rise time and the fall time in Fig.9 are typically 0.3ns and 0.4ns, respectively.

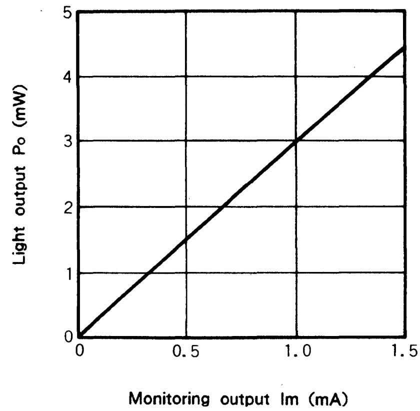
Fig. 9 Pulse response waveform



9 Light output vs. monitoring output characteristic

The laser diodes emit beams form both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs. monitoring photocurrent characteristics. When the fornt beam output is 3mW, the monitor output becomes 1.0mA.

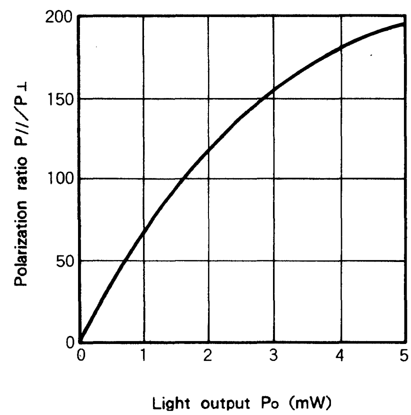
Fig. 10 Light output vs. monitoring output current



10 Polarization ratio vs. light output characteristic

The main polarization of ML4XX3 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 11 shows the standard polarization ratio vs. total light output characteristic.

Fig. 11 Polarization ratio vs. light output



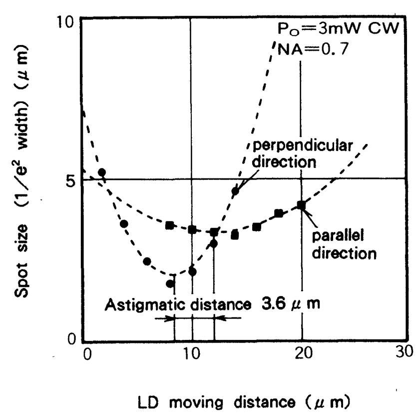
11 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX3 is shown in Fig.12.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 12 Astigmatic distance

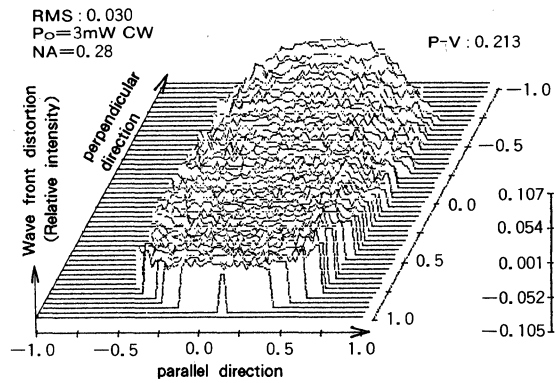


12 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML4XX3 is shown in Fig.13. This figure shows wave front (phase front) when laser beam is collimated.

Various aberrations are calculated by Zernike's polynomaial approximation for the interference fringes observed by the Mach-Zehnder interferometer.

Fig. 13 Wave front distortion



13 Droop

Droop characteristics indicate the amount which optical light output is down by heating up when constant pulse current is loaded on LD.

Definition is follows.

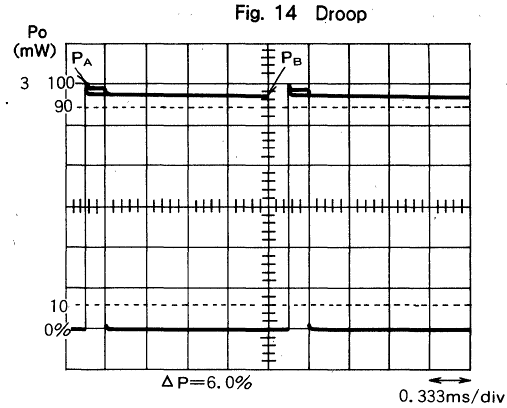
$$\Delta P = \frac{P_A - P_B}{P_B} \times 100\ (\%)$$

P_A : Initial value of monitoring current at 10% duty pulse.(600Hz)

P_B : Final value of monitoring current at 90% duty pulse.(600Hz)

Typical droop characteristic of ML4XX3 is shown in Fig.14. Typical droop value is 6% at P_A = 3mW.

Fig. 14 Droop



MITSUBISHI ELECTRIC

TYPE NAME

ML4405, ML4445N

DESCRIPTION

ML4XX5 is a visible light AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 750nm and standard light output of 3mW.

ML4XX5 uses a hermetically sealed package incorporating the photodiode for optical output monitoring.

This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as the light sources for a bar code readers and printer.

FEATURES

- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Bar code reader, laser beam printer

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case Temperature	–	–40～+60	℃
T_{stg}	Storage temperature	–	–55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

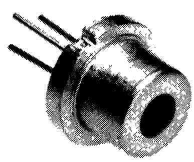
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

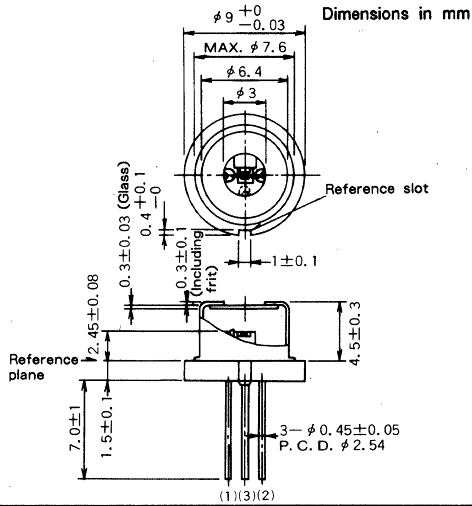
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	35	70	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	45	80	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	–	2.0	3.0	V
η	Slope efficiency	CW, P_O = 3mW	–	0.3	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	735	750	765	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	33	45	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.15	0.35	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

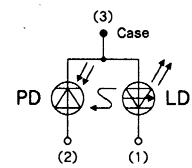
Note 2 : R_L is load resistance of the photodiode.

OUTLINE DRAWINGS

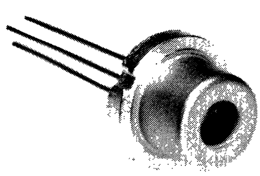
ML4405

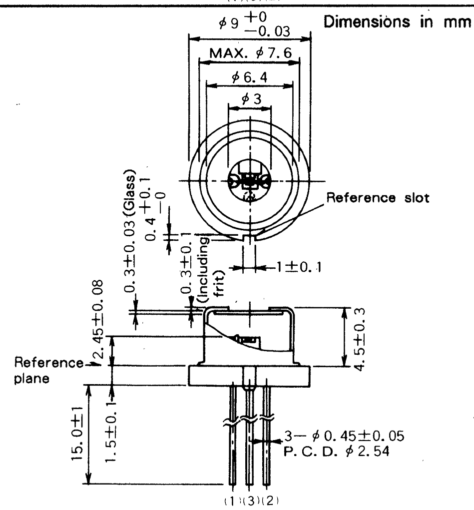


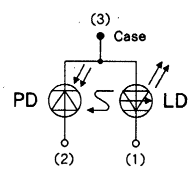




ML4445N







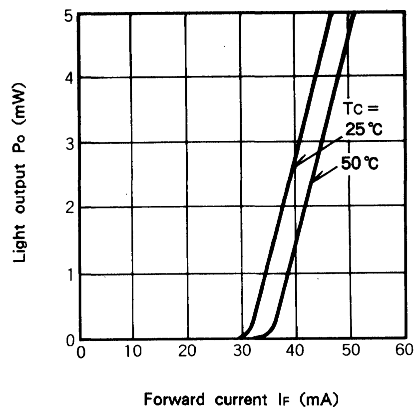
SAMPLE CHARACTERISTICS

1 Ligth output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 35mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 10mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

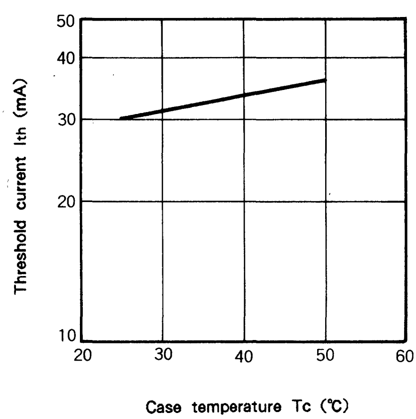
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current is typically 130K in $T_C \leqq 50$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$

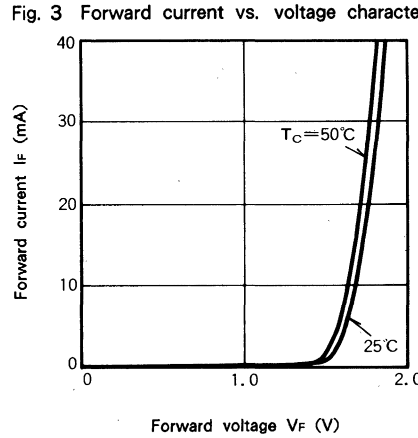
Fig. 2 Temperature dependence of threshold current



3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.3. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

Fig. 3 Forward current vs. voltage characteristics

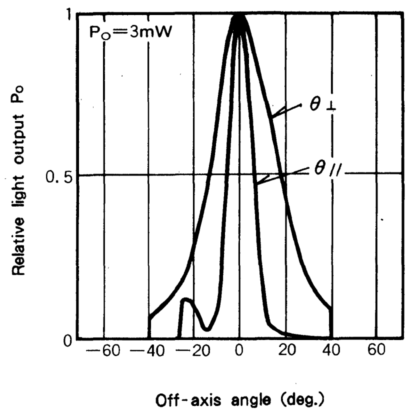


4 Far-field pattern

ML4XX5 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area (size of near-field pattern) of 2.1 × 0.7 μm^2. Fig.4 shows typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 33°.

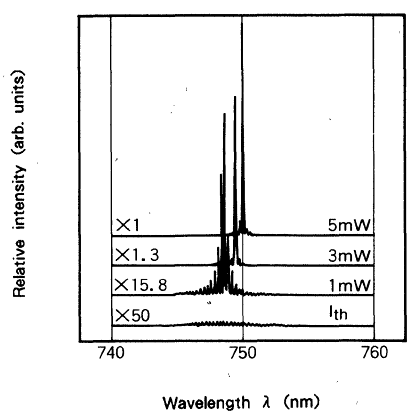
Fig. 4 Far-field patterns in parallel and plane perpendicular to heterojunctions



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

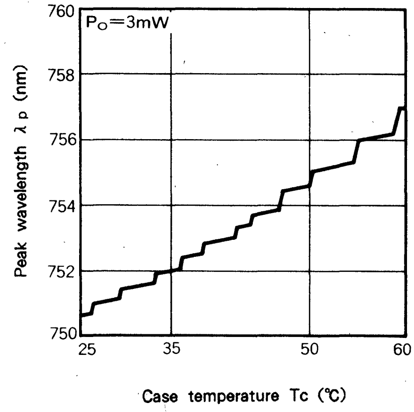


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.20nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength

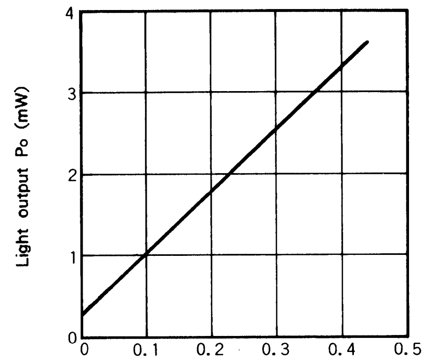


7 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.7 shows an example of light output vs. monitoring photocurrent characteristics.

When the front beam output is 3mW, the monitor output becomes 0.35mA.

Fig. 7 Light output vs. monitoring output current



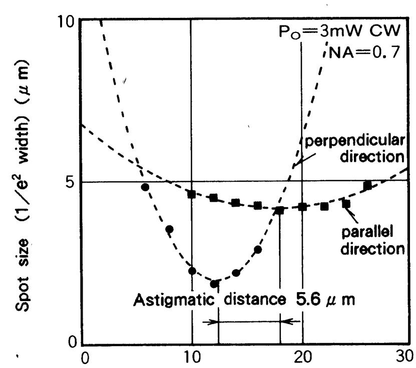
8 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX5 is shown in Fig.8.

The LD position which minimizes the horizontal and vertical spot diameters is obtaained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 8 Astigmatic distance



TYPE NAME **ML40110R**

DESCRIPTION

ML4XX10 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX10 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as the light sources for an optical communications including data link.

FEATURES

- Built-in monitor photodiode
- High reliability, long operation life
- Low noise

APPLICATION

Optical communication system (Data link)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case Temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

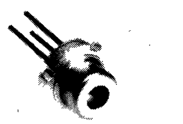
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	45	60	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	53	70	mA
V_{OP}	Operating voltage (Laser diode)	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.32	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	765	780	800	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	8	11	20	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	20	33	48	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10Ω (Note 2)	0.15	0.4	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

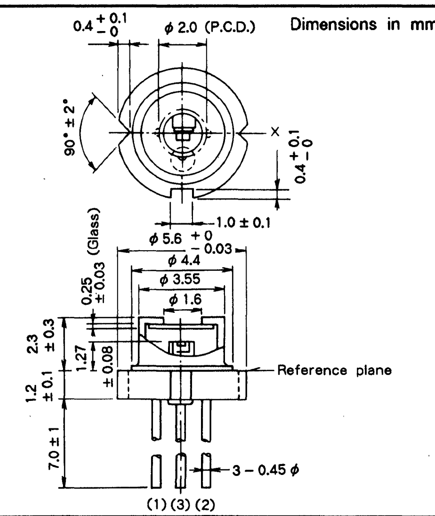
Note 2 : R_L is load resistance of the photodiode.

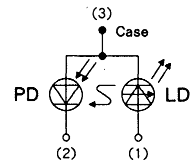
FOR OPTICAL COMMUNICATION

OUTLINE DRAWINGS

ML40110R







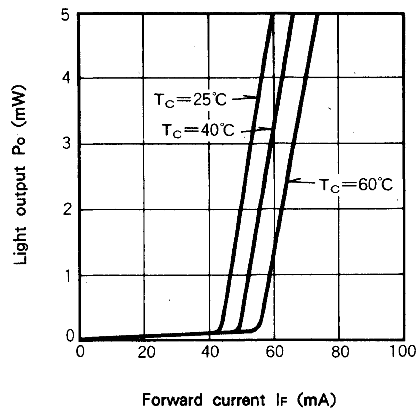
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 45mA at room temperature. Above the threshold, the light output increases. linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 8mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

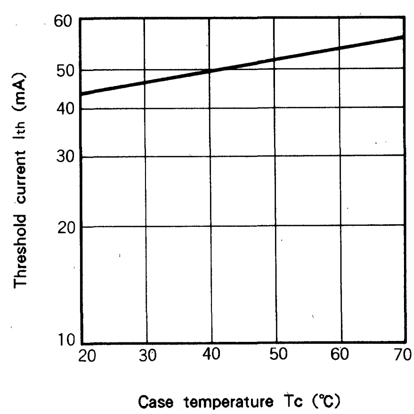
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the thershold current is typically 170K in $T_C \leqq 60℃$, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

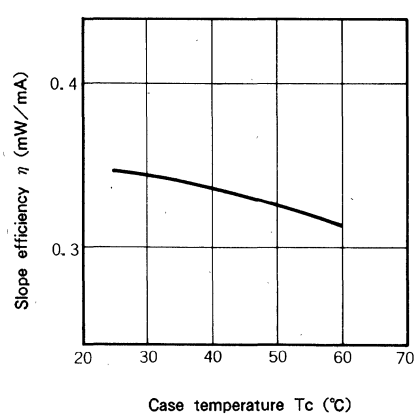
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is − 0.001mW/mA/℃.

Fig. 3 Temperature dependence of slope efficiency

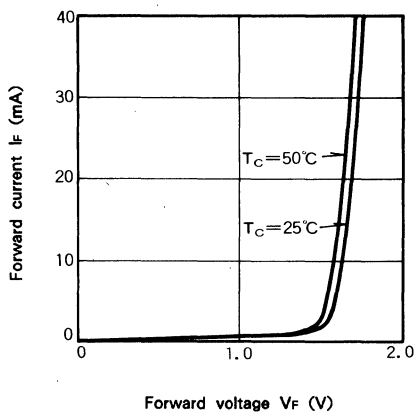


MITSUBISHI ELECTRIC

4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-2.0mV/℃$ at $I_F = 1mA$.

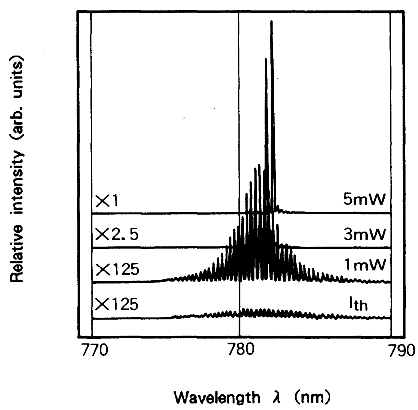
Fig. 4 Forward current vs. voltage characteristics



5 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig.5. Generally, at the output of about 3mW, the laster oscillates in the multi-mode; when the output is raised to about 5mW, it begins oscillating in the single mode. The peak wavelength depends on the operating case temperature and forward current (output levle).

Fig. 5 Emission spectra under CW operation

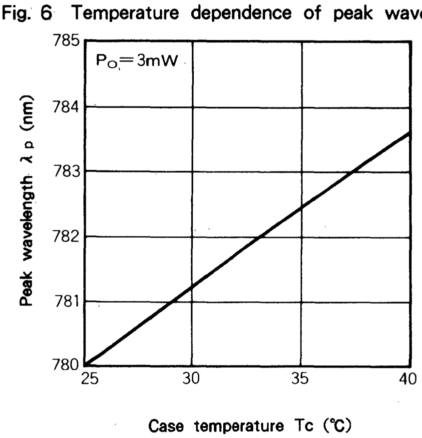


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW 3mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

ML4XX10 oscillates in the standard transverse mode (TE_{00}) regardless of the optical output level. They have a typical emitting area (size of near-field pattern) of 2.1 × 0.7 μm². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 1.1° and 33°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions θ//

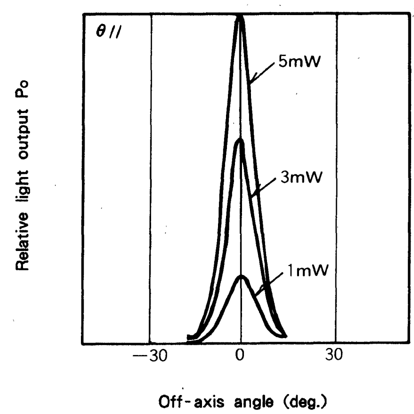
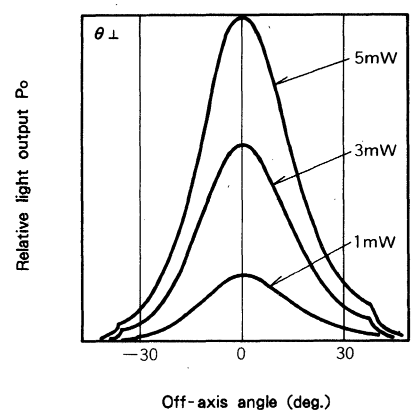


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions θ⊥

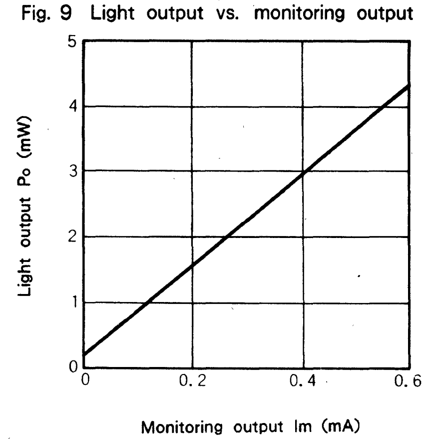


8 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the foront one. Fig.9 shows an example of light output vs monitoring photocurrent characteristics.

When the front beam output is 3mW, the monitor output becomes 0.4mA.

Fig. 9 Light output vs. monitoring output current



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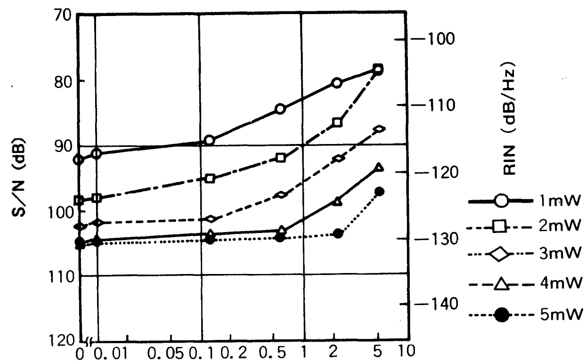
9 S/N vs optical feedback ratio

S/N vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.10.

And that where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.11.

The S/N value (RIN value) is the worst value obtained at case temperatures of 25℃ to 50℃.

Fig. 10 S/N vs. optical feedback ratio
f=20kHz, BW=300Hz, T_C=25—50℃



10 Impedance characteristics

Typical impedance characteristics of the ML4XX10, with lead lengths of 2mm, are shown in Fig.12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance can be approximated by a series connection of a resistance of 3.5ohm and an inductance of 2.3nH.

Fig. 11 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz, T_C=25—50℃

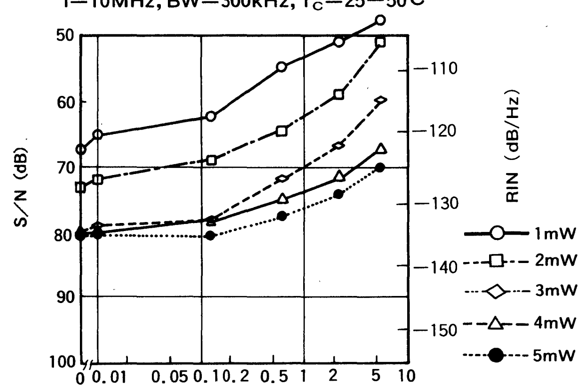
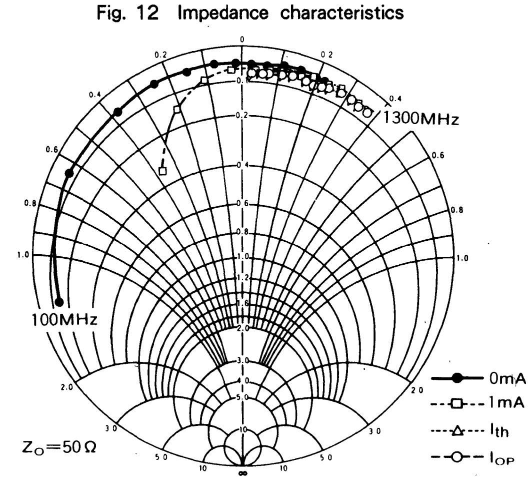


Fig. 12 Impedance characteristics



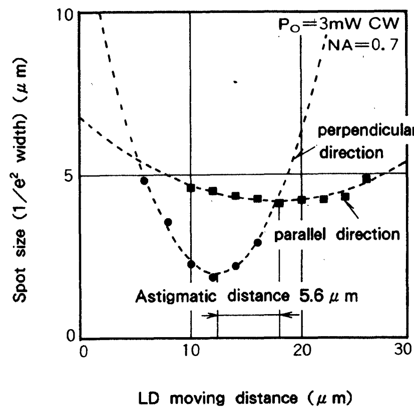
11 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX10 is shown in Fig.13.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 13 Astigmatic distance



TYPE NAME

ML44114N, ML44114C, ML44114R ML40114N, ML40114R

DESCRIPTION

ML4XX14 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX14 is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- Single longitudinal mode oscillation
- Short astigmatic distance
- Low threshold current
- Built-in monitor photodiode
- High reliability, long operation life
- Low droop

APPLICATION

Laser beam printer, digital copy

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	−	2	V
V_{RD}	Reverse voltage (Photodiode)	−	15	V
I_{FD}	Forward current (Photodiode)	−	10	mA
T_C	Case temperature	−	−40～+60	℃
T_{stg}	Storage temperature	−	−55～+100	℃

Note 1 : Duty less than 50%, pulse widty less than 1 μs.

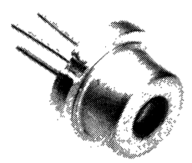
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

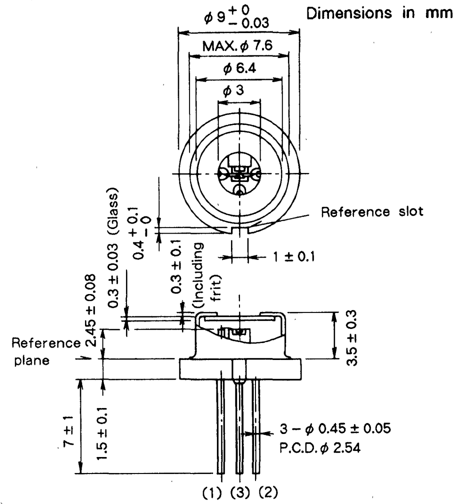
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	−	30	50	mA
I_{OP}	Operating current	CW, P_O = 3mW	−	50	70	mA
V_{OP}	Operating voltage	CW, P_O = 3mW	−	2.0	2.5	V
η	Slope efficiency	CW	−	0.25	−	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 3mW	9	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	26	33	40	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.25	1.0	2.0	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	−	−	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	−	7	−	pF

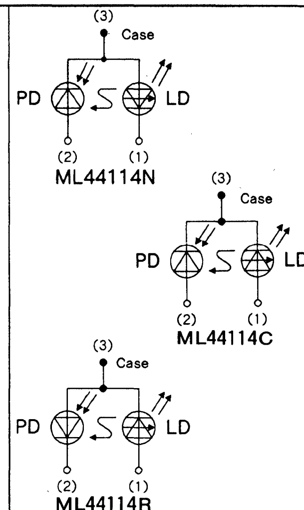
Note 2 : R_L is load resistance of the photodiode.

OUTLINE DRAWINGS

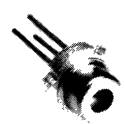
ML44114N/ ML44114C/ ML44114R

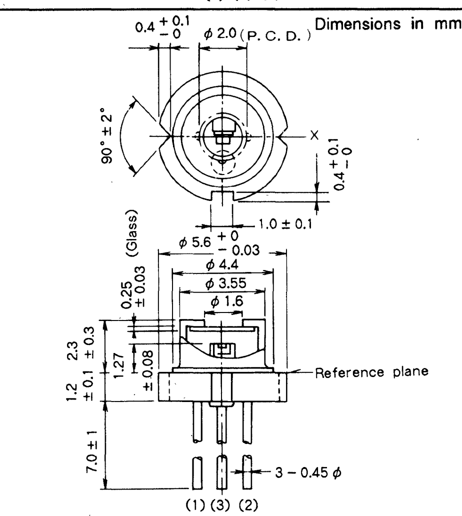


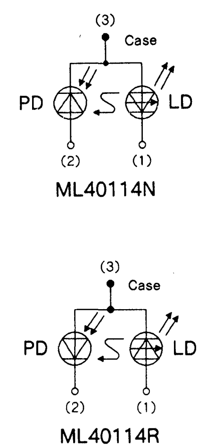




ML40114N /ML40114R







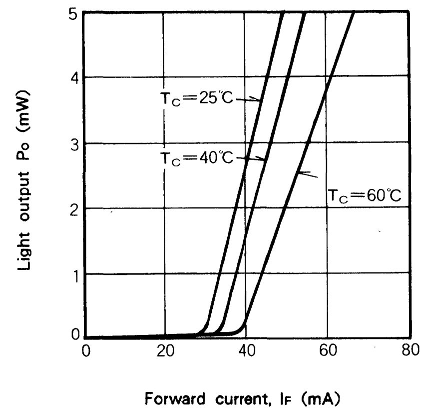
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 30mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 12 mA.

Beacause I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying tem-peratures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

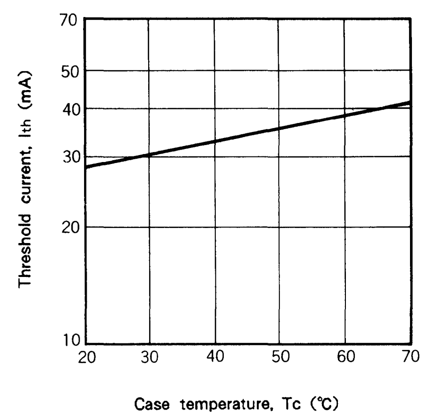
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current is typically 150K in $T_C \leqq 60$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

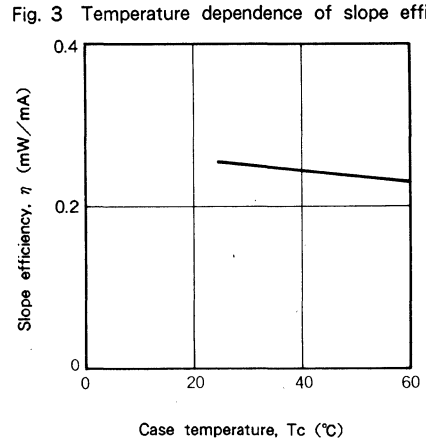
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is − 0.0003mW/mA/℃.

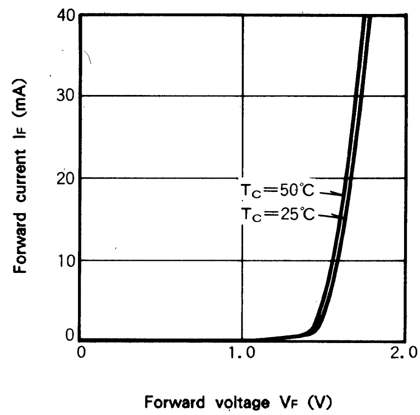
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.5mV/°C$ at $I_F = 1mA$.

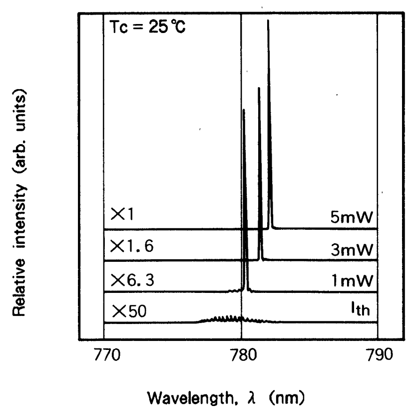
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

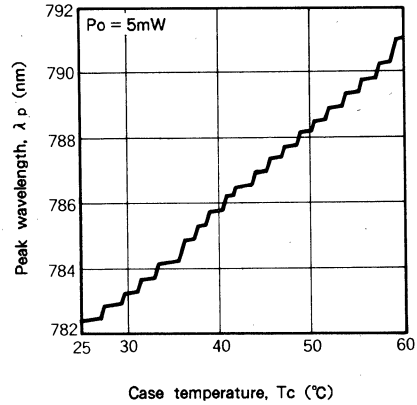


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.26nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



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7 Far-field pattern

The ML4XX14 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.8 × 0.7 μm². Fig.7 and Fig. 8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximun points (FAHM) are typically 13° and 33° .

Fig. 7 Far-field patterns in plane parallel to heterojunction θ//

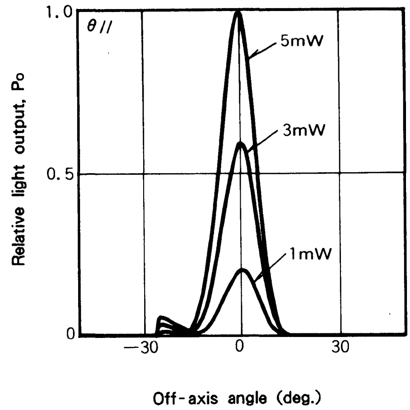
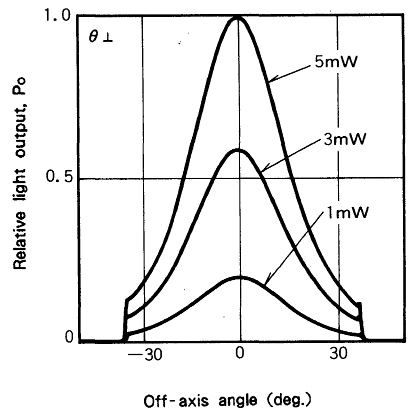


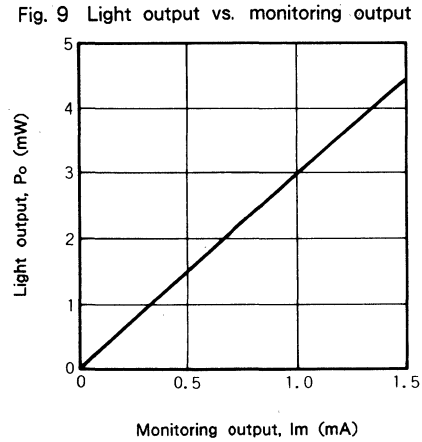
Fig. 8 Far-field patterns in plane perpendicular to heterojunction θ⊥



8 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.9 shows an example of light output vs monitoring photocurrent characteristics. When the front beam output is 3mW, the monitor output becomes 1.0mA.

Fig. 9 Light output vs. monitoring output current

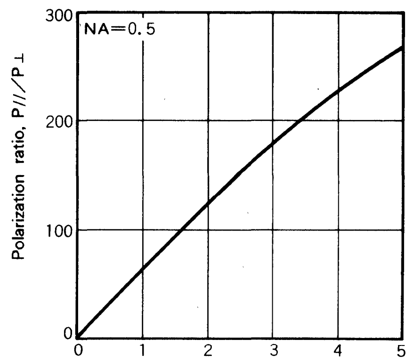


9 Polarization ratio vs. light output characteristic

The main polarization of ML4XX14 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 10 shows the standard polarization ratio vs. total light output characteristic.

The polarization ratio increases with the light output.

Fig. 10 Polarization ratio vs. light output



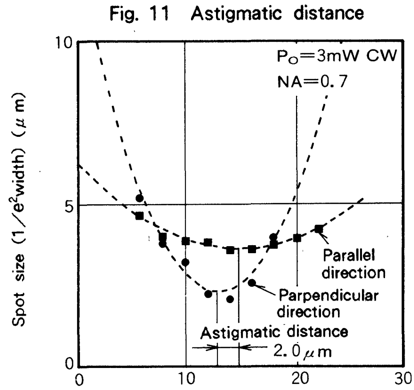
10 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML4XX14 is shown in Fig.11.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

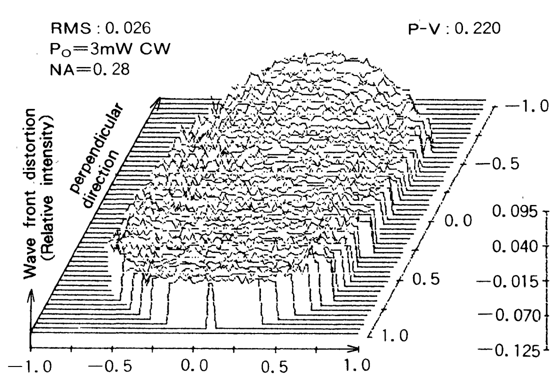
Fig. 11 Astigmatic distance



11 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML4XX14 is shown in Fig.12. This figure shows wave front (phase front) when laser beam is collimated. Various abberrations are calculated by Zernike ' s polynomial approximation for the interference fringes observed by the Mach-Zehnder interferometer.

Fig. 12 Wave front distortion



12 Droop

Droop characteristics indicate the amount which optical light output is down by heating up when constant pulse current is loaded on LD.

Definition is follows.

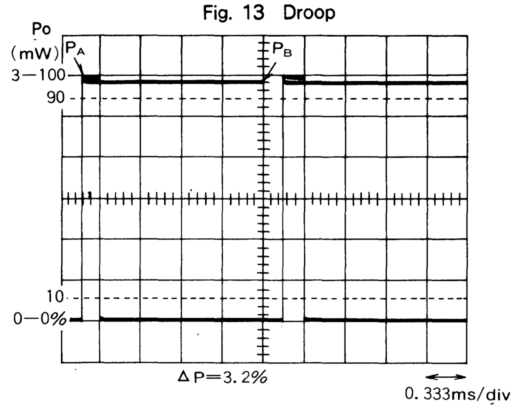
$$\Delta P = \frac{P_A - P_B}{P_B} \times 100\ (\%)$$

PA : Initial value of monitoring current at 10% duty pulse.(600Hz)

PB : Final value of monitoring current at 90% duty pulse.(600Hz)

Typical droop characteristic of ML4XX14 is shown in Fig.13. Typical droop value is 4% at $P_A = 3mW$.

Fig. 13 Droop



TYPE NAME

ML40115C, ML40115R

DESCRIPTION
ML4XX15 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX15 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. It is produced by the MOCVD crystal growth method which is excellent is mass production and characteristics uniformity. This high-perfomance, highly reliable, and long-life semiconductor laser is suitable for such applications as the light source for a compact disk player.

FEATURES
- Built-in monitor photodiode
- High reliability, long operation life
- Low noise
- Multiple longitudinal mode

APPLICATION
Audio compact disc player

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μ s.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	45	60	mA
I_{OP}	Operating current	CW, P_O = 3mW	–	58	70	mA
V_{OP}	Oprating voltage (Laser diode)	CW, P_O = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, P_O = 3mW	–	0.3	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 3mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (paraller)	CW, P_O = 3mW	9	11	16	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 3mW	30	38	48	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.15	0.35	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 2 : R_L is load resistance of the photodiode.

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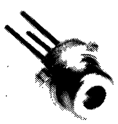
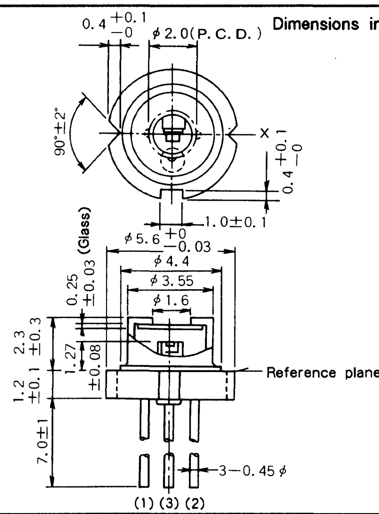
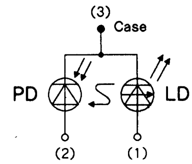
OUTLINE DRAWINGS

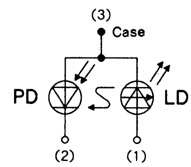
ML40115C/ ML40115R







ML40115C



ML40115R

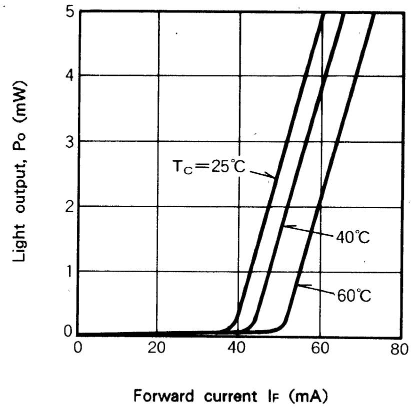
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs . forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 45mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at I_{th} + 13mA.

Beacause I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

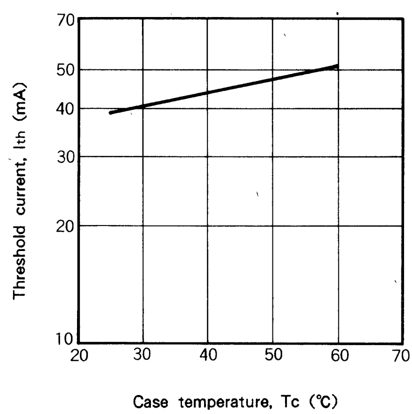
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current is typically 130K in $T_C \leqq 60$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

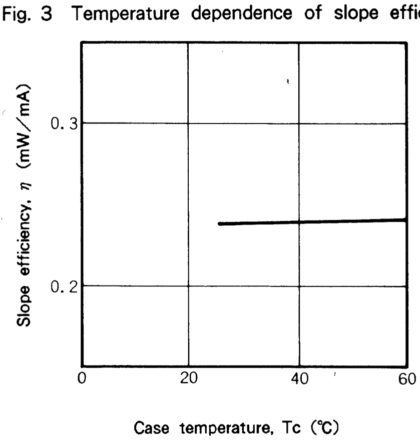
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is about 0mW/mA/℃.

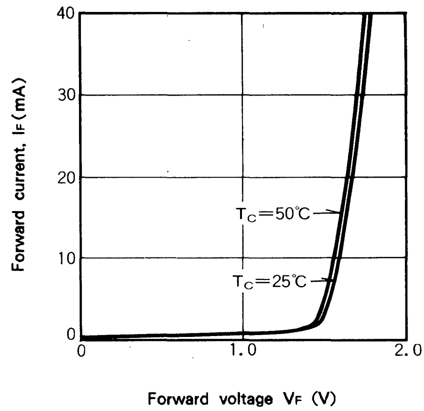
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.5mV/℃$ at $I_F = 1mA$.

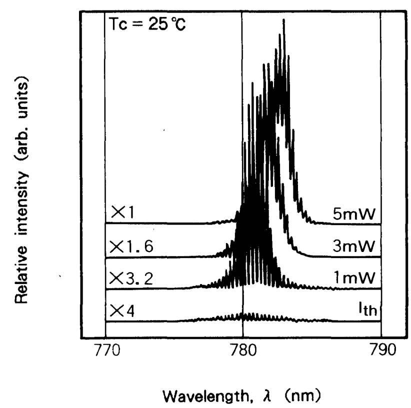
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. ML4XX15 oscillates in the longitudinal multiple mode. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

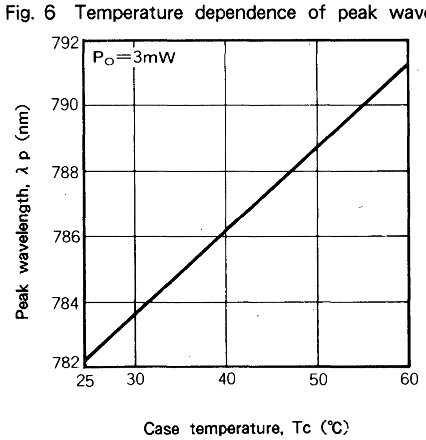


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 3mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.26nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML4XX15 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.8 × 0.5 μm². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximun points (FAHM) are typically 11° and 38°.

Fig. 7 Far-field patterns in plane parallel to heterojunction θ//

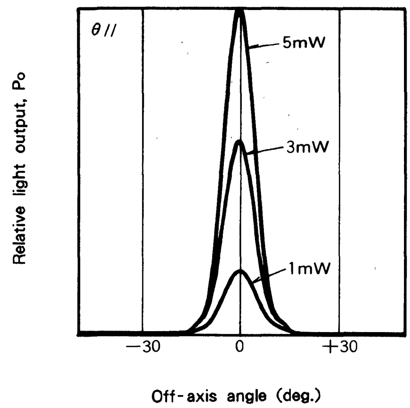
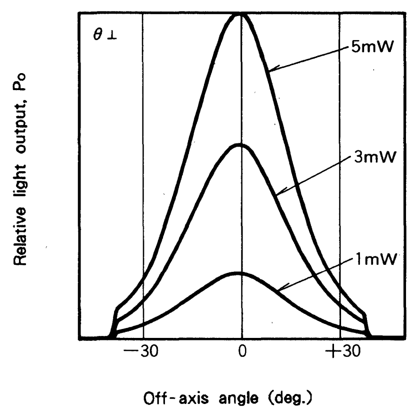


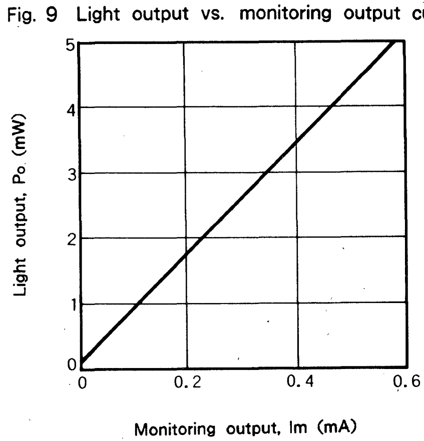
Fig. 8 Far-field patterns in plane perpendicular to heterojunction θ⊥



8 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.9 shows an example of light output vs monitoring photocurrent characteristics. When the front beam output is 3mW, Im is 0.5mA typical and the monitor output current increases in proportion to the front beam output.

Fig. 9 Light output vs. monitoring output current



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9 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.10.

And that where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.11.

The S/N value is the worst value at case temperatures of 25℃ to 50℃.

Fig. 10 S/N vs. optical feedback ratio
f=20kHz, BW=300Hz, T_C=25−50℃

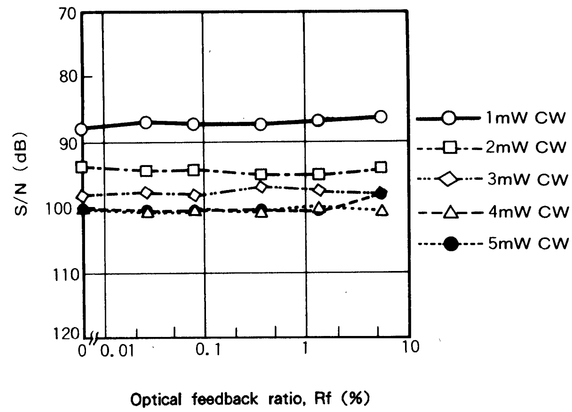
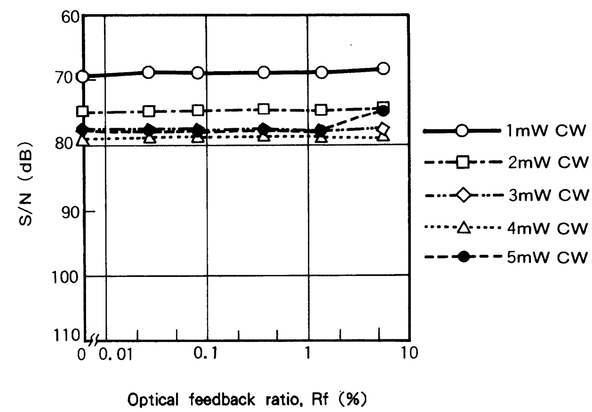


Fig. 11 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz, T_C=25−50℃

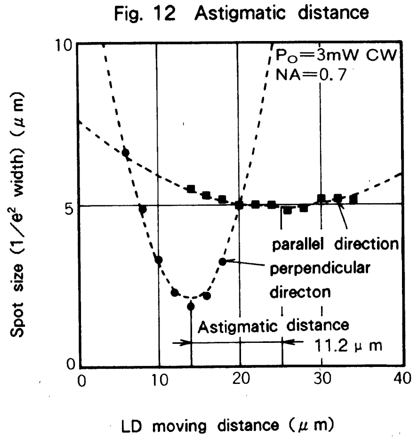


10 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7 of ML4XX15 is shown in Fig.12.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 12 Astigmatic distance



TYPE NAME **ML40116R**

DESCRIPTION

ML4XX16 is AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 3mW.

ML4XX16 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-perfomance, highly reliable, and long-life semiconductor laser provides multi-mode oscillation (longitudinal mode) and is suitable for such applications as the light sources for optical communications including data links.

FEATURES

- Built-in monitor photodiode
- High reliability, long operation life
- Low noise
- Multiple longitudinal oscillation (Self pulsation)

APPLICATION

Digital communication system (Data link)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_o	Light output power	CW	5	mW
		Pulse (Note 1)	6	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (Tc = 25 ℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	45	70	mA
I_{OP}	Operating current	CW, Po = 3mW	–	55	80	mA
V_{OP}	Operating voltage (Laser diode)	CW, Po = 3mW	–	1.8	2.5	V
η	Slope efficiency	CW, Po = 3mW	–	0.3	–	mW/mA
λ_P	Peak wavelength	CW, Po = 3mW	765	780	800	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, Po = 3mW	8	11	20	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, Po = 3mW	20	38	48	deg.
I_m	Monitoring output current (Photodiode)	CW, Po = 3mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.15	0.4	0.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 2 : R_L is load resistance of the photodiode.

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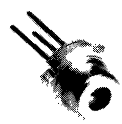
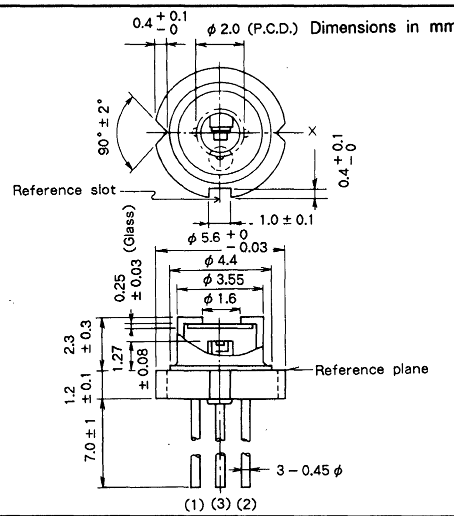
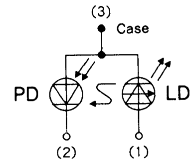
FOR OPTICAL COMMUNICATION SYSTEMS

OUTLINE DRAWINGS

ML40116R





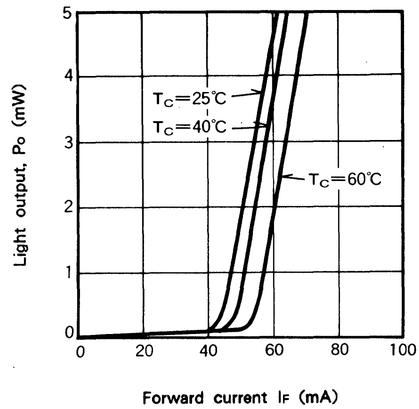


SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. THe threshold current for lasing is typically 45mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 3mW is obtained at Ith + 10mA. Beacause Ith and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

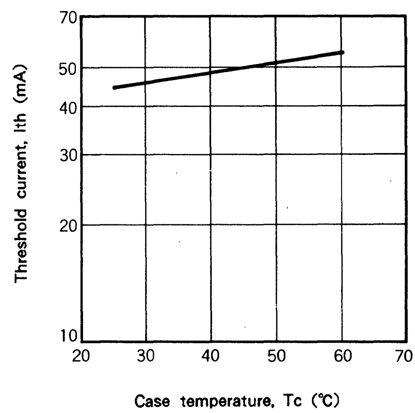
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (Ith)

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature To of the threshold current is typically 170K in Tc≦60°C, where the definition of To is $Ith \propto \exp(T_C/T_O)$.

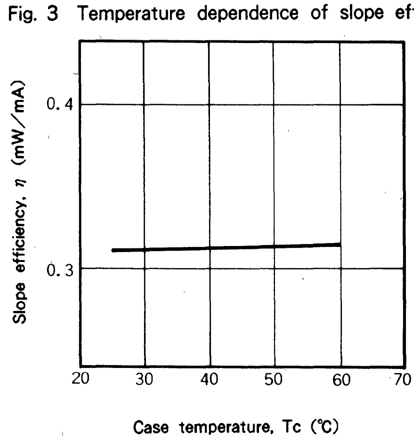
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is about 0mW/mA/°C.

Fig. 3 Temperature dependence of slope efficiency



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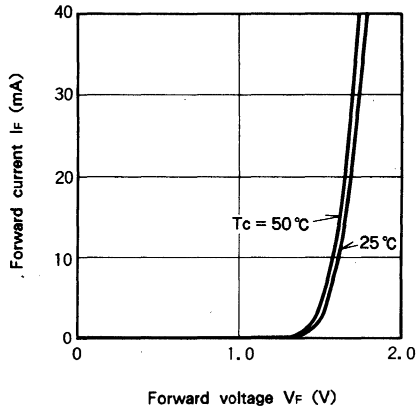
4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

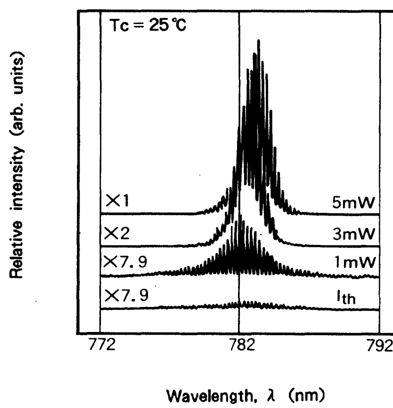
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. ML4XX16 oscillates in the longitudinal multiple mode. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation



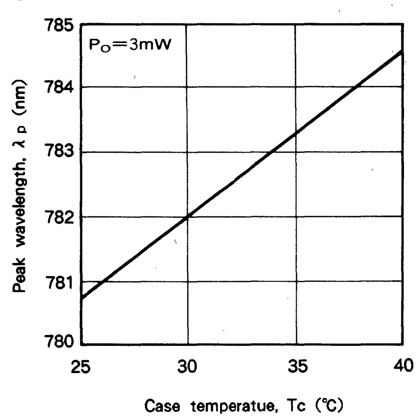
6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 3mW is shown in Fig.6.

The peak wavelength of the beam shifts to adjacent longitudinal mode by variation of operating temperature.

Averaged temperature coefficient is about 0.26nm/℃

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML4XX16 laser diodes lase in fundamental treanverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 2.1 × 0.7 μ m². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximun points (FAHM) are typically 11° and 38° .

Fig. 7 Far-field patterns in plane parallel to heterojunction θ//

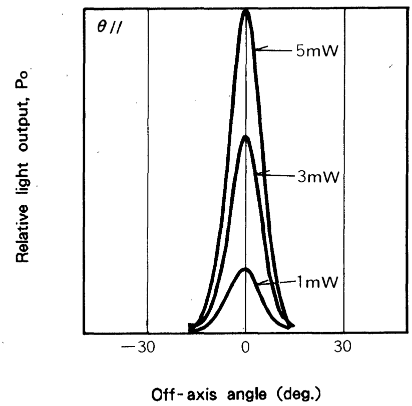
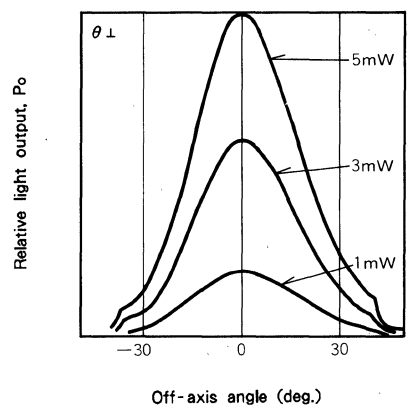


Fig. 8 Far-field patterns in plane perpendicular to heterojunction θ⊥

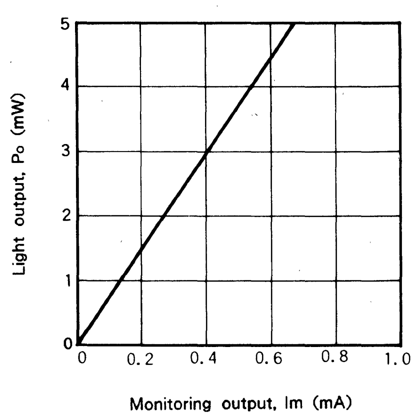


8 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig. 9 shows an example of light output vs. monitoring photocurrent characteristics.

When the front baeam output is 3mW, Im is 0.4mA typical and the monitor output current increases in proportion to the front beam output.

Fig. 9 Light output vs. monitoring output current



9 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.10.

That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.11.
The S/N value is the worst value at case temperatures of 25℃ to 50℃.

Fig. 10 S/N vs. optical feedback ratio

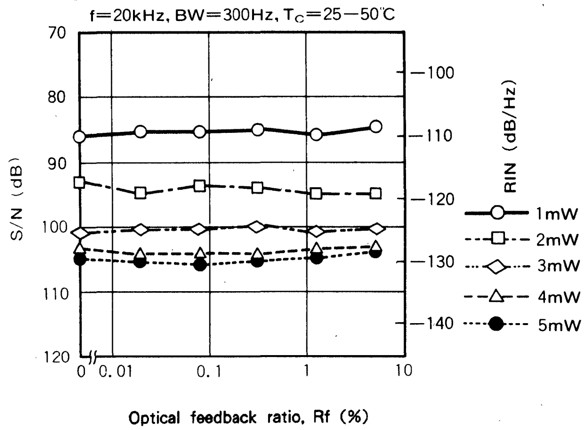
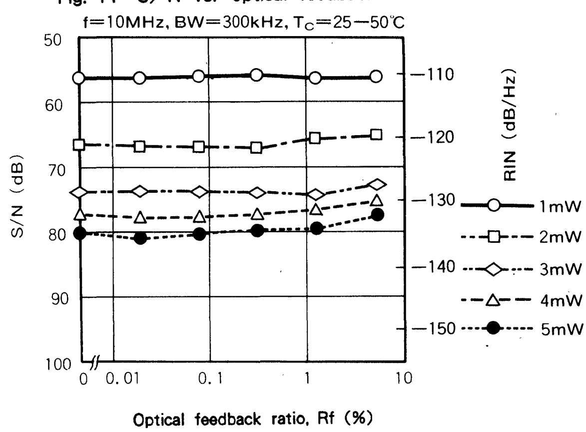


Fig. 11 S/N vs. optical feedback ratio

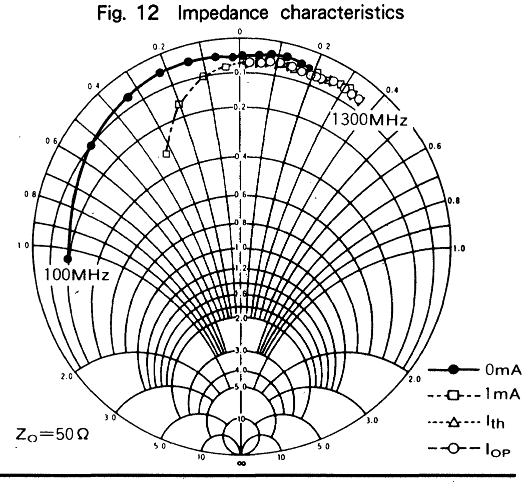


10 Impedance characteristics

Typical impedance characteristics of the ML4XX16, with lead lengths of 2mm, are shown in Fig.12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance can be approximated by a series connection of a resistance of 3 ohm and an inductance of 2nH.

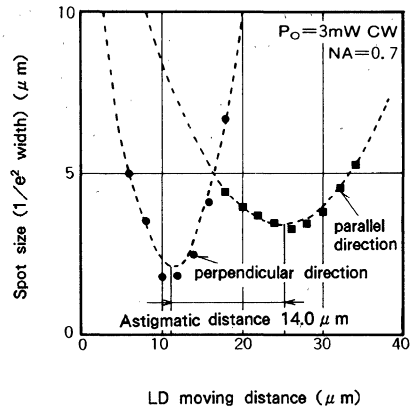
Fig. 12 Impedance characteristics



11 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular directions with the laser beam.This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7 of ML4XX16 is shown in Fig.13. The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 13 Astigmatic distance



TYPE NAME

ML44119N, ML44119R

DESCRIPTION

ML4XX19 is an AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 5mW.

It is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- Low droop
- Short astigmatic distance
- Low threshold current
- Single longitudinal mode
- Built-in photodiode

APPLICATION

Laser beam printer and digital copy

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	8	mW
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	30	50	mA
I_{OP}	Operating current	CW, P_O = 5mW	–	45	70	mA
V_{OP}	Operating voltage	CW, P_O = 5mW	–	2.0	2.5	V
η	Slope efficiency	CW, P_O = 5mW	–	0.35	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	9	11	15	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	26	33	40	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 5mW, V_{RD} = 1V, R_L * = 10Ω	0.3	0.7	1.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

* R_L = The load resistance of photodiode.

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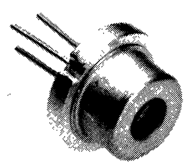
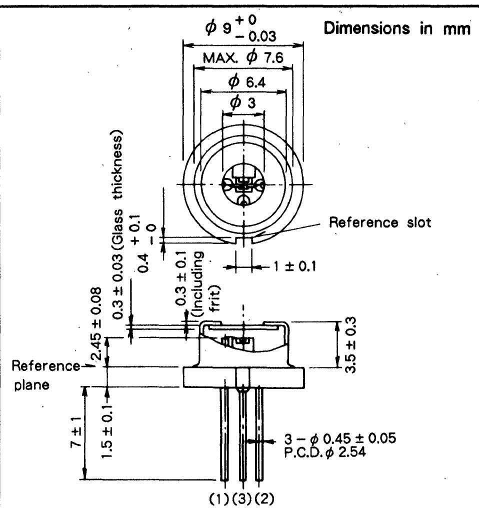
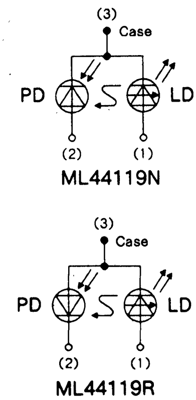
FOR OPTICAL COMMUNICATION SYSTEMS

OUTLINE DRAWINGS

ML44119N/ ML44119R







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ML5XX1A SERIES

FOR OPTICAL INFORMATION SYSTEMS

TYPE NEME

ML5101A, ML5401A

DESCRIPTION

ML5XX1A is a high-power semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 850nm and standard light output of 15mW.

ML5XX1A uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semi-conductor laser is suitable for such high-power applications as instrumentation.

FEATURES

- High power (pulse 30mW)
- Single longitudinal mode
- Short astigmatic distance
- Low threshold currrent, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Laser printer, optical communication, and instrumentation

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	18	mW
		Pulse (Note 1)	30	
V_{RL}	Reverse voltage (Laser diode)	−	3	V
V_{RD}	Reverse voltage (Photodiode)	−	15	V
I_{FD}	Forward current (Photodiode)	−	10	mA
T_C	Case temperature	−	−40～+50	℃
T_{stg}	Storage temperature	−	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
I_{th}	Threshold current	CW	−	30	50	mA
I_{OP}	Operating current	CW, P_O = 15mW	−	60	90	mA
V_{OP}	Operating voltage	CW, P_O = 15mW	−	1.8	2.5	V
η	Slope efficiency	CW, P_O = 15mW	−	0.45	−	mW/mA
λ_P	Peak wavelength	CW, P_O = 15mW	830	850	870	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 15mW	8	11	16	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 15mW	20	30	40	deg.
I_m	Monitoring output curren (Photodoide)	CW, P_O = 15mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.5	1.0	3.0	mA
I_D	Dark current (Photodoide)	V_{RD} = 10V	−	−	0.5	μA
C_t	Total capacitance (Photodoide)	V_{RD} = 0V, f = 1MHz	−	7	−	pF

Note 2 : R_L is load resistance of the photodiode.

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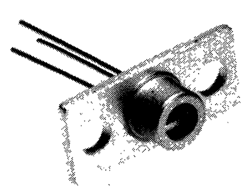
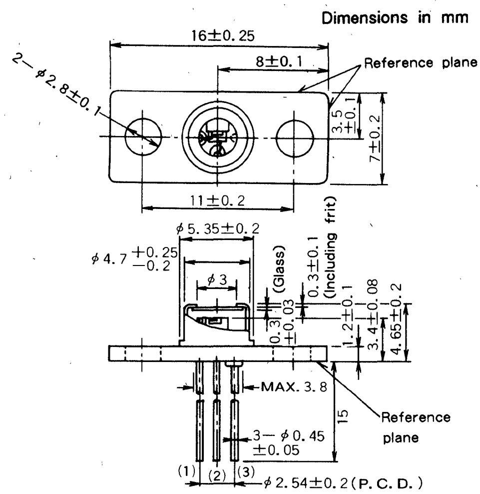
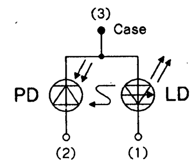
OUTLINE DRAWINGS

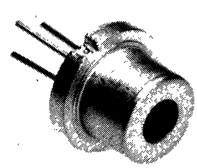
ML5101A

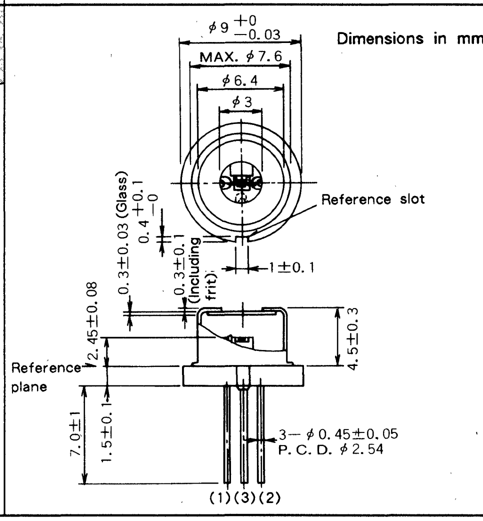


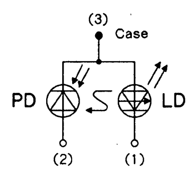




ML5401A







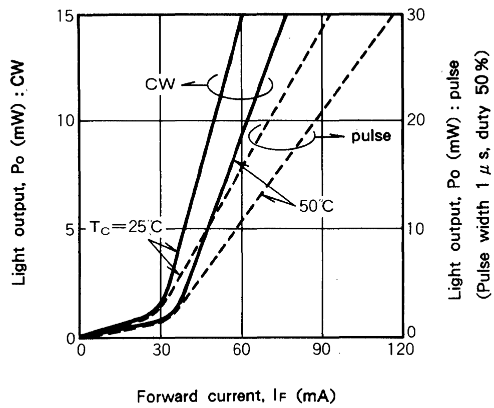
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 30mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 15mW is obtained at I_{th} + 30 mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

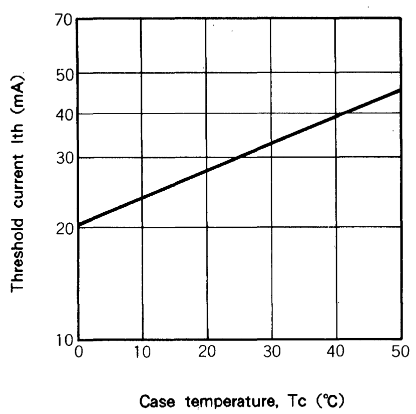
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_O of the threshold current is typically 65K in $T_C \leqq 50$°C, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

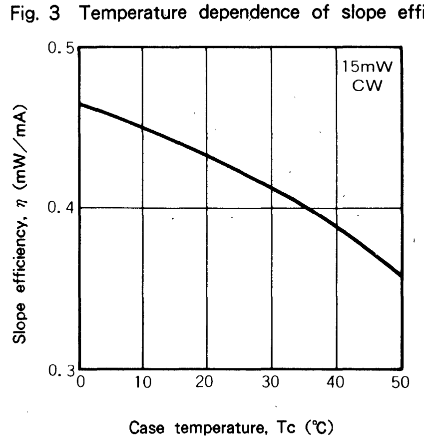
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of shope efficiency

A typical temperature dependence of the slope efficiency η is Fig.3. The gradient is −0.002mW/mA/°C typ.

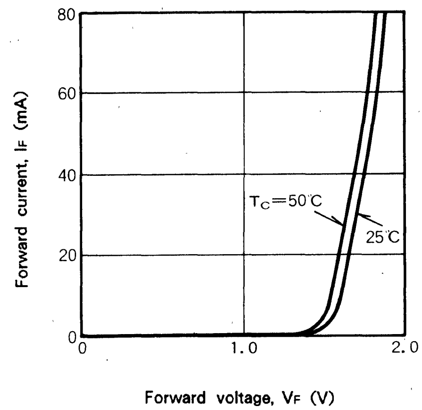
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-2.0mV/℃$ at $I_F = 1mA$.

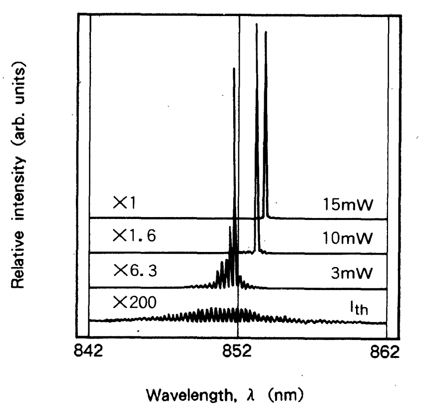
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 10mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

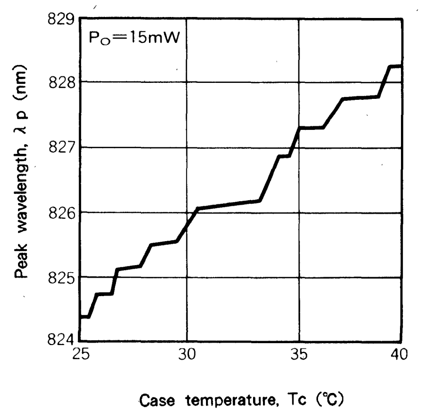


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW 15mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about $0.25nm/℃$ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML5XX1A laser diodes in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 2.3 × 0.8 μm². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 30°.

Fig. 7 Far-field patterns in plane parallel to heterojunction θ//

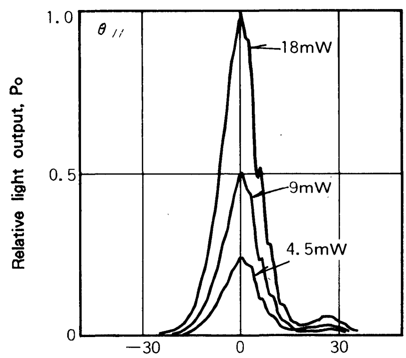
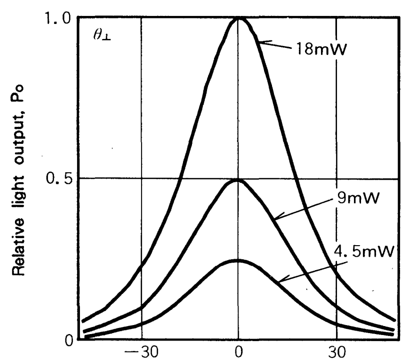


Fig. 8 Far-field patterns in plane perpendicular to heterojunction θ⊥



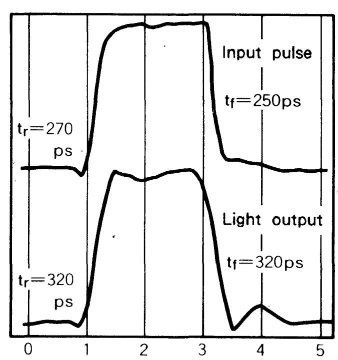
8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current.

Figure 9 shows a standard response waveform obtained by biasing ML5XX1A to I_{th} and applying a square pulse current (top of Fig.9) up to 15mW. A quick response is obtained with rising and falling times being both 0.3ns typical.

Fig. 9 Pulse response waveform

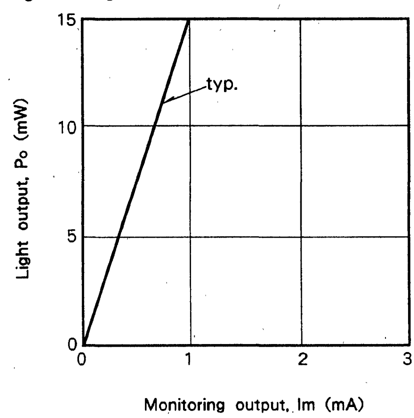


9 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs. monitoring photocurrent characteristics.

When the front beam output is 15mW, the monitor output becomes about 1.0mA.

Fig. 10 Light output vs. monitoring output current

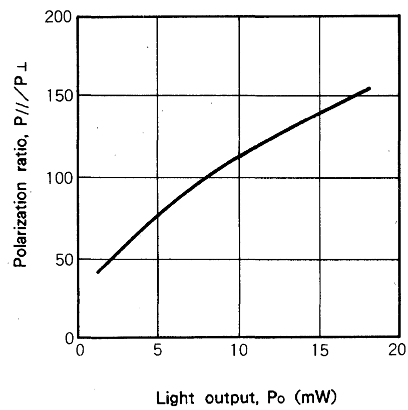


10 Polarization ratio vs. light output characteristic

The main polarization of ML5XX1A is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure11 shows the standard polarizastion ratio vs. total light output characteristic.

The polarization ratio increases with the light output.

Fig. 11 Polarization ratio vs. light output

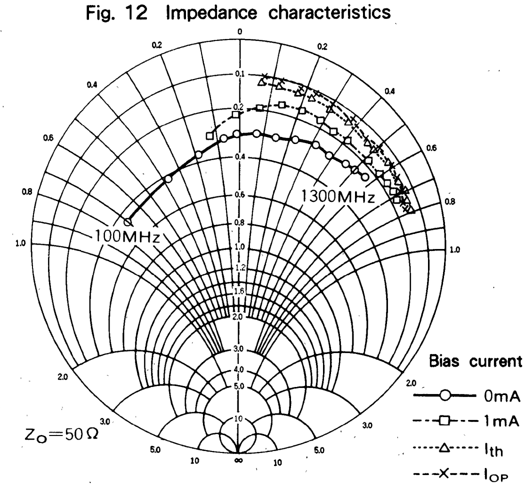


11 Impedance characteristics

Typical impedance characteristics of the ML5XX1A, with lead lengths of 2mm, are shown in Fig.12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold current, the impedance of the ML5XX1A is nearly equal to a series connection of a resist-ance of 5 ohm and an inductance of 5nH.

Fig. 12 Impedance characteristics



12 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.13.

That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.14.

The S/N value is the worst value at case temperatures of 25℃ to 50℃.

Fig. 13 S/N vs. optical feedback ratio

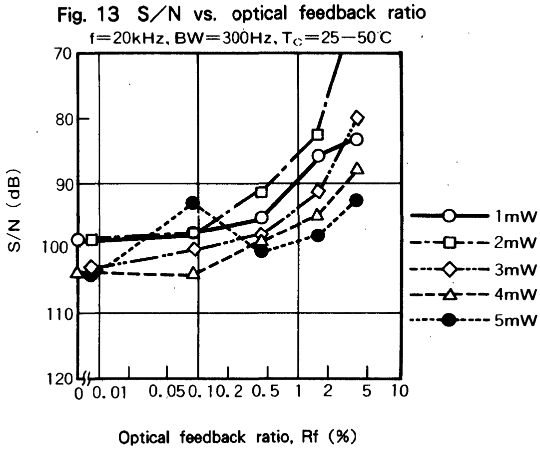
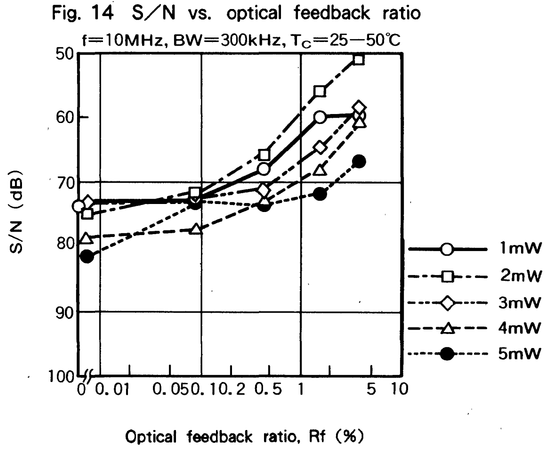


Fig. 14 S/N vs. optical feedback ratio



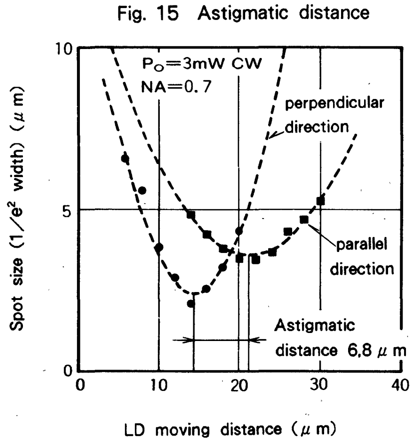
13 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points in the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult ot converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML5XX1A is shown in Fig.15.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 15 Astigmatic distance



TYPE NAME

ML5413A

DESCRIPTION
ML5XX3A is a high-power semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 820 nm and standard continuous oscillation of 10mW.

ML5XX3A uses a hermetically sealed package incorporating the photodiode for optiocal output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such high-power applications as optical disk memory writing.

FEATURES
- High-power, stable single longitudinal mode
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliabillity, long operation life

APPLICATION
Optical disk drive, laser beam printer, optical communication

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	25	mW
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	40	60	mA
I_{OP}	Operating current	CW, P_O = 10mW	–	65	100	mA
V_{OP}	Operating voltage (Laser diode)	CW, P_O = 10mW	–	2.0	2.5	V
η	Slope efficiency	CW, $I_F = I_{th} + 25$mA	–	0.4	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 10mW	800	820	840	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 10mW	10	12	17	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 10mW	20	30	35	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 10mW, V_{RD} = 1V, R_L = 10 Ω (Note 1)	0.3	0.8	1.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 1 : R_L is load resistance of the photodiode.

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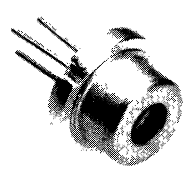
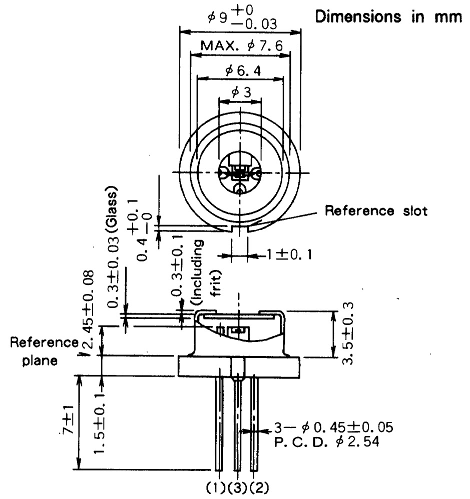
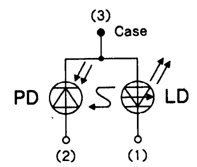
OUTLINE DRAWINGS

ML5413A







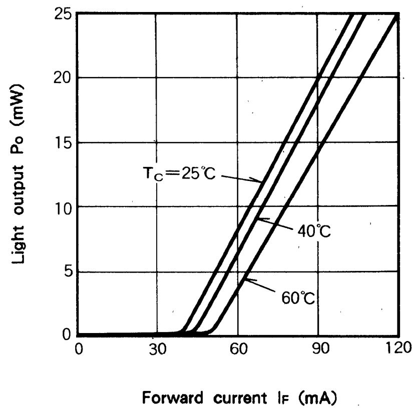
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 40mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 10mW is obtained at I_{th} + 25mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

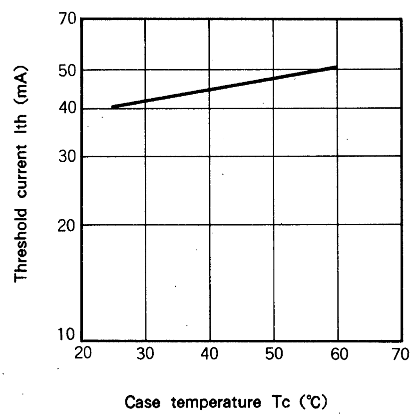
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. the characteristic temperature T_O of the threshold current is typically 150K in $T_C \leqq 60$℃, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

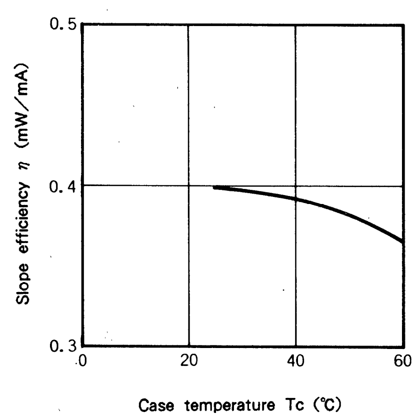
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency(η)

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is −0.001mW/mA/℃

Fig. 3 Temperature dependence of slope efficiency



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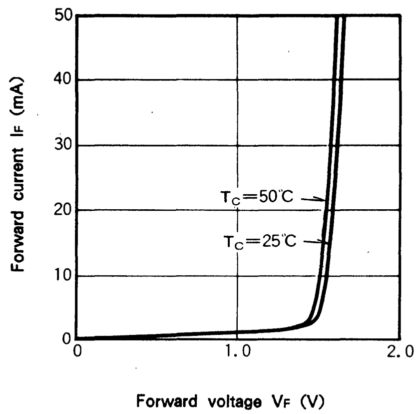
4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

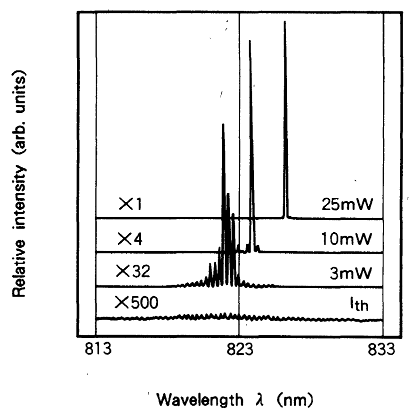
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 10mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

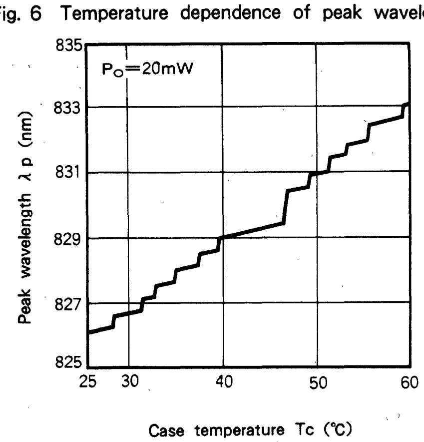


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of cw, 20mW is shown in Fig.6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.2nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML5XX3A laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 2.1 × 0.8 μm². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 12° and 30°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions θ//

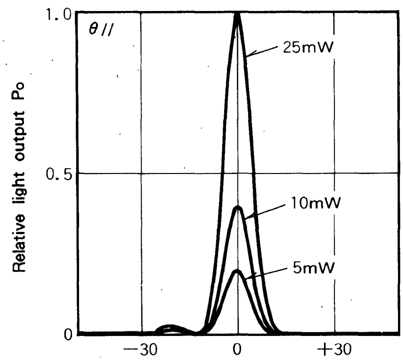
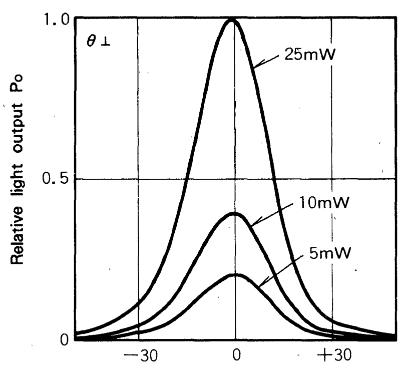


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions θ⊥

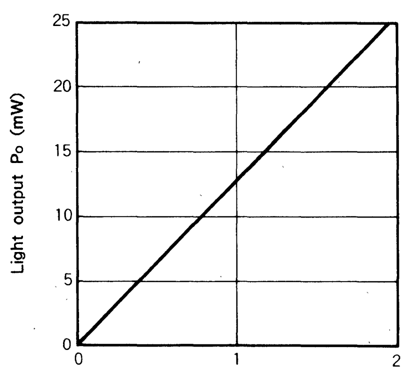


8 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.9 shows an example of light output vs. monitoring photocurrent characteristics.

When the front beam output is 10mV, the monitor output becomes about 0.8mA.

Fig. 9 Light output vs. monitoring output current

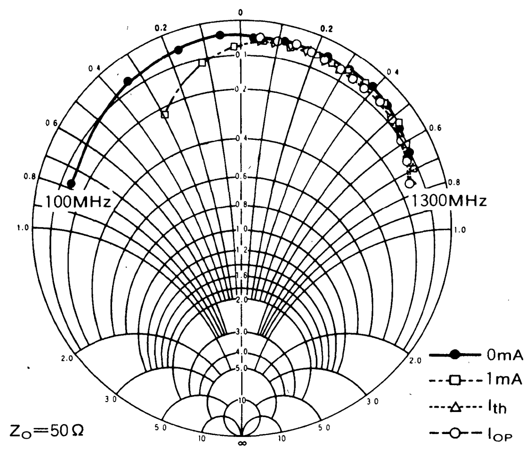


9 Impedance characteristics

Typical impedance characteristics of the ML5XX3A, with lead lengths of 2mm, are shown in Fig.10 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.

Above the threshold, the impedance of the ML5XX3A is nearly equal to a series connection of a resistance of 4 ohm and an inductance of 4nH.

Fig. 10 Impedance characteristics



10 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where frequency is 20kHz and the bandwidth is 300Hz is shown in Fig. 11.That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig. 12.

The S/N value is the value obtained at CW drive and high-frequency superimpose drive. It the worst value at case temperatures of 25 ℃ to 50℃ and an environmental temperature of 25 ℃. The frequency of high-frequency superimpose is about 700MHz and the input level is the value obtained at aobut 35mAp-p.

Fig. 11 S/N vs. optical feedback ratio
f=20kHz, BW=300Hz, T_C=25~50℃

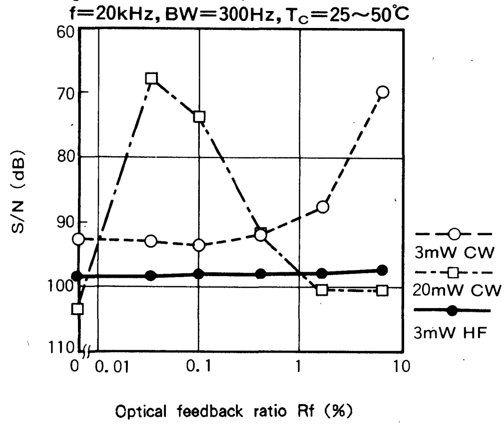
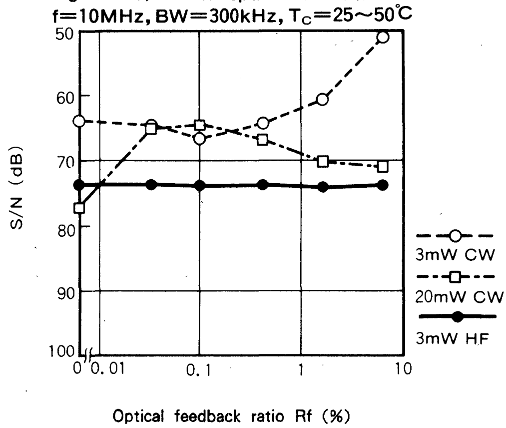


Fig. 12 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz, T_C=25~50℃



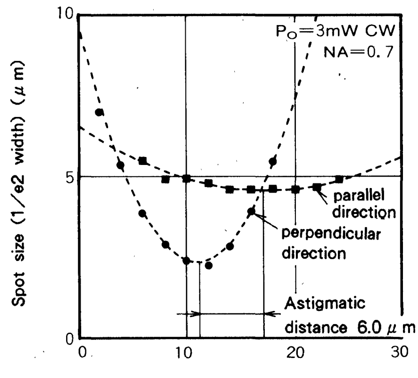
11 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML5XX3A is shown in Fig.13.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

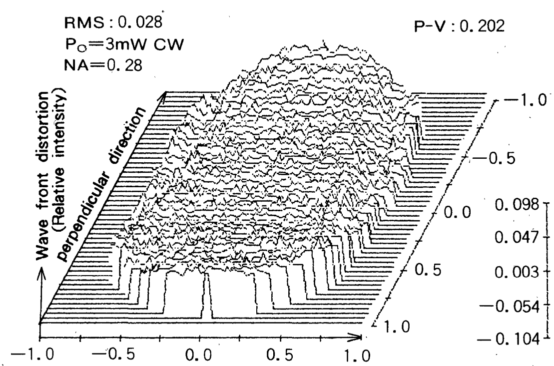
Fig. 13 Astigmatic distance



12 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML5XX3A is shown in Fig.14. This figure shows wave front (phase front) when laser beam is collimated. Various aberrations are calculated by Zernike's polynomial approximation for the interference fringes observed by the Mach - Zehnder interferometer.

Fig. 14 Wave front distortion



MITSUBISHI ELECTRIC

TYPE NAME **ML5784F**

DESCRIPTION

The ML5XX4 series is a high-power semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 850 nm and standard continuous oscillation of 15 mW.

ML5XX4 uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such applications as the light sources for optical fiber broken-point detector and long-distance communication.

FEATURES

- High power (CW 20mW, pulse 80mW)
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

OTDR, optical communication system

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	20	mW
I_F	Forward current (Laser diode)	Pulse (Note 1)	450	mA
V_{RL}	Reverse voltage (Laser diode)	–	3	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+50	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 1 %, pulse width less than 4 μs.

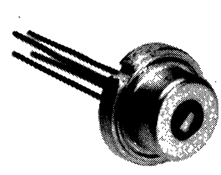
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25 ℃)

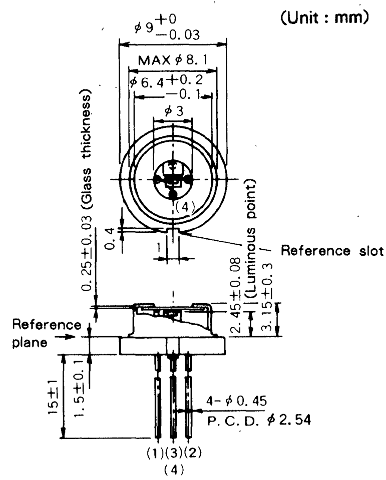
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	25	50	mA
I_{OP}	Operating current	CW, P_O = 15mW	–	50	90	mA
V_{OP}	Operating voltage	CW, P_O = 15mW	–	1.8	2.5	V
$P_{O\ (P)}$	Pulse light output	Pulse, I_F = 400mA (Note 2)	80	–	–	mW
λ_P	Peak wavelength	CW, P_O = 15mW	830	850	870	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 15mW	8	11	16	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 15mW	20	30	40	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 15mW, V_{RD} = 1V, R_L = 10 Ω (Note 3)	0.04	0.12	1.0	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 2 : Pulse width 2 μs, 0.2 % duty
3 : R_L is load resistance of the photodiode.

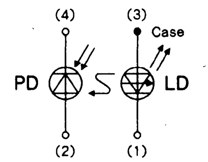
OUTLINE DRAWINGS

ML5784F





(φ 9mm, 4-pin low-cap package)



MITSUBISHI ELECTRIC

SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Figure 1 shows the typical light output vs. current characteristic in the CW drive of ML5XX4. The threshold current Ith at room temperature is about 30mA. The optical output increases at currents larger than Ith and no kink is observed. An optical output of about 15mA can be obtained at I_{th} + 25mA. Figure 2 shows the typical optical output vs. current characteristic in the pulse drive at a pulse width of 2μm and duty cycle of 0.2%. An optical output of about 80mW or more can be obtained at room temperature with a forward current I_F of 400mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

Fig. 1 Light output vs. forward current

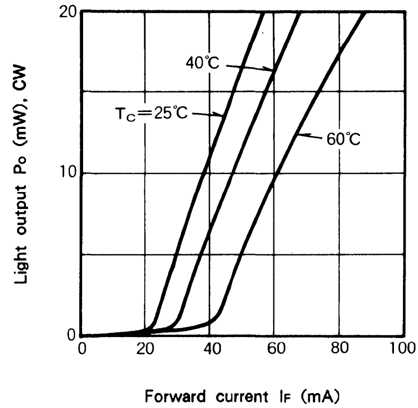
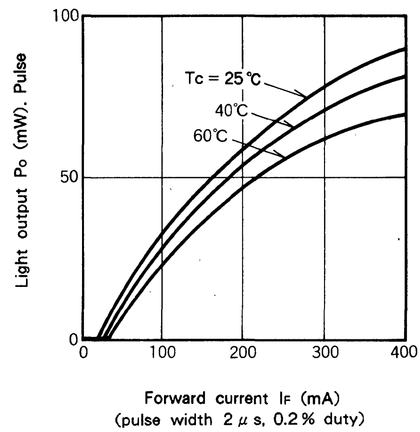


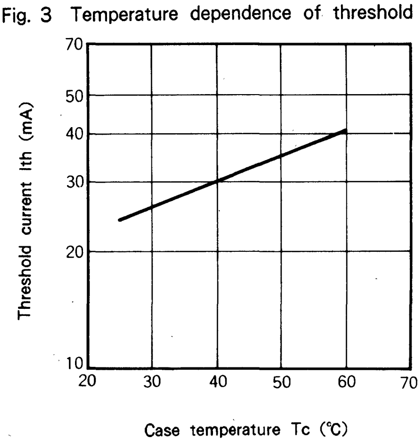
Fig. 2 Light output vs. forward current



2 Temperature dependence of threshold current(I_{th})

A typical temperature dependence of the threshold current is shown in fig.3. The characteristic temperature T_O of the threshold current is typically 65K in $T_C \leqq 50$°C, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

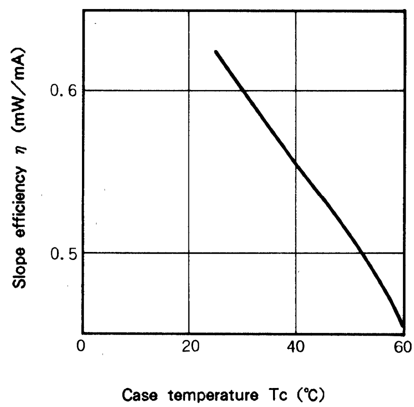
Fig. 3 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency(η o)

A typical temperature dependence of the slope efficiency η is shown in Fig.4. The gradient is −0.005mW/mA/℃.

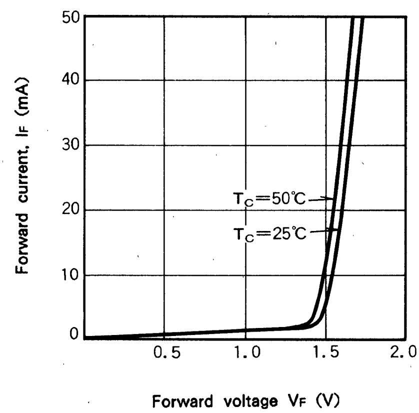
Fig. 4 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.5. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a tate of −2.0mV/℃ at I_F = 1mA.

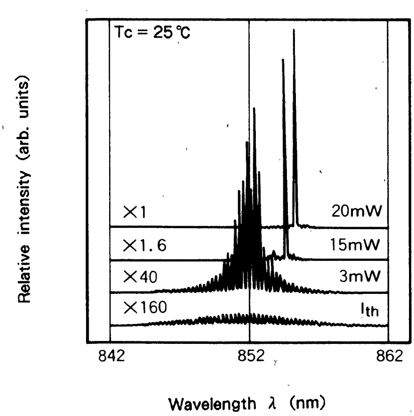
Fig. 5 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.6. In general, at an output of 15mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 6 Emission spectra under CW operation

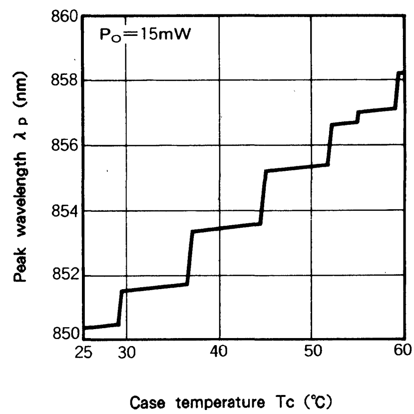


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 15mW is shown in Fig.7.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25 nm/℃ typical.

Fig. 7 Temperature dependence of peak wavelength



7 Far-field pattern

The ML5XX4 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 2.3×0.8μm². Fig.8 and Fig.9 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 30°.

Fig. 8 Far-field patterns in plane parallel to heterojunctions θ//

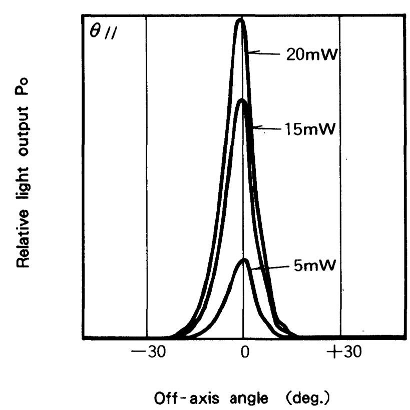
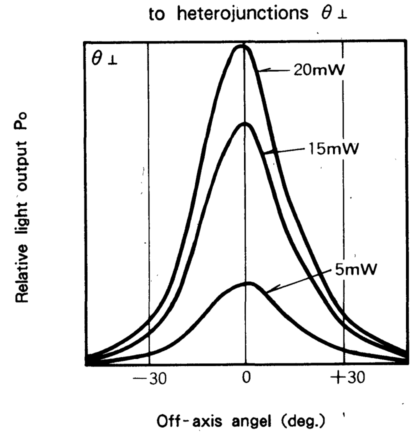


Fig. 9 Far-field patterns in plane perpendicular to heterojunctions θ⊥

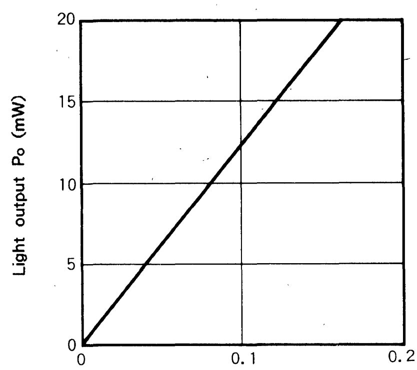


8 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear sufaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig.10 shows an example of light output vs. monitoring photocurrent characteristics.

When the front beam output is 15mW, the monitor output becomes about 0.12mA.

Fig. 10 Light output vs. monitoring output current

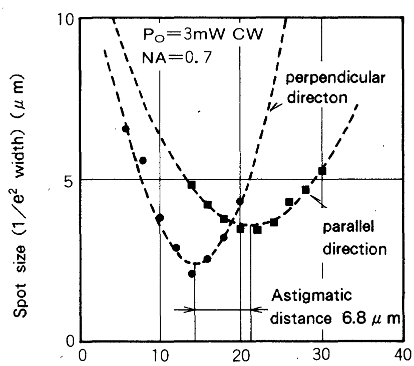


9 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7of ML5XX4 is shown in Fig.11.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 11 Astigmatic distance



TYPE NAME

ML5415N, ML5415C, ML5415R

DESCRIPTION

ML5XX5 is a high-power AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 825nm and standard light output of 30mW.

It is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- High power (35mW CW, 45mW pulse)
- Short astigmatic distance (2 μm typical)
- Built-in monitor photodiode
- High reliability, long life

APPLICATION

Optical disk drive (rewritable, write once)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	35	mW
		Pulse (Note 1)	45	
V_{RL}	Reverse Voltage (Laser diode)	–	2	V
V_{RD}	Reverse Voltage (Photodiode)	–	30	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

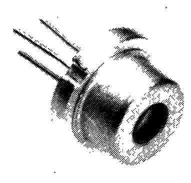
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

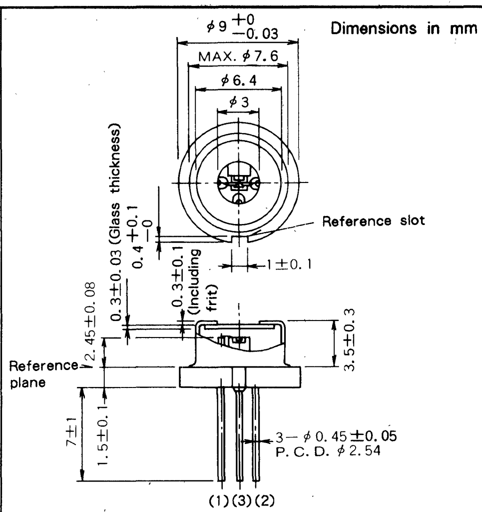
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	50	70	mA
I_{OP}	Operating current	CW, P_O = 30mW	–	125	150	mA
η	Slope efficiency	CW, P_O = 30mW	–	0.4	–	mW/mA
V_{OP}	Operating voltage	CW, P_O = 30mW	–	2.0	2.5	V
λ_P	Peak wavelength	CW, P_O = 30mW	810	825	840	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 30mW	9	11	14	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 30mW	23	26	29	deg.
I_m (Note 2)	Monitoring output current (Photodiode)	CW, P_O = 30mW, V_{RD} = 1V, R_L = 10 Ω (Note 4)	2.0	4.0	6.0	mA
I_m (Note 3)			0.6	1.7	3.0	
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

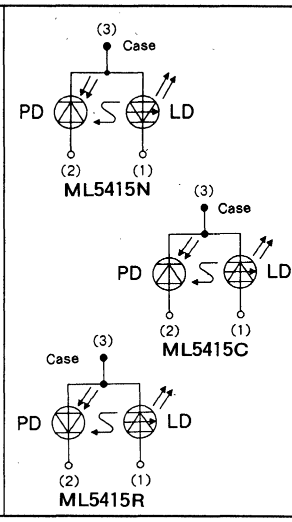
Note 2 : This specification applies to ML5415N, ML5415C.
3 : This specification applies to ML5415R.
4 : R_L is load resistance of the photodiode.

OUTLINE DRAWINGS

**ML5415N/
ML5415C/
ML5415R**







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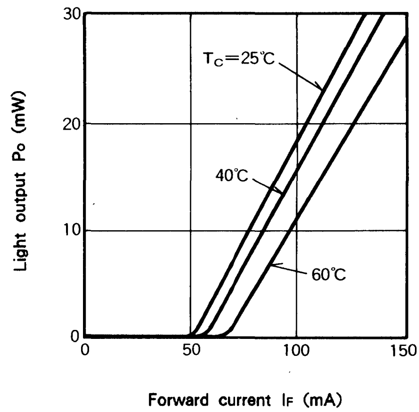
1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig.1. The threshold current for lasing is typically 50mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinds are observed in the curves. An optical power of about 30mW is obtained at I_{th} + 75mA.

Because I_{th} and slope efficiency η (dP_o/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_c or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

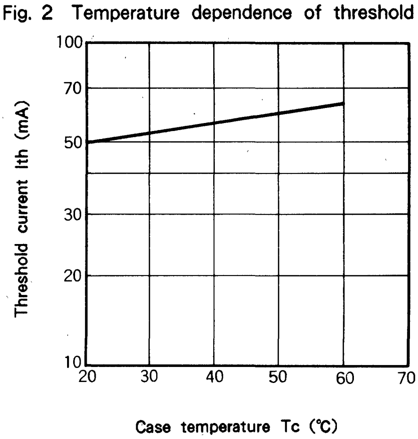
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig.2. The characteristic temperature T_o of the threshold current is typically 140K in $T_c \leq 60$℃, where the definition of T_o is $I_{th} \propto \exp(T_c/T_o)$.

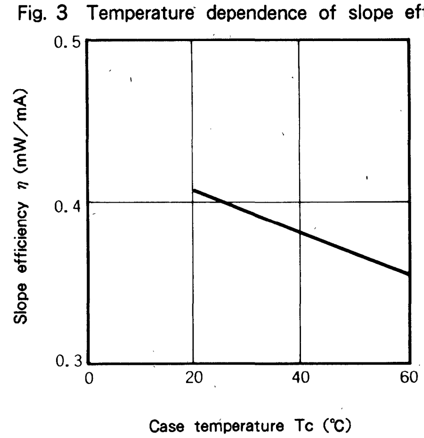
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency (η)

A typical temperature dependence of the slope efficiency η is shown in Fig.3. The gradient is −0.0014mW/mA/℃.

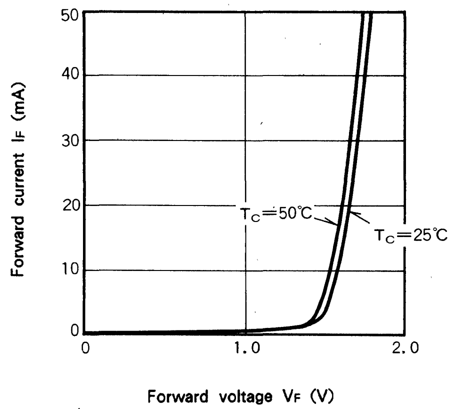
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.6mV/°C$ at $IF = 1mA$.

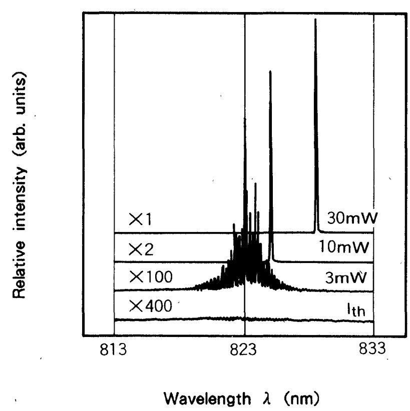
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig.5. In general, at an output of 3mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

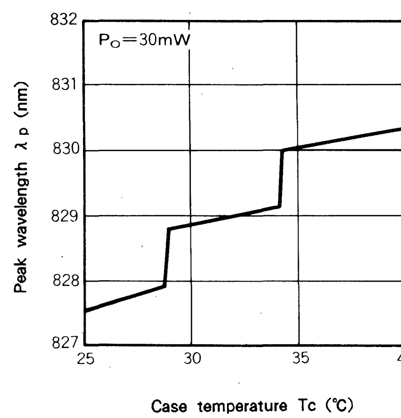


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of 30mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about $0.20nm/°C$ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML5XX5 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 2.3 × 0.9 μ m². Fig.7 and Fig.8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 11° and 26°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions θ//

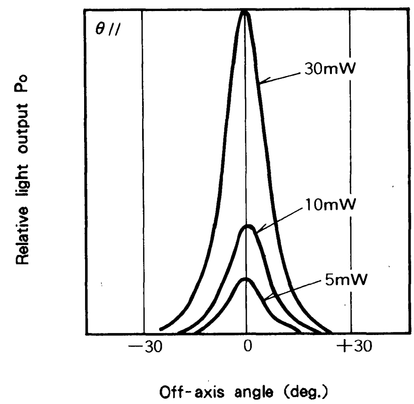
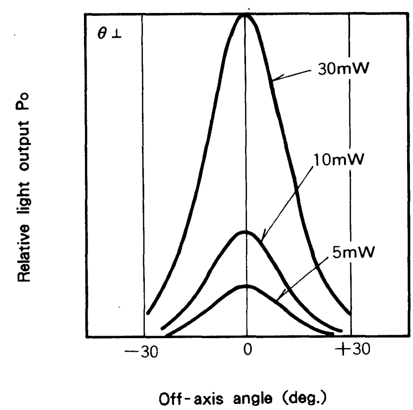


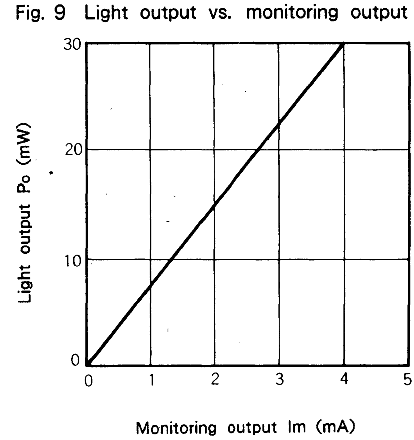
Fig. 8 Far-field patterns in plane perpendicular to heterojunctions θ⊥



8 Optical output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Figure 9 shows the typical front beam output vs. monitoring output current characteristics of ML5415N and ML5415C. When the front beam output is 30mW, the monitoring output becomes 4.0mA typical. (With ML5415R, the monitoring output becomes 1.7mA typical when the front beam output is 30mA.)

Fig. 9 Light output vs. monitoring output current

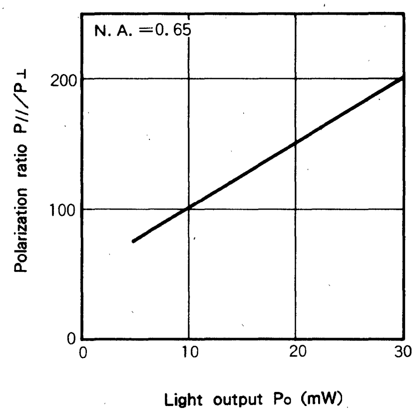


9 Polarization ratio vs. optical output characteristic

The main polarization of ML5XX5 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 10 shows the standard polarization ratio vs. total light output characteristic.

The polarization ratio increases with the light power.

Fig. 10 Polarization ratio vs. light output

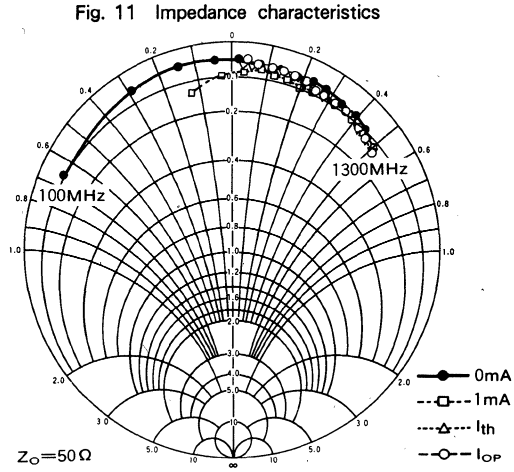


10 Impedance characteristics

Typical impedance characteristics of the ML5XX5, with lead lengths of 2mm, are shown in Fig.11 with the bias currents as the parameter. Test frequency is swept from 100MHZ to 1300MHZ with 100MHz steps.

Above the threshold, the impedance of the ML5XX5 is nearly equal to a series connection of a resistance of 4 ohm and an inductance of 3nH.

Fig. 11 Impedance characteristics



11 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig.12. That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig.13.

S/N ratio is worst on CW driving and on HF superimposed driving, when case temperature is 25 ~50℃ and atmosphere temperature is 25℃. The frequency and input level of HF superimposition are about 700MHz, 35mA$_{P-P}$.

Fig. 12 S/N vs. optical feedback ratio
f=20kHz, BW=300Hz

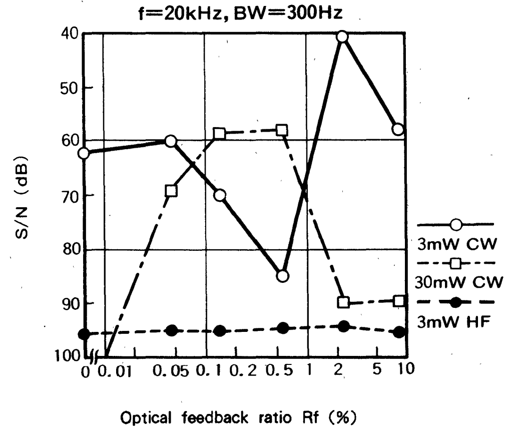


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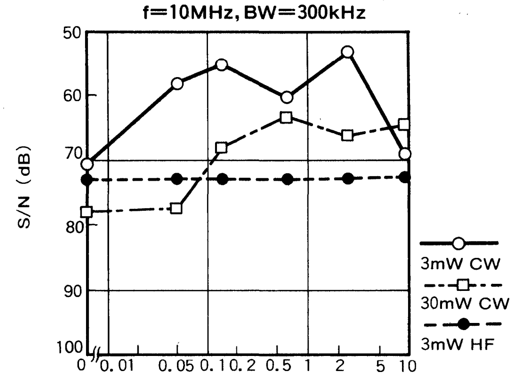
Fig. 13 S/N vs. optical feedback ratio
f=10MHz, BW=300kHz



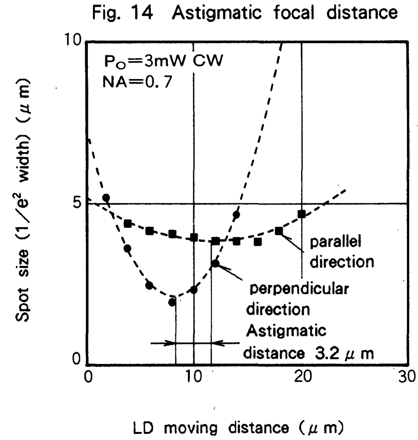
12 Astigmatic focal distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit.

The typical astigmatic focal distance at NA = 0.7 of ML5XX5 is shown in Fig. 14.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

Fig. 14 Astigmatic focal distance

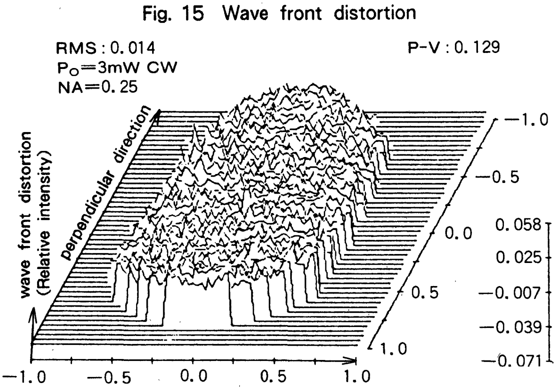


13 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML5XX5 is shown in Fig.15. This figure shows wave front (phase front) when laser beam is collimated.

Various aberrations are calculated by Zernike's polynomial approximation for the interference fringes observed by the Mach - Zehnder interferometer.

Fig. 15 Wave front distortion



TYPE NAME

ML6101A, ML6411A, ML6411C

DESCRIPTION

ML6XX1A is a high-power semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780 nm and standard light output of 10mW.

ML6XX1A uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such high-power applications as optical disk memory writing.

FEATURES

- High power (CW 20mW)
- Single longitudinal mode
- Short astigmatic distance
- Low noise
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Optical disk drive, laser beam printer, optical communication

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	20	mW
		Pulse (Note 1)	25	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse votage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			min.	Typ	max.	
I_{th}	Threshold current	CW	–	40	60	mA
I_{OP}	Operating current	CW, P_O = 10mW	–	65	100	mA
V_{OP}	Operating voltage	CW, P_O = 10mW	–	2.0	2.5	V
η	Slope efficiency	CW, P_O = 10mW	–	0.4	–	mW/mA
λ_P	Peak wavelangth	CW, P_O = 10mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 10mW	10	12	17	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 10mW	20	30	35	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 10mW V_{RD} = 1V R_L = 10 Ω (Note 2)	0.3	0.8	1.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 2 : R_L is load resistance of the photodiode.

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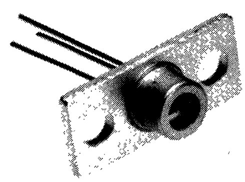
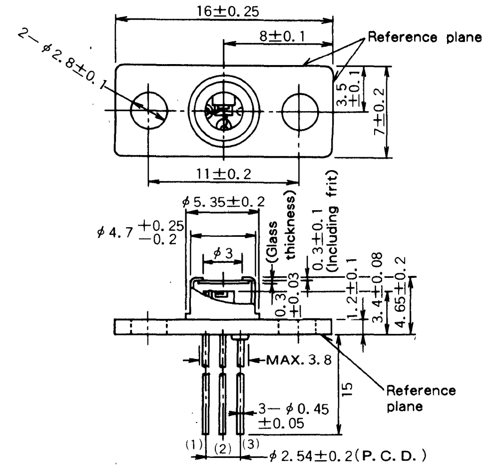
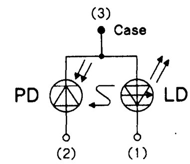
FOR OPTICAL INFORMATION SYSTEMS

OUTLINE DRAWINGS

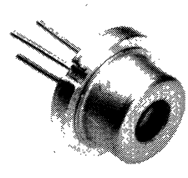
ML6101A

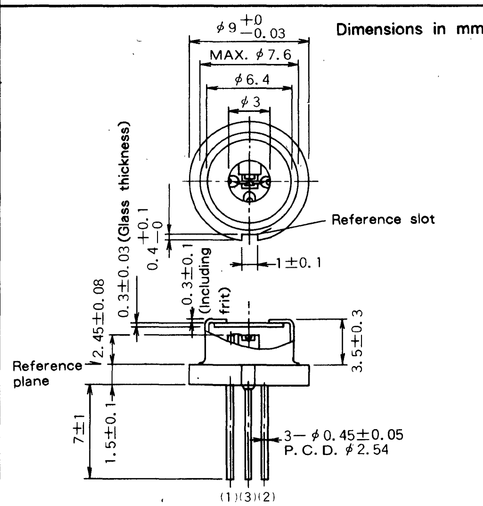


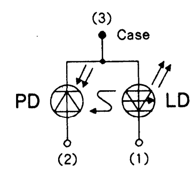




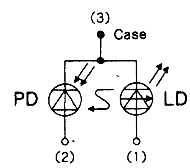
ML6411A/ ML6411C







ML6411A



ML6411C

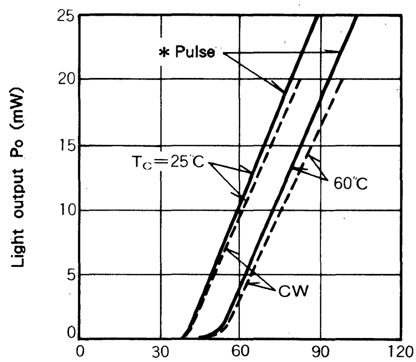
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs . forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 40mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 10mW is obtained at I_{th} + 25mA.

Because I_{th} and slope efficeency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

Fig. 1 Light output vs. forward current

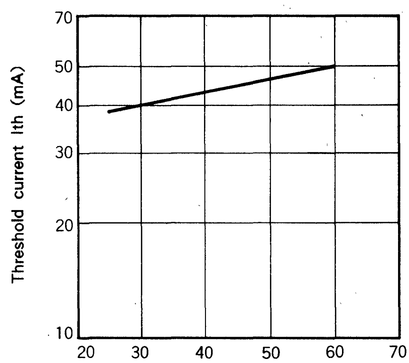


* Duty less than 50% pulse width less than 1 μs.

2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically 140K in $T_C \leqq 60$℃, where the definition of T_O is $I_{th} \propto \exp\ (T_C/T_O)$.

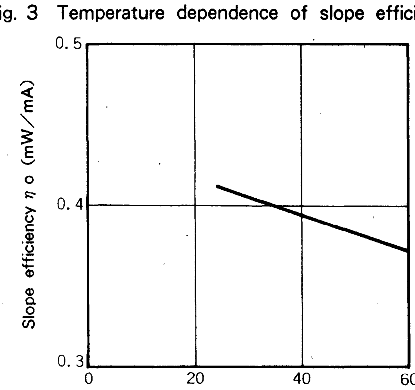
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency (η)

A typical temperature dependence of the slope efficiency η is shown in Fig. 3. The gradient is −0.001mW/mA/℃.

Fig. 3 Temperature dependence of slope efficiency



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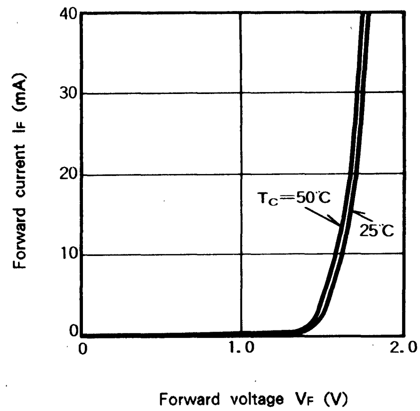
4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

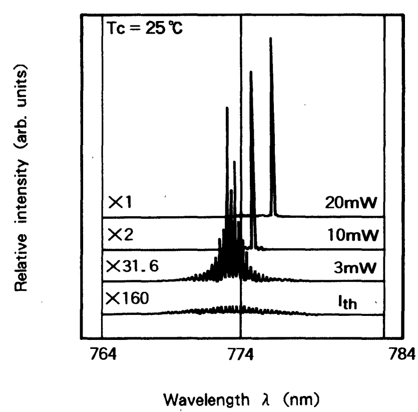
Fig. 4 Forward current vs. voltage



5 Emission spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 10mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

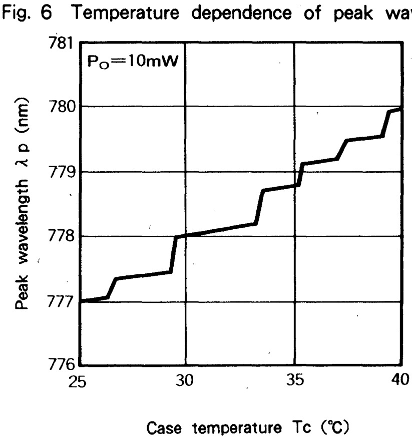


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 10mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML6XX1A laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of $0.7 \times 2.0\ \mu m^2$. Fig. 8 show typical farfield radiation patterns in "parallel" and "perpendicular" planes. The full angles at half maximum points (FAHM) are typically 12° and 30°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

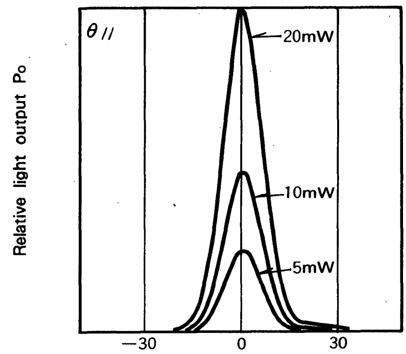
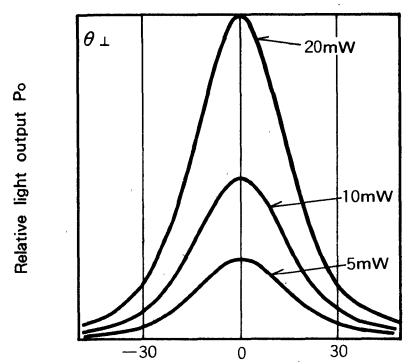


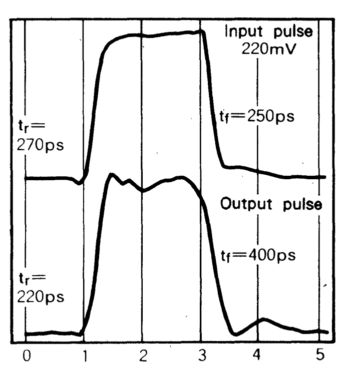
Fig. 8 Far-field patterns in plane perpendicular to heterojunctins $\theta_{\perp}$



8 Pulse response waveform

In the digital optical transmission systems, the response waveform and speed of the light output against the input current pulse waveform is one of the main concerns. In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current, Figure 9 shows a standard response waveform obtained by biasing ML6XX1A to Ith and applying a square pulse current (top of Fig. 9) up to 10mW. A quick response is obtained with rising and falling times being 0.3ns and 0.4ns typical respectively.

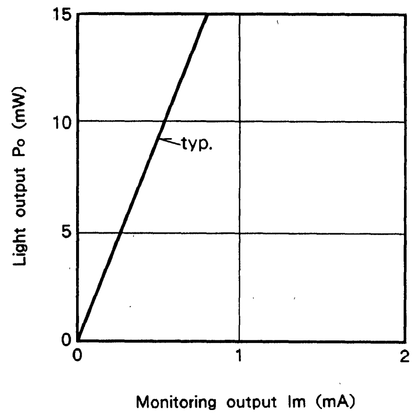
Fig. 9 Pulse response waveform



9 Light output vs. monitoring output characteristic

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig. 10 shows an example of light output vs. monitoring photocurrent characteristics. When the front beam output is 15mW, the monitor output becomes about 1.0mA.

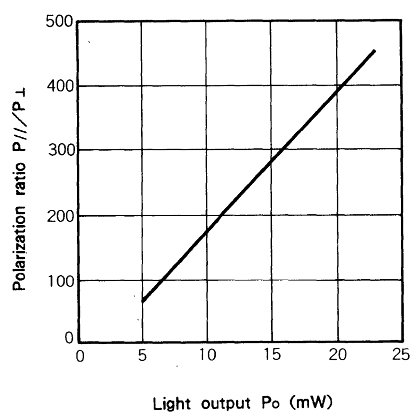
Fig. 10 Light output vs. monitoring output current



10 Polarization ratio vs. light output characteristic

The main polarization of ML6XX1A is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 11 shows the standard polarization ratio vs. total light output characteristic.The polarizastion ratio increases with the light power.

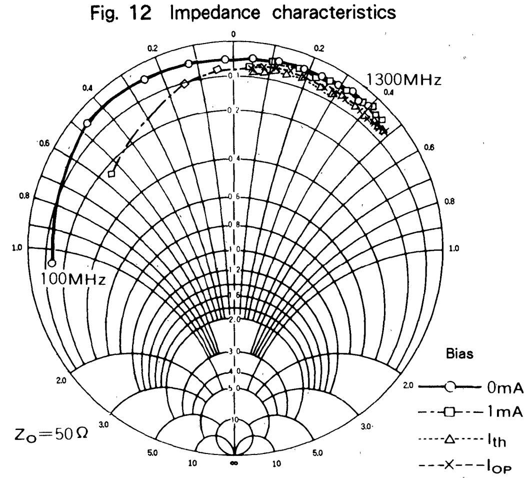
Fig. 11 Polarization ratio vs. light output



11 Impedance characteristics

Typical impedance characteristics of the ML6XX1A, with lead lengths of 2mm, are shown in Fig. 12 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz steps.Above the threshold, the impedance of the ML6XX1A is nearly equal to a series connection of a resistance of 3ohm and an inductance of 3nH.

Fig. 12 Impedance characteristics



12 S/N vs. optical feedback ratio

S/N vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig. 13. That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig. 14. S/N ratio is worst on CW driving and on HF superimposed driving, when case temperature is 25～50 ℃ and atmosphere temperature is 25 ℃ respectively. The frequency and input level of HF superimposition are about 700MHz, 35mAp-p.

Fig. 13 S/N vs. optical feedback ratio
$f=20kHz, BW=300Hz, T_C=25\sim50℃$

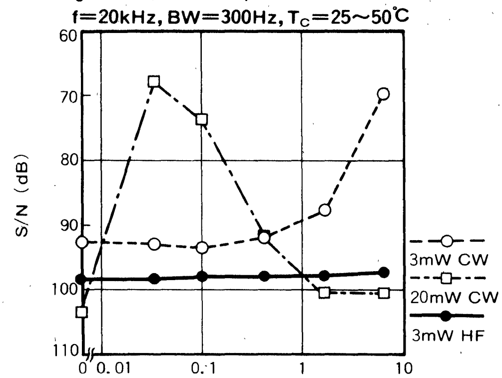
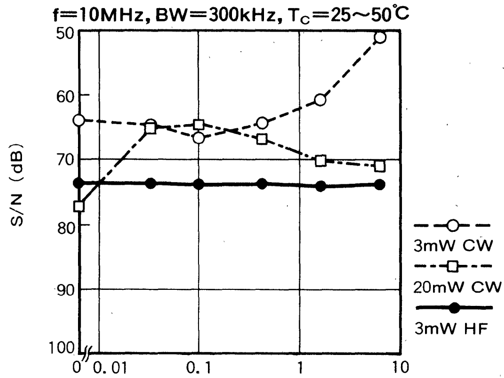


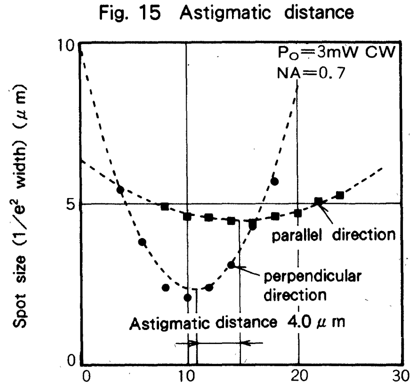
Fig. 14 S/N vs. optical feedback ratio
$f=10MHz, BW=300kHz, T_C=25\sim50℃$



13 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular direction with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it diffeicult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7 of ML6XX1A is shown in Fig. 15. The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtasined.

Fig. 15 Astigmatic distance



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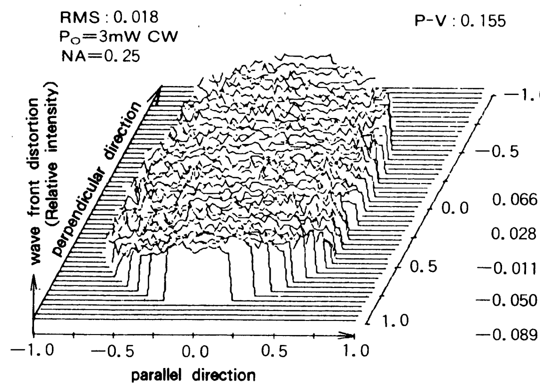
14 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML6XX1A is shown in Fig. 16. This figure shows wave front (phase front) when laser beam is collimated.Various aberrations are calculated by Zernike ' s polynomial approximation for the interference fringes observed by the Mach-Zehnder interferometer.

Fig. 16 Wave front distortion



TYPE NAME

ML6413A, ML6413C

DESCRIPTION

ML6XX3A is a high-power semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 780nm and standard light output of 10mW.

ML6XX3A uses a hermetically sealed package incorporating the photodiode for optical output monitoring. This high-performance, highly reliable, and long-life semiconductor laser is suitable for such high-power applications as optical disk memory writing and the light source for high-speed printer.

FEATURES

- Optical power 15mW CW
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

Optical disk drive, high speed laser beam printer

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	15	mW
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	15	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	40	60	mA
I_{OP}	Operating current	CW, P_O = 10mW	–	65	100	mA
V_{OP}	Operating voltage	CW, P_O = 10mW	–	2.0	2.5	V
η	Slope efficiency	CW, P_O = 10mW	–	0.4	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 10mW	765	780	795	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 10mW	10	12	17	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 10mW	20	30	35	deg.
I_m	Monotoring output current (Photodiode)	CW, P_O = 10mW V_{RD} = 1V R_L = 10Ω (Note 1)	0.3	0.8	1.7	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

Note 1 : R_L is load resistance of the photodiode.

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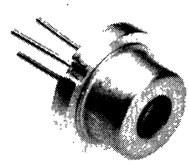
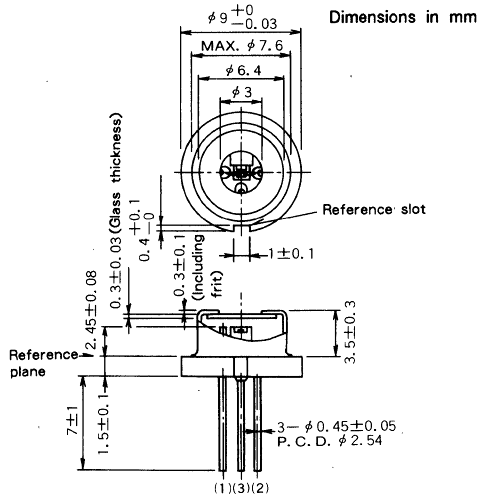
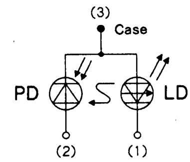
OUTLINE DRAWINGS

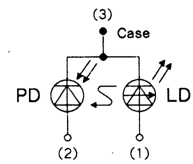
ML6413A/ ML6413C







ML6413A



ML6413C

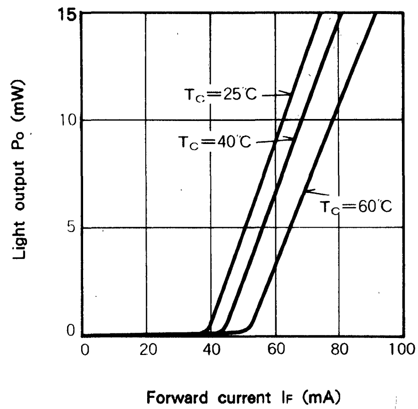
SAMPLE CHARACTERISTICS

1 Light ouput vs forward current

Typical light output vs forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 40mA at room temperature. An optical power of about 10mW is obtained at I_{th} + 25mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

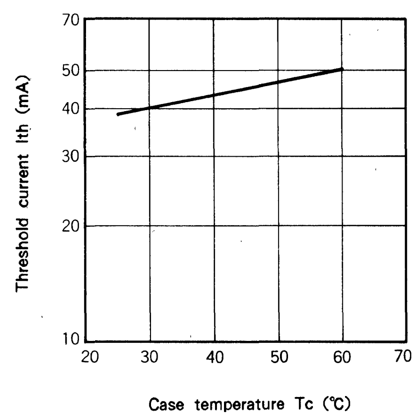
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th})

A typical temperature dependence of the threshold current is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically 140K in $T_C \leqq 60°C$, where the defintion of T_O is $I_{th} \propto \exp\ (T_C/T_O)$.

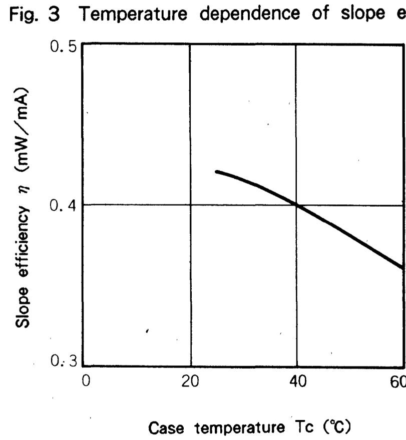
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η is shown in Fig. 3. The gradient is $-0.001mW/mA/°C$.

Fig. 3 Temperature dependence of slope efficiency



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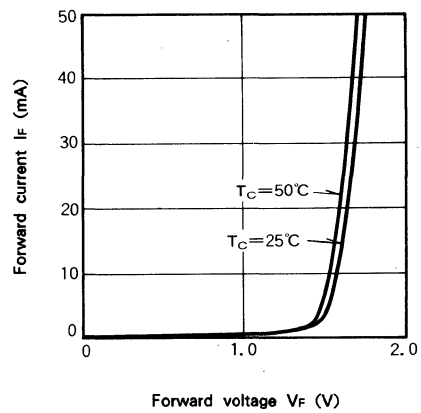
4 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −2.0mV/℃ at I_F = 1mA.

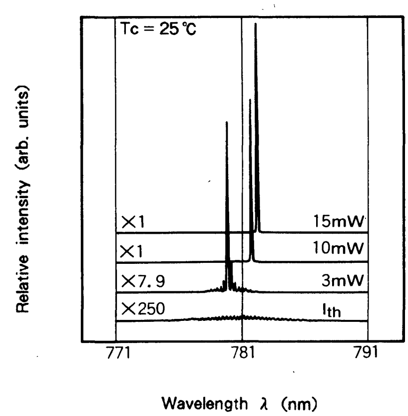
Fig. 4 Forward current vs. voltage



5 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 10mW, single mode is observed. The peak wavelength depends on the operating case temperature and forward current (output level).

Fig. 5 Emission spectra under CW operation

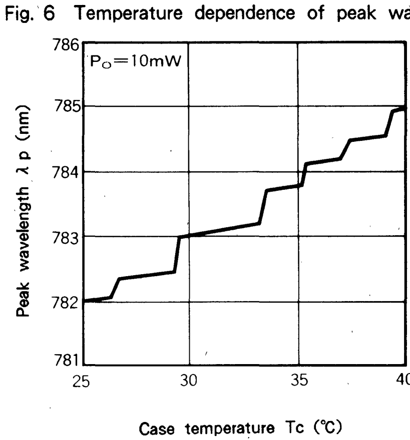


6 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of CW, 10mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.25nm/℃ typical.

Fig. 6 Temperature dependence of peak wavelength



7 Far-field pattern

The ML6XX3A laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of $2.0\times0.7\mu m^2$. Fig. 7 shown typical farfield radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 12° and 30°.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

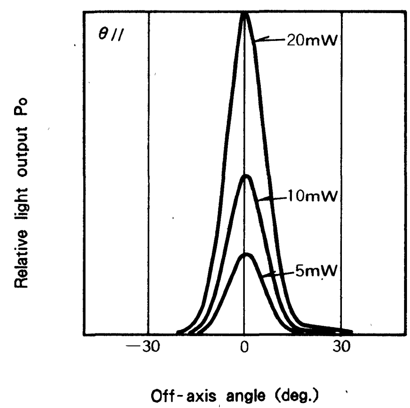
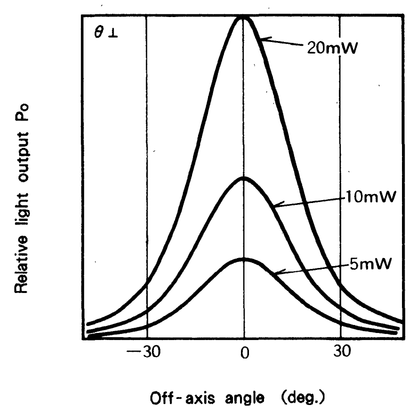


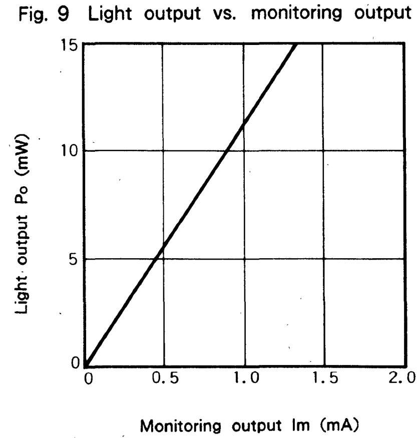
Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$



8 Monitoring output

The laser diodes emit beams from both of their mirro surfaces, front and rear surfaces. The rear beam can be used for monitoring power of front beam since the rear beam is proportional to the front one. Fig. 9 shows an example of light output vs monitoring photocurrent characteristics. When the front beam output is 10mW, the monitor output becomes about 0.8mA.

Fig. 9 Light output vs. monitoring output current



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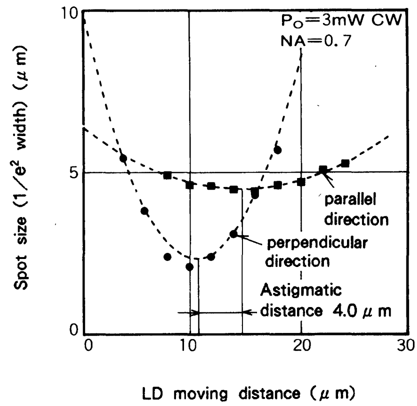
9 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular directions with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two directions, making it difficult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7 of ML6XX3A is shown in Fig. 10. The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

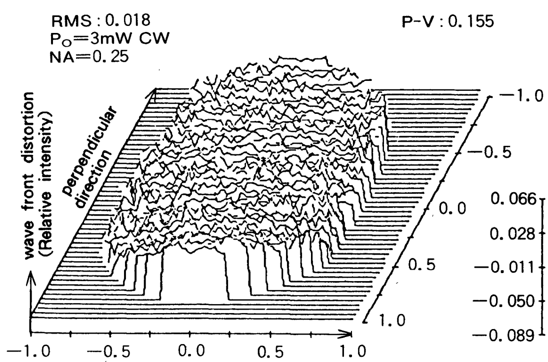
Fig. 10 Astigmatic distance



10 Wave front distortion characteristics

Typical wave front distortion (mainly astigmatism) of ML6XX3A is shown in Fig. 11. This figure shows wave front (phase front) when laser beam is collimated. Various aberrations are calculated by Zernike's polynomial approximation for the interference fringes observed by the Mach-Zehnder interferomerer.

Fig. 11 Wave front distortion



TYPE NAME

ML64110N, ML64110C, ML64110R

DESCRIPTION

ML6XX10 is a high-power AlGaAs semiconductor laser which provides a stable, single transverse oscillation output with emission wavelength of 785nm and standard light output of 30mW.

ML6XX10 is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- Output 35mW (CW), 45mW (pulse)
- Short astigmatic distance
- Built-in monitor photodiode
- Highly reliable, long operation life

APPLICATION

Optical disk drive (rewritable, write once)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	35	mW
		Pulse (Note 1)	45	
V_{RL}	Reverse voltage (laser diode)	−	2	V
V_{RD}	Reverse voltage (Photodiode)	−	30	V
I_{FD}	Forward current (Photodiode)	−	10	mA
T_C	Case temperature	−	−40～+60	℃
T_{stg}	Storage temperature	−	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (Tc = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	−	70	85	mA
I_{OP}	Operating current	CW, P_O = 30mW	−	140	160	mA
η	Slope efficiency	CW, P_O = 30mW	−	0.4	−	mW/mA
V_{OP}	Operating voltage	CW, P_O = 30mW	−	2.0	2.5	V
λ_P	Peak wavelength	CW, P_O = 30mW	770	785	800	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 30mW	9	10.5	13	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 30mW	24	26.5	28	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 30mW, V_{RD} = 1V, R_L = 10 Ω (Note 3)	1.0	3.0	6.0	mA
I_m (Note 2)			0.6	2.7	4.0	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	−	−	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	−	7	−	pF

Note 2 : Applicable to ML64110R.
3 : R_L = the load resistance of photodiode.

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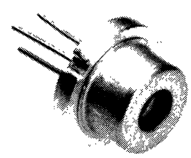
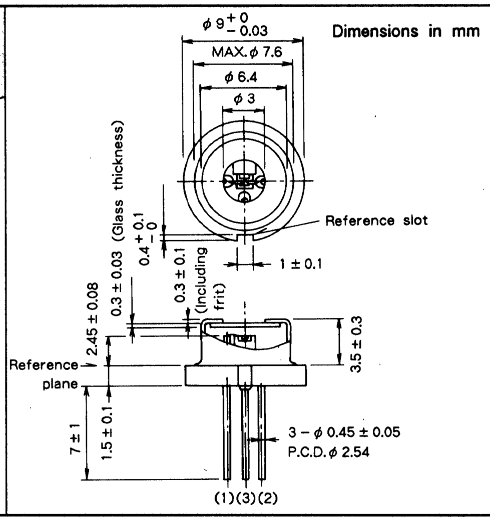
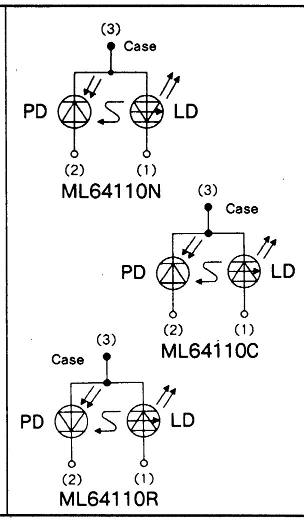
OUTLINE DRAWINGS

**ML64110N/
ML64110C/
ML64110R**







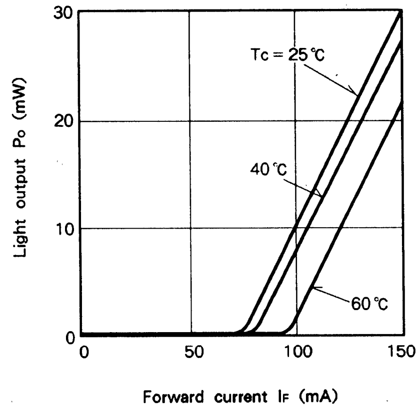
SAMPLE CHARACTERISTICS

1 Light output vs. forward current characteristics

Figure 1 shows the typical light output vs. current characteristic of ML6XX10. The threshold current Ith at room temperature is about 70mA. The optical output linearly increases at currents larger than Ith and no kink is observed. An optical output of about 30mA can be obtained at I_{th} + 70mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

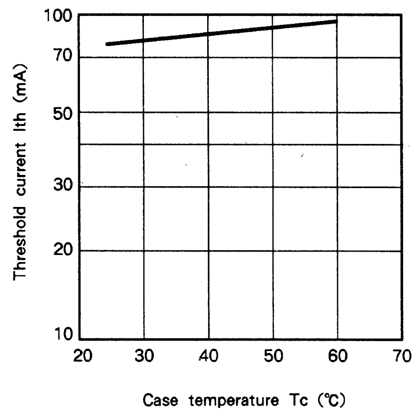
Fig. 1 Light output vs. forward current



2 Temperature dependance of threshold current

A typical temperature depndence of the threshold current of ML6XX10 is shown in Fig. 2. The characteristic temperature To of the threshold current is typically about 160K in Tc ≦ 60℃, where the definition of To is $I_{th} \propto \exp(T_C/T_O)$.

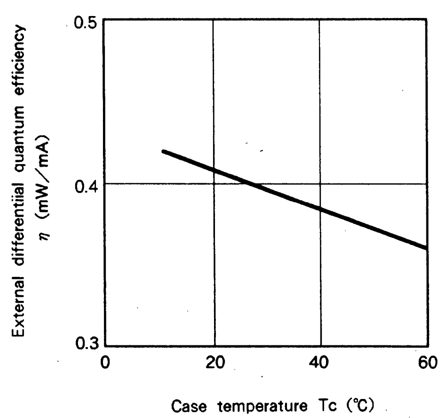
Fig. 2 Temperature dependence of threshold current



3 Temperature dependance of slope efficiency

A typical temperature dependance of the slop efficiency η of ML6XX10 is shown in Fig. 3. The gradient is −0.0013mW/mA/℃ typical.

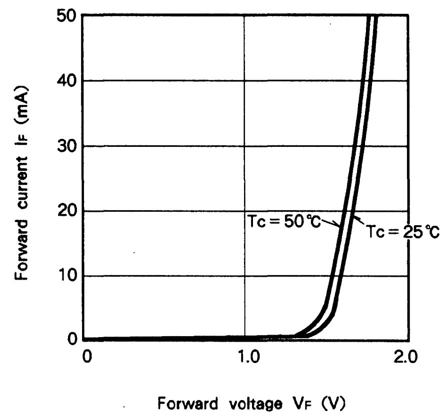
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage characteristic

Typical forward current vs. voltage characteristics of ML6XX10 are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −1.4mV/℃ at I_F = 1mA.

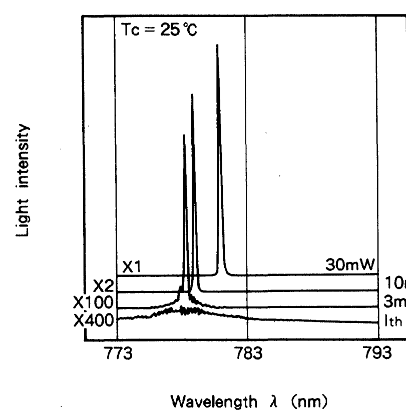
Fig 4 Forward current vs. voltage



5 Light output dependence of emission spectra

Typical emission spectra of ML6XX10 under CW operation are shown in Fig. 5. In general, at an output of 30mW, the laser oscillates in the single mode. The peak wavelength depends on the current (light output level) and the case temperature.

Fig. 5 Light output dependence of emission spectra Light intensity

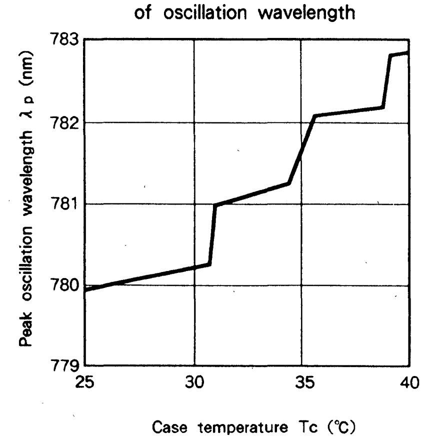


6 Temperature dependence of emission spectra

A typical temperature dependence of the peak oscillation wavelength of ML6XX10 at a constant output (CW, 30mW) is shown in Fig. 6.

As the temperature rises, the peak oscillation wavelength shifts to the long wavelength side at a rate of about 0.20nm/℃ typical.

Fig. 6 Case temperature dependence of oscillation wavelength



7 Far-field pattern

ML6XX10 oscillates in the fundamental transverse mode (TE_{00}) regardless of light output level. The typical size of the light emitting area (the spot size of near field pattern) is about 2.3 μm × 0.9 μm.

Figures 7 and 8 respectively show the typical near field patterns which are parallel (θ//) and perpendicular (θ⊥) to the active layer. The full angles at half maximum points are typically 11° and 26°.

Fig. 7 Far field pattern θ//

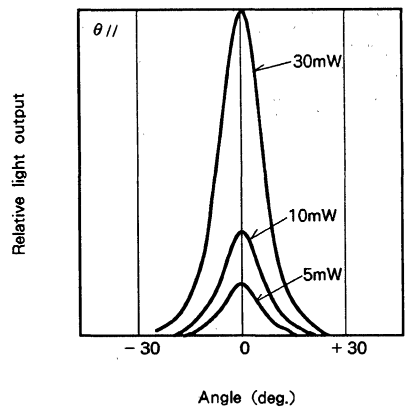
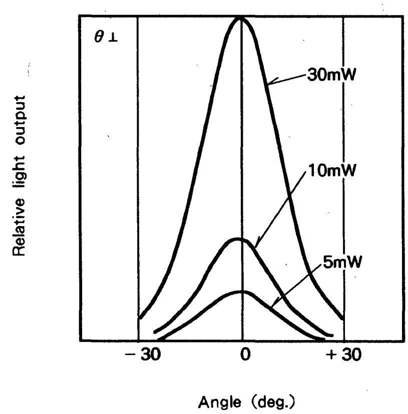


Fig. 8 Far field pattern θ⊥

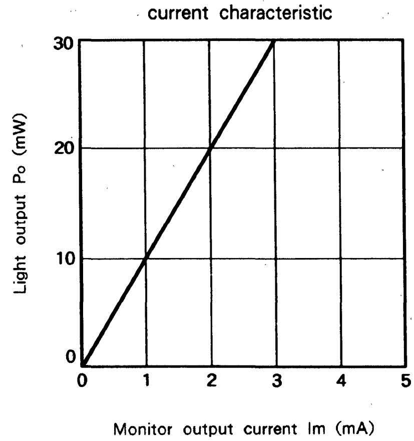


8 Light output vs. monitoring output characteristic

The laser diode emits beams from both the front and rear sides. The intensities of these beams are in proportional relationship. Therefore, the rear beam is used for monitoring the front beam. Figure 9 shows the typical front beam output vs. monitor output current characteristic of ML64110N and ML64110C.

When the front beam output is 30 mW, the monitor output typically becomes 3.0mA. With ML64110R, when the front beam output is 30mW, the monitor output typically becomes 2.7mA.

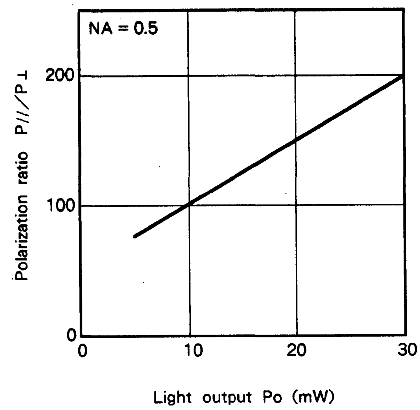
Fig. 9 Light output vs. monitor output current characteristic



9 Polarization ratio vs. light output characteristic

The main polarization of ML6XX10 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it.Fig. 10 shows the standard polarization ratio vs. total light output characteristic. The polarization ratio increases with the light output.

Fig. 10 Polarization ratio vs. light output

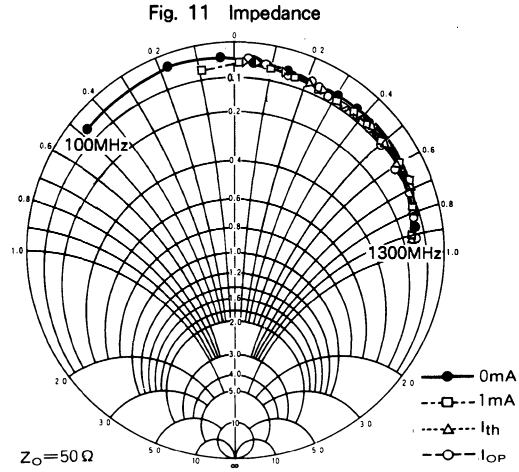


10 Impedance characteristic

Typical impedance characteristic of ML6XX10, with a lead length of 2mm and the bias current being used as the parameter is shown in Fig. 11. Test frequencies are 100MHz to 1300MHz in steps of 100MHz.

Above the threshold, the impedance of ML6XX10 is nearly equal to a series connection of a resistance of 4ohms and an inductance of 3nH.

Fig. 11 Impedance



11 S/N vs. optical feedback ratio characteristic

S／NA vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig. 12. That where the frequency is 10MHz and the bandwidth is 300kHz is shown in Fig. 13. S／N ratio is worst on CW driving and HF superimposed driving, when case temperature is 25 ℃ to 50℃ and ambient temperature is 25℃. The frequency and input level of HF superimposition are the values obtained at about 700MHz and about 35mAp-p, respectively.

Fig. 12 S／N vs. optical feedback ratio
f = 20kHz, BW = 300Hz

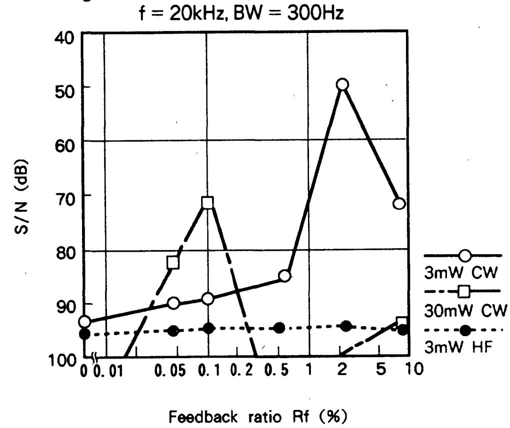
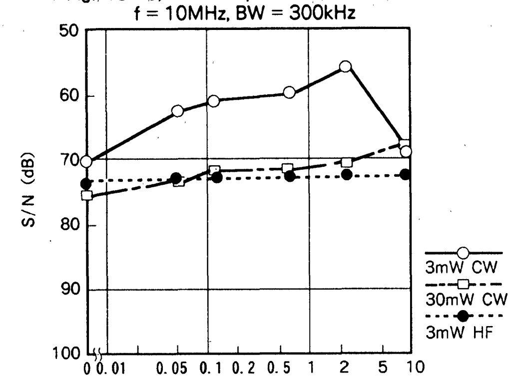


Fig. 13 S/N vs. optical feedback ratio
f = 10MHz, BW = 300kHz

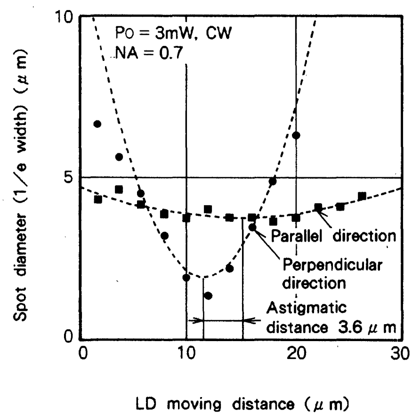


12 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular directions with the laser beam.This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the two direcctions, making it difficult to converge the beam spot to the diffraction limit. The typical astigmatic focal distance at NA = 0.7 of ML6XX10 is shown in Fig. 14.

The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

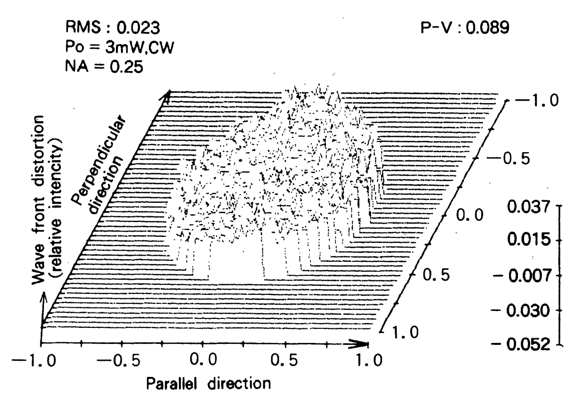
Fig. 14 Astigmatic distance



13 Wave front distortion characteristic

Typical wave front distortion (mainly astigmatism) of ML6XX10 is shown in Fig. 15. This figure shows wave front (phase front) when the laser beam is collimated. Various aberrations are calculated by Zernike ' s polynomial approximation for the interferance fringes observed by the Mach-Zehnder interferometer.

Fig. 15 Wave frong distortion



MITSUBISHI ELECTRIC

TYPE NAME

ML60111R, ML64111N

DESCRIPTION

ML6XX11 is a high-power AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 785nm and standard light output of 30mW.

ML6XX11 is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- Output 35mW (CW), 45mW (pulse)
- Short astigmatic distance
- Built-in monitor photodiode
- Low Iop specifications

APPLICATION

Optical disk drive (rewritable, write once)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	35	mW
		Pulse (Note 1)	45	
V_{RL}	Reverse voltage (laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	30	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40∼+60	℃
T_{stg}	Storage temperature	–	−55∼+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

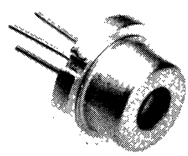
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	60	75	mA
I_{OP}	Operating current	CW, P_O = 30mW	–	120	135	mA
η	Slope efficiency	CW, P_O = 30mW	–	0.5	–	mW/mA
V_{OP}	Operating voltage	CW, P_O = 30mW	–	2.0	2.5	V
λ_P	Peak wavelength	CW, P_O = 30mW	770	785	800	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 30mW	9	10.5	13	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 30mW	24	26.5	28	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 30mW, V_{RD} = 1V, R_L = 10 Ω (Note 3)	–	0.9	–	mA
I_m (Note 2)			–	0.7	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	–	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 0V, f = 1MHz	–	7	–	pF

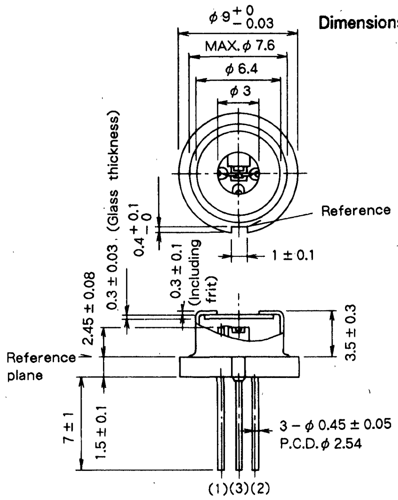
Note 2 : Applicable to ML60111R.
3 : R_L = the load resistance of photodiode.

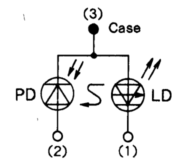
FOR OPTICAL INFORMATION SYSTEMS

OUTLINE DRAWINGS

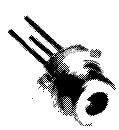
ML64111N

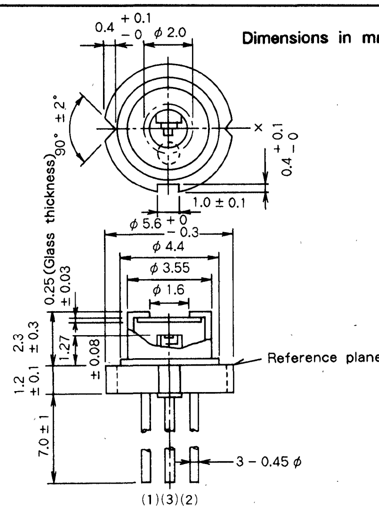


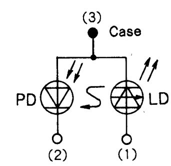




ML60111R







MITSUBISHI ELECTRIC

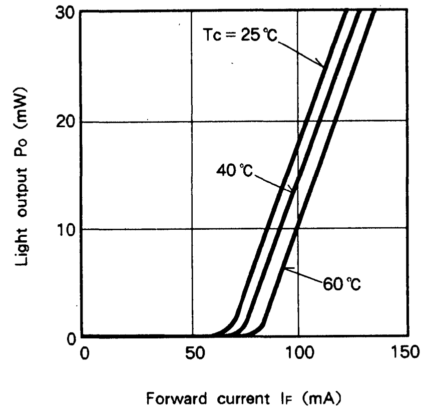
SAMPLE CHARACTERISTICS

1 Light output vs. forward current characteristic

Figure 1 shows the typical light output vs. current characteristic of ML6XX11. The thershold current Ith at room temperature is about 60mA. The optical output linearly increases at currents larger than I_{th} and no kink is observed. An optical output of about 30mW can be obtained at I_{th} + 60mA.

Because I_{th} and slope efficiency η (dP_O/dI_F) is temperature dependent, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

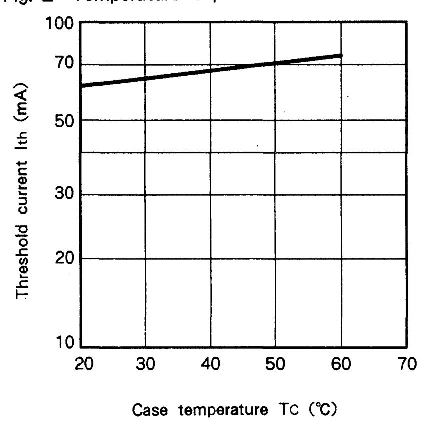
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current

A typical temperature dependance of the threshold current of ML6XX11 is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically about 160K in $T_C \leqq 60$°C, where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

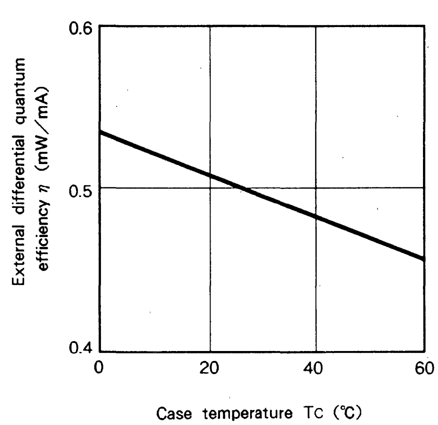
Fig. 2 Temperature dependence of threshold current



3 Temperature dependence of slope efficiency

A typical temperature dependence of the slope efficiency η of ML6XX11 is shown in Fig. 3. The gradient is −0.0012mW/mA/°C typical.

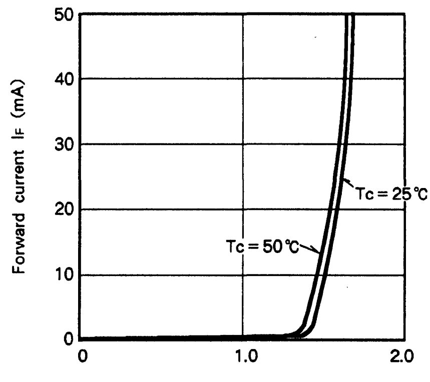
Fig. 3 Temperature dependence of slope efficiency



4 Forward current vs. voltage characteristic

Typical forward current vs. voltage characteristics of ML6XX11 are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.4mV/℃$ at $I_F = 1mA$.

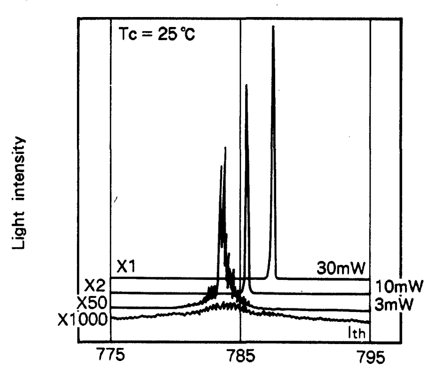
Fig. 4 Forward current vs. voltage



5 Light output dependence of emission spectra

Typical emission spectra of ML6XX11 under CW operation are shown in Fig. 5. In general, at an output of 30mW, the laser oscillates in the single mode. The peak wavelength depends on the current (light output level) and the case temperature.

Fig.5 Light output dependence of emission spectra

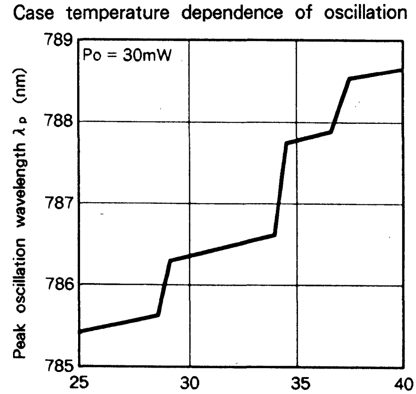


6 Temperature dependence of emission spectra

A typical temperature dependence of the peak oscillation wavelength ML6XX11 at a constant output (CW, 30mW) is shown in Fig. 6.

As the temperature rises, the peak oscillation wavelength shifts to the long wavelength side at rate of about 0.20nm/℃ typical.

Fig. 6 Case temperature dependence of oscillation wavelength



7 Far field pattern

ML6XX11 oscillates in the fundamental transverse mode (TE00) regardless of light output level. The typical size of the light emitting area (the spot size of near field pattern) is about 2.3 μm × 0.9 μm. Figures 7 and 8 respectively show the typical near field patterns which are parallel ($\theta_{//}$) and perpendicular ($\theta_{\perp}$) to the active layer. The full angles at half maximum points are typically 11° and 26°.

Fig. 7 Far field pattern $\theta_{//}$

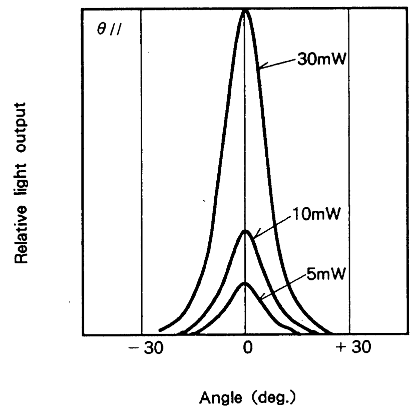
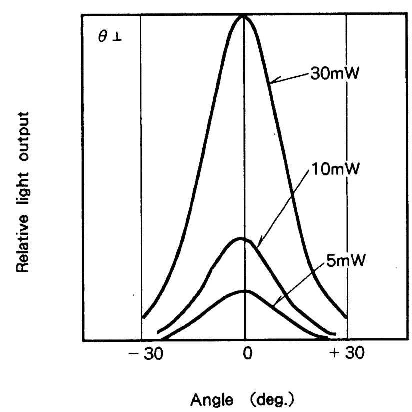


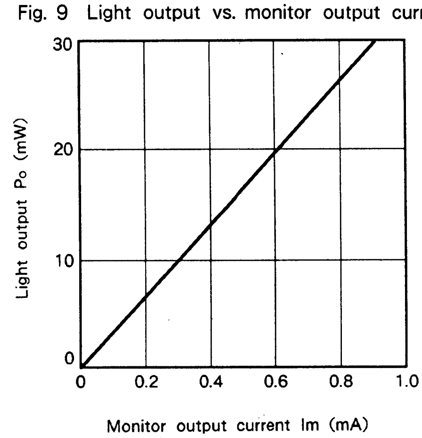
Fig. 8 Far field pattern $\theta_{\perp}$



8 Light output vs. monitoring output characteristic

The laser diode emits beams from both the front and rear sides.The intesities of these beams are in proportional relationship. Therefore, the rear beam is used for monitoring the front beam. Figure 9 shows the typical front beam output vs. monitor output current characteristic of ML64111N. When the front beam output is 30mW, the monitor output typically becomes 0.9mA.

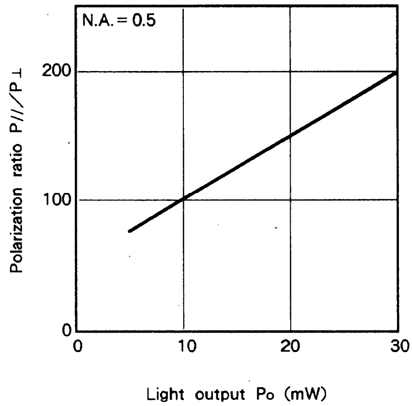
Fig. 9 Light output vs. monitor output current



9 Polarization ratio vs. light output characteristic

The main polarization of ML6XX11 is made in the direction parallel to the active layer. Polarization ratio refers to the intensity ratio of the light polarized in parallel to the active layer to the light polarized in perpendicular to it. Figure 10 shows the standard polarization ratio vs. total light output characteristic. The polarization ratio increases with the light output.

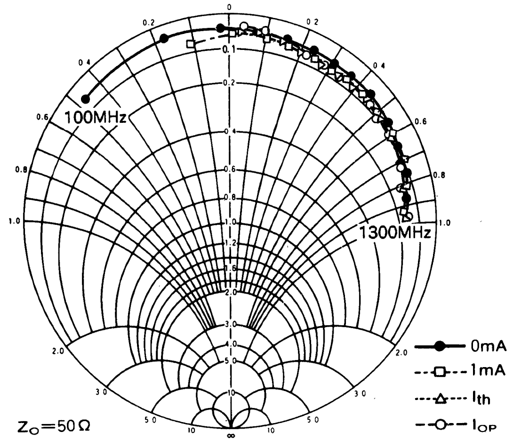
Fig. 10 Polarization ratio vs. light output



10 Impedance characteristic

Typical impedance characteristic of ML6XX11, with a lead length of 2mm and the bias current being used as the parameter is shown in Fig. 11. Test frequencies are 100MHz to 1300 MHz in steps of 100MHz. Above the threshold, the impedance of ML6XX10 is nearly equal to a series connection of a resistance of 4ohms and an inductance of 3nH.

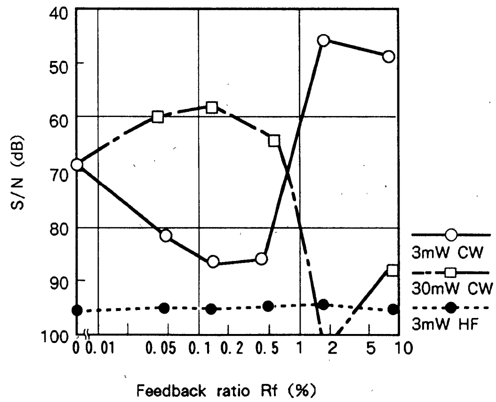
Fig. 11 Impedance



11 S/N vs. optical feedback ratio characteristic

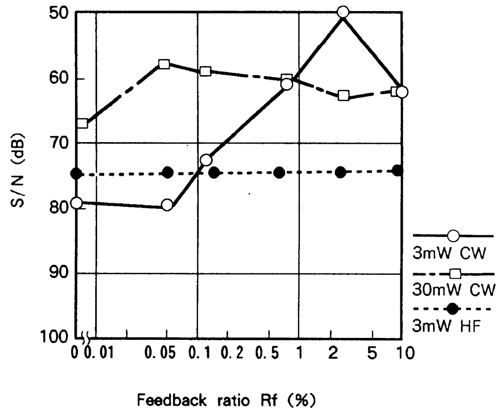
S/NA vs. optical feedback ratio, where the frequency is 20kHz and the bandwidth is 300Hz is shown in Fig. 12. That where the frequency is 10 MHz and the bandwidth is 300kHz is shown in Fig. 13. S/N ratio is worst on CW driving and HF superimposed driving, when case temperature is 25 ℃ to 50℃ and ambient temperature is 25℃. The frequency and input level of HF superimposition are the values obtained at about 700MHz and about 35mAp-p, respectively

Fig. 12 S/N vs. optical feedback ratio
f = 20kHz, BW = 300Hz



MITSUBISHI ELECTRIC

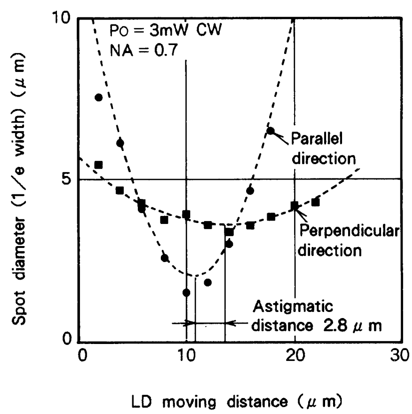
Fig. 13 S/N vs. optical feedback ratio
f = 10MHz, BW = 300kHz



12 Astigmatic distance

There seems to be a difference in luminous point in the parallel and perpendicular directions with the laser beam. This distance between the two points is the astigmatic focal distance. Therefore, when the laser beam is focused, there is a difference in focal point in the directions, making it difficult to converge the beam spot to the diffraction limit.The typical astigmatic focal distance at NA = 0.7 of ML6XX11 is shown in Fig. 14. The LD position which minimizes the horizontal and vertical spot diameters is obtained. The astigmatic distance is the difference in moved distances thus obtained.

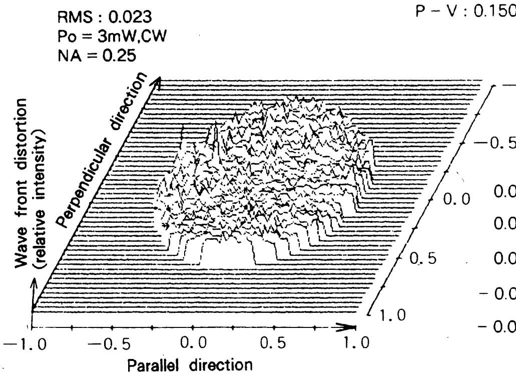
Fig. 14 Astigmatic distance



13 Wave front distortion characteristic

Typical wave front distortion (mainly astigmatism) of ML6XX11 is shown in Fig. 15. This figure shows wave front (phase front) when the laser beam is collimated. Various aberrations are calculated by Zernike's polynomial approximation for the interference fringes observed by the Mach-Zehnder interferometer.

Fig. 15 Wave front distortion



TYPE NAME

ML60114R, ML64114R

DESCRIPTION

ML6XX14 is a high-power AlGaAs semiconductor laser which provides a stable, single transverse mode oscillation with emission wavelength of 785nm and standard light output of 50mW.

ML6XX14 is produced by the MOCVD crystal growth method which is excellent in mass production and characteristics uniformity. This is a high-performance, highly reliable, and long-life semiconductor laser.

FEATURES

- Output 60mW (CW), 70mW (pulse)
- Short astigmatic distance
- Built-in monitor photodiode
- MQW active layer

APPLICATION

Optical disk drive (rewritable, write once)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	60	mW
		Pulse (Note 1)	70	
V_{RL}	Reverse voltage (laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	30	V
I_{FD}	Forward current (Photodiode)	–	10	mA
T_C	Case temperature	–	−40～+60	℃
T_{stg}	Storage temperature	–	−55～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS ($T_C = 25$℃)

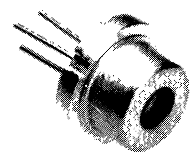
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	55	–	mA
I_{OP}	Operating current	CW, $P_O = 50$mW	–	135	–	mA
η	Slope efficiency	CW, $P_O = 50$mW	–	0.6	–	mW/mA
V_{OP}	Operating voltage	CW, $P_O = 50$mW	–	2.0	2.5	V
λ_P	Peak wavelength	CW, $P_O = 50$mW	770	785	800	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, $P_O = 50$mW	–	9.5	–	deg.
$\theta_{\perp}$	Beam drivergence angle (perpendicular)	CW, $P_O = 50$mW	–	25	–	deg.
I_m	Monitoring output current (Photodiode)	CW, $P_O = 50$mW, $V_{RD} = 1$V, $R_L = 10\,\Omega$ (Note 3)	–	0.3	–	mA
I_m (Note 2)			–	0.3	–	mA
I_D	Dark current (Photodiode)	$V_{RD} = 10$V	–	–	0.5	μA
C_t	Capacitance (Photodiode)	$V_{RD} = 0$V, f = 1MHz	–	7	–	pF

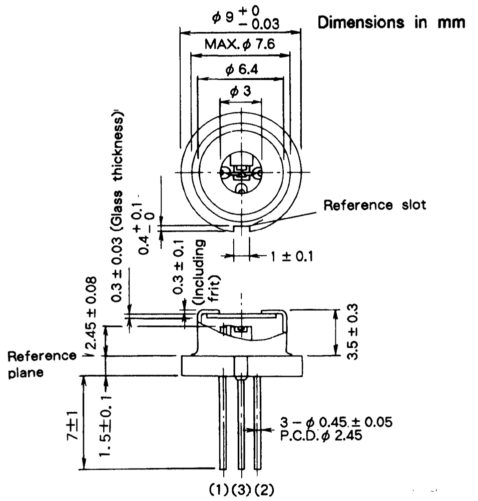
Note 2 : Applicable to ML60114R.
3 : R_L = the load resistance of photodiode.

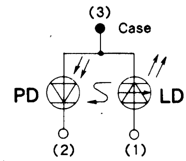
FOR OPTICAL INFORMATION SYSTEMS

OUTLINE DRAWINGS

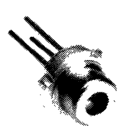
ML64114R

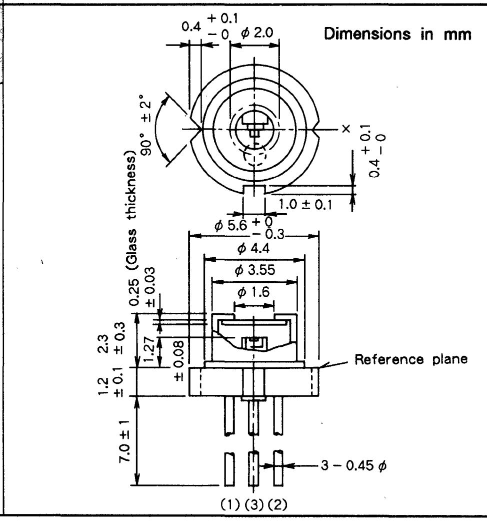


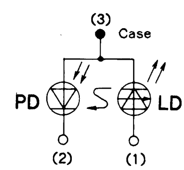




ML60114R







TYPE NAME

ML7011R, ML720A1S, ML7701 ML774A1F, ML776B1F, ML7781 ML7911

DESCRIPTION

ML7XX1 series are InGaAsP laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1300nm and standard continuous light output of 5mW.

ML7XX1 are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such applications as the light sources for long-distance optical communication systems and optical mesurment systems.

FEATURES

- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in monitor photodiode (except ML7911)
- High reliability, long operation life
- 1300nm typical emission wavelength
- High speed of response

APPLICATION

- Optical communication systems
- Optical measurment systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	unit
P_O	Light output power	CW	10	mW
		Pulse (Note 1)	10	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case Temperarure	–	−20∼+70	℃
T_{stg}	Storage temperature	–	−40∼+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	10	30	mA
I_{OP}	Operating current	CW, P_O = 5mW	–	25	50	mA
V_{OP}	Operating voltage	CW, P_O = 5mW	–	1.2	1.6	V
η	Slope efficiency	CW, P_O = 5mW	0.2	0.35	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	1280	1300	1330	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 5mW	–	3	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	–	25	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	–	30	–	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 5mW, 10%∼90%	–	0.3	0.7	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 5mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.2	0.5	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Total capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF
P_m (Note 3)	Monitoring Light Output	CW, P_O = 5mW	–	1.0	–	mW

Note 2 : R_L is load resistance of the photodiode.
3 : P_m only apply to ML7911.

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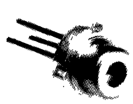
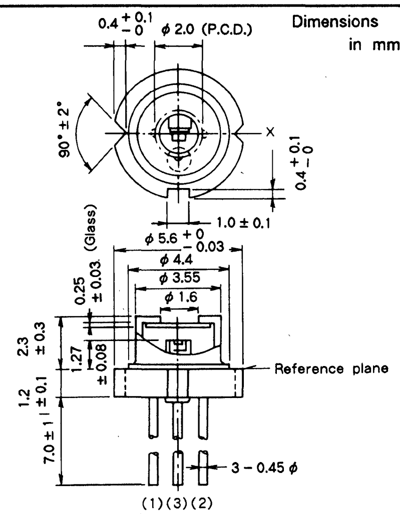
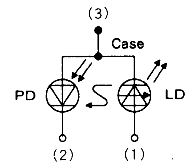
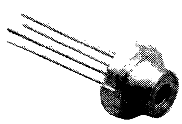
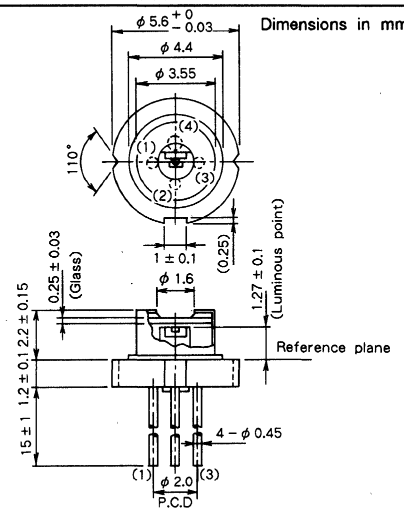
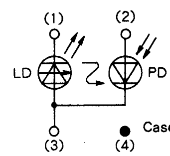
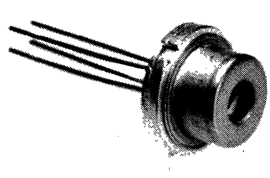
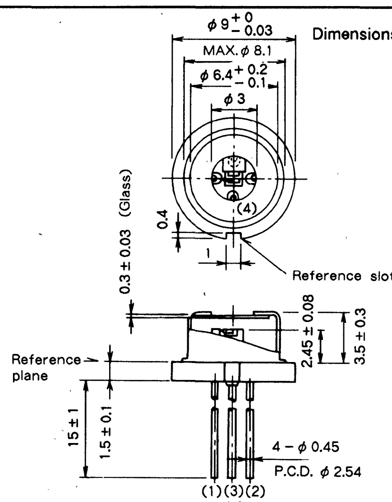
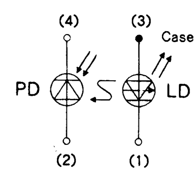
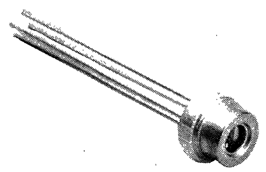
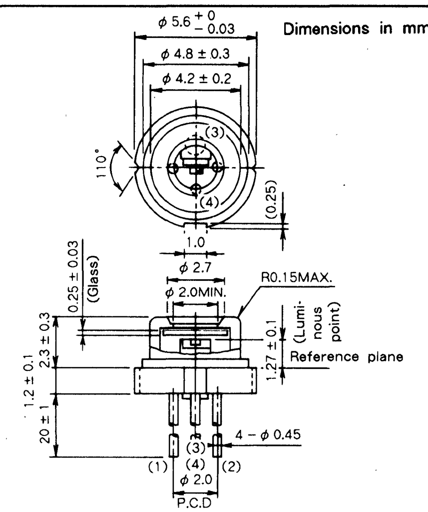
OUTPUT DARAWINGS

Type	Outline drawing	Package
ML7011R 		(φ 5.6mm 3pin small package) 
ML720A1S 		(φ 5.6mm 4pin LD, PD floating) 
ML7701 		(φ 9mm 4pin Standard package) 

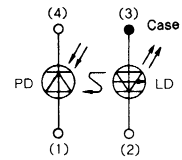
FOR OPTICAL COMMUNICATION

ML774A1F

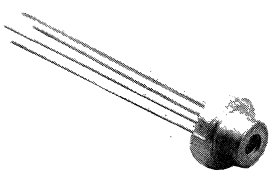


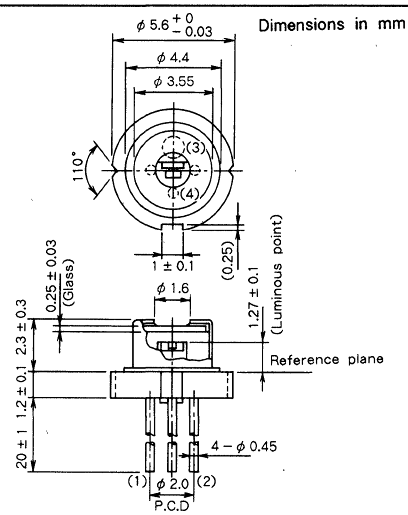


(φ 5.6mm 4pin with thick cap)

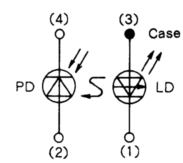


ML776B1F

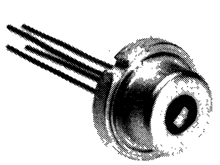


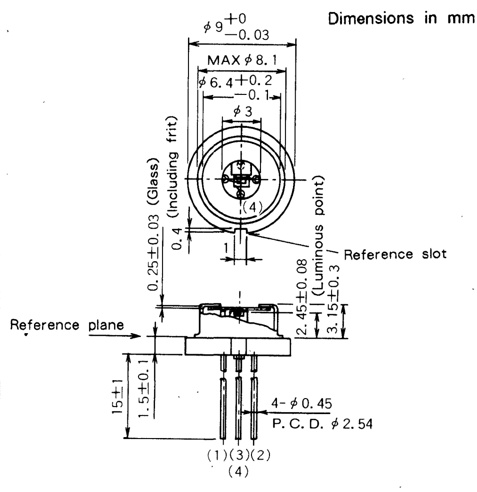


(φ 5.6mm 4pin small package)

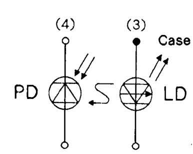


ML7781

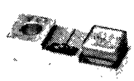




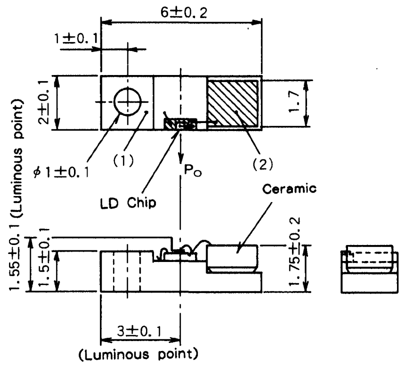
(φ 9mm, 4pin, Low cap package)



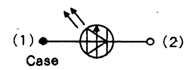
ML7911



Dimensions in mm



(Chip carrier package)



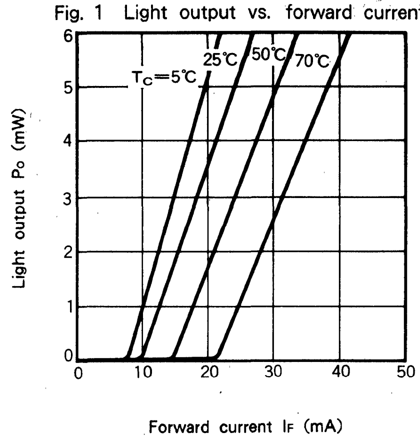
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristic are shown in Fig. 1. The threshold current for lasing is typically 10mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 5mW is obtained at I_{th} + 15mA.

As can be seen in Fig.1. I_{th} and slope efficiency η (dP_O/dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

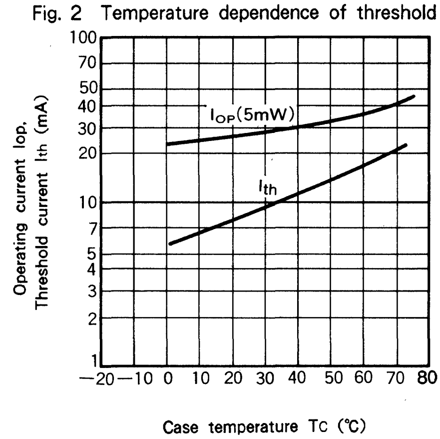
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th}), operating current (I_{op}) and slope efficiency (η)

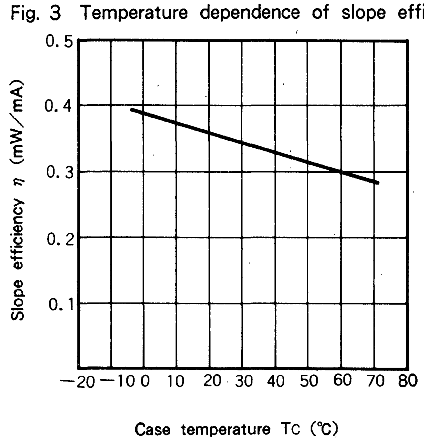
A typical temperature dependence of the threshold current and operating current (5mW) is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically 55K in $T_C \leqq 50$°C, 45K in $T_C > 50$°C where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

Fig. 2 Temperature dependence of threshold current



A typical temperature dependences of the slope efficiency η is shown in Fig. 3. The gradient is − 0.0015mW/mA/°C.

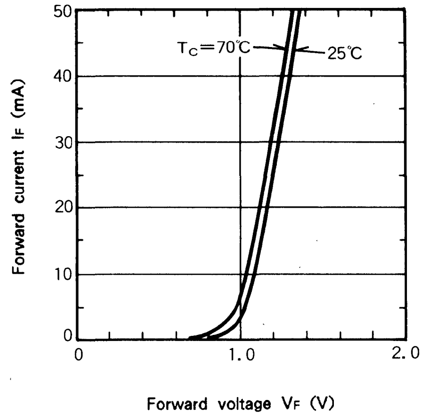
Fig. 3 Temperature dependence of slope efficiency



3 Forward current vs. voltage

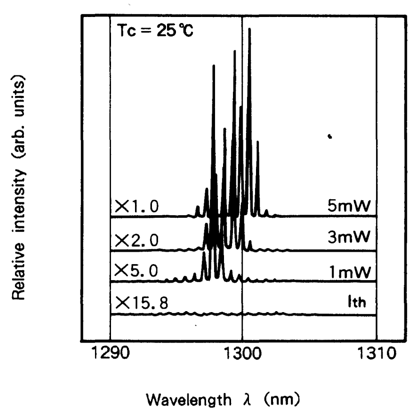
Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −1.3mV/℃ and −1mV/C at I_F = 1mA and 10mA, respectively.

Fig. 4 Forward current vs. voltage



4 Emission spectra

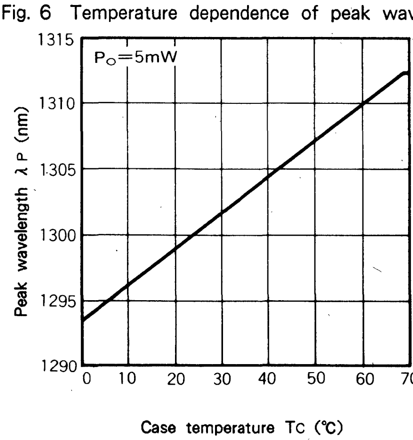
Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 5mW, several modes are observed. Longitudinal mode spacings are typically 1nm and spectral width (FWHM) is typically 3nm at an output of 5mW. The peak wavelength depends on the operating case temperature and the forward current (output level).



A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.35nm/℃.

Fig. 6 Temperature dependence of peak wavelength



5 Far-field pattern

The ML7XX1 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of $1.0 \times 1.25 \mu m^2$. Fig. 7 and Fig. 8 show typical far-field radiation patterns in "parallel" and "perpendicular" planes.

The full angles at half maximum points (FAHM) are typically 25deg. and 30deg., respectively.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

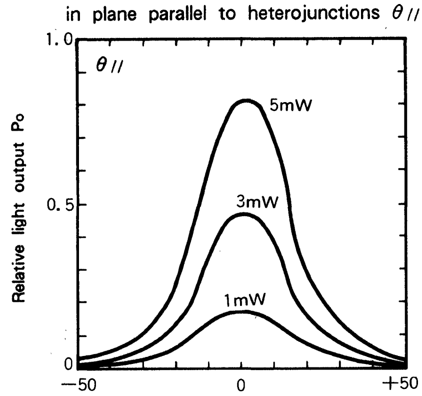
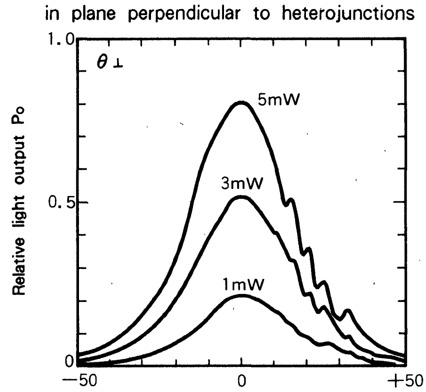


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$

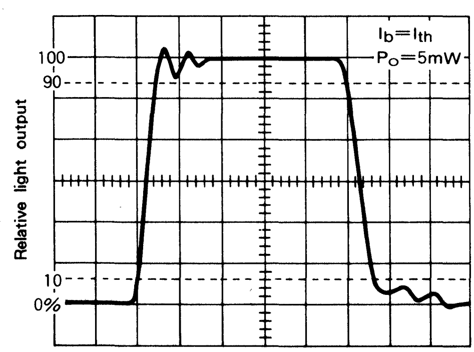


6 Pulse response

In digital transmission systems, the response waveform and speed of the light output against the input pulse current waveform is a main concern. In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Fig. 9 shows a typical response waveform when a rectangular pulse current (rise/fall time is shorter than 0.2ns) is applied.

Rise/fall time is typically 0.3ns at $I_b = I_{th}$ and $P_o =$ 5mw.

Fig. 9 Pulse response waveform



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7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring the power of the front beam since the power of the rear beam is proportional to the front one. In the ML7XX1 series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 10 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring output current is typically 0.5mA when the front light output is 5mW. In the ML7911, monitor photodiodes are not installed in the laser package. Monitoring output is emitted from the back of package.
Monitoring output is typically 1mW when front light output is 5mW.

8 Impendance characteristics

Typical impendance characteristics of the ML7XX1, with lead lengths of 2mm is shown in Fig. 11 with the bias currents as the parameter. Test frequency is swept from 100MHz to 1300MHz with 100MHz step.

Fig. 10 Light output vs. monitoring output current

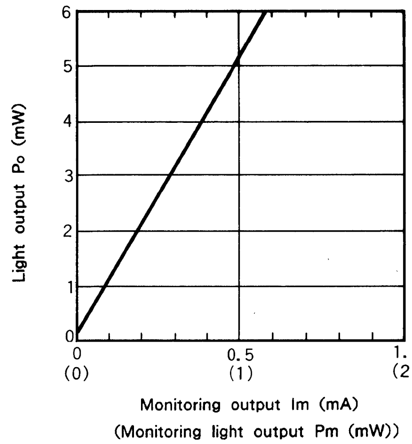
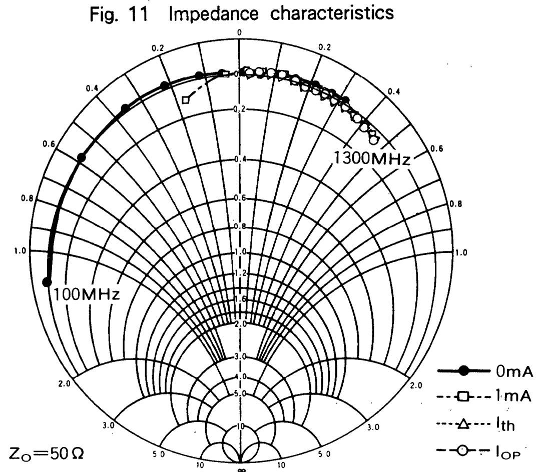


Fig. 11 Impedance characteristics



TYPE NAME

ML7781A, ML7911A

DESCRIPTION

ML7XX1A series are InGaAsP high power laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1310nm and standard continuous light output of 25mW.

ML7XX1A are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such high-power applications as the light sources for OTDR systems and long-distance optical communication systems.

FEATURES

- Low threshold current, low operating current
- Built-in photodiode (ML7781A)
- High reliability, long operation life
- High power (CW 25mW, Pulse 100mW)
- 1310nm typical emission wavelength
- High speed of response
- Stable fundamental transverse mode oscillation

APPLICATION

Digital communication systems, OTDR systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	30	mW
I_F	Forward current	Pulse (Note 1)	400	mA
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case temperature	–	−20～+50	℃
T_{stg}	Stroage temperature	–	−40～+100	℃

Note 1 : Duty less than 1%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTIC (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	10	30	mA
I_{OP}	Operating current	CW, P_O = 25mW	–	70	130	mA
V_{OP}	Operating voltage	CW, P_O = 25mW	–	1.5	2.0	V
$P_{O (P)}$	Pulse ligth output	Pulse (Note 1), I_F = 350mA	100	–	–	mW
λ_P	Peak wavelength	CW, P_O = 25mW	1280	1310	1330	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 25mW	–	8	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 25mW	–	25	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 25mW	–	30	–	deg.
t_r, t_f	Rise and fall times	$I_F = I_{th}$, P_O = 25mW, 10%～90%	–	0.3	–	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 25mW, V_{RD} = 1V, R_L = 10Ω (Note 2)	0.2	0.5	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF
P_m (Note 3)	Monitoring light output	CW, P_O = 25mW	–	1.0	–	mW

Note 2 : R_L is load resistance of the photodiode.
3 : P_m only apply to ML7911A.

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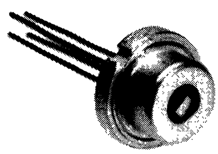
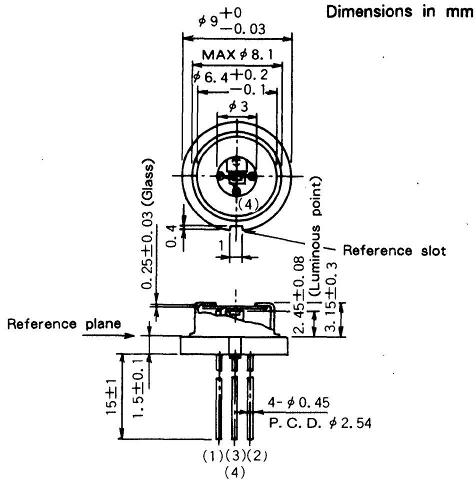
OUTLINE DRAWINGS

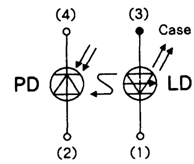
ML7781A



Dimensions in mm

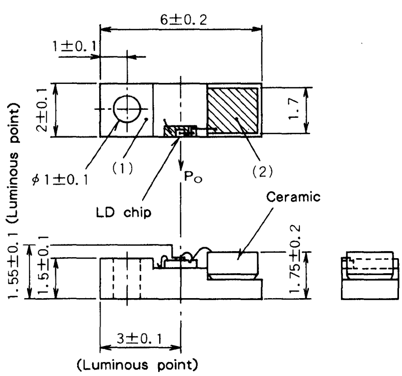


(φ 9mm, 4pin, Low cap package)

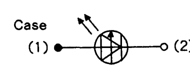


ML7911A

Dimensions in mm



(Chip carrier package)



SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs . forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 10mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 25mW is obtained at I_{th} + 60mA.

As can be seen in Fig. 1. I_{th} and slope efficiency η (dP_O/dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperatureT_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

Fig. 1 Light output vs. forward current (CW)

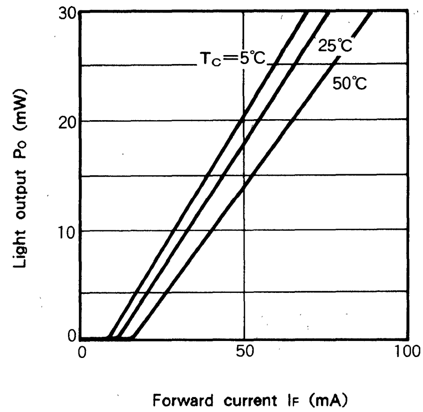
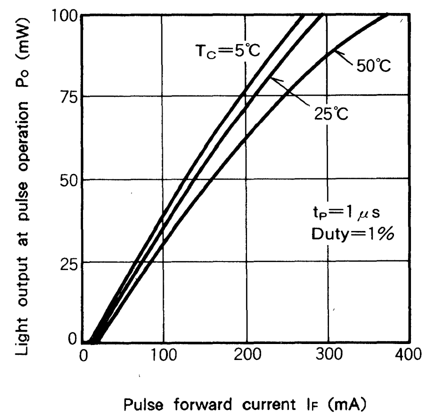


Fig. 2 shows a typical light output vs. forward current under pulse operation.

Pulse conditions are pulse width t_P = 1 μ sec and duty = 1 %.They emit light power of 100mW up to 50℃ case temperature.

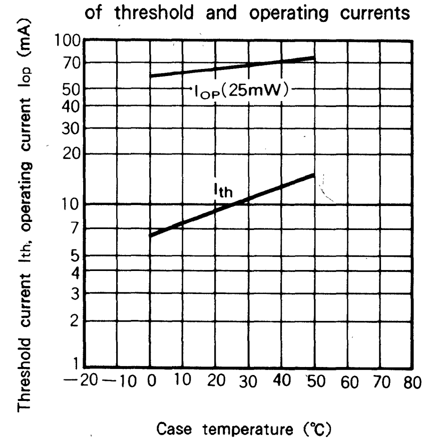
Fig. 2 Pulse light output vs. forward current at pulse operation



2 Temperature dependence of I_{th}, I_{op}

Typical temperature dependence of the threshold and operating currents is shown in Fig. 3. The characteristic temperature T_O of the threshold current is typically 55K for $T_C \leqq 50$℃, where the definition of T_O is I_{th} (T_C/T_O).

Fig. 3 Temperature dependence of threshold and operating currents



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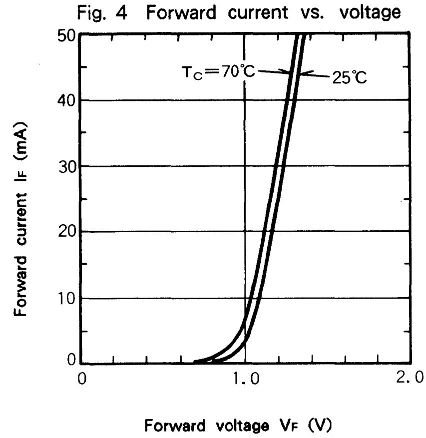
3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig.4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −1.3mV/℃ and −1mW/℃ at I_F = 1mA and 10mA, respectively.

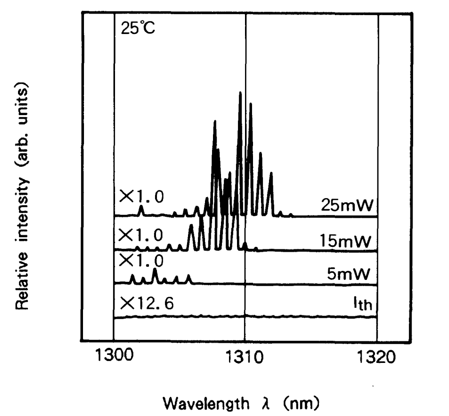
Fig. 4 Forward current vs. voltage



4 Emission spectra

Typical emission spectra under CW opertaion are shown in Fig.5. In general, at an output of 25mW, several modes are observed. Longitudinal mode spacings are typically 1nm and spectral width (FWHM) is typically 8nm at an output of 25mW.
The peak wavelength depends on the operating case temperature and the forward current (output level).

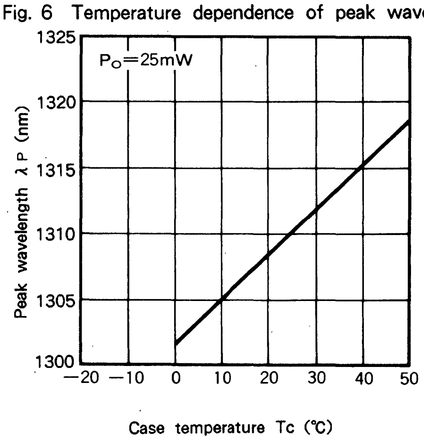
Fig. 5 Emission spectra under CW operation



5 Temperature dependence of peak wavelength

A typical temperature dependence of the peak wavelength at an output of 25mW is shown in Fig. 6
As the temperature rises, the peak wavelength shifts to the long−wavelength side at a rate of about 0.35nm/℃.

Fig. 6 Temperature dependence of peak wavelength



6 Far-field pattern

The ML7XX1A laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.0 × 1.25 μm^2. Fig. 7 and 8 show the typical far-field patterns.

The full angles at half maximum points (FAHM) are typically 25deg. and 30deg., respectively.

Fig. 7 Far-field patterns
in plane parallel to heterojunctions $\theta_{//}$

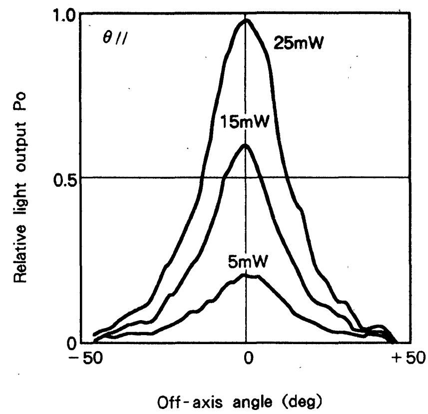
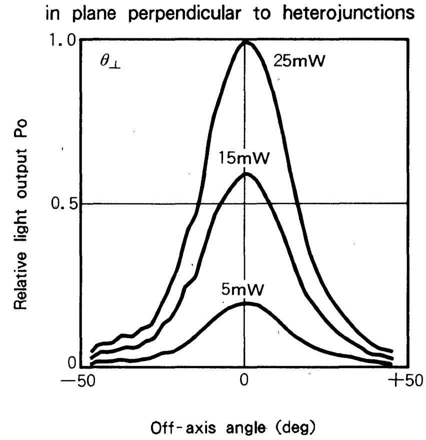


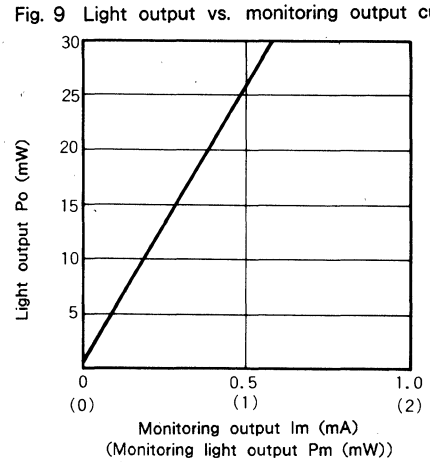
Fig. 8 Far-field patterns
in plane perpendicular to heterojunctions $\theta_{\perp}$



7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring the power of the front beam since the power of the rear beam is proportional to the front one. In the ML7XX1A series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 9 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring output current is typically 0.5mA when the front light output is 25mW. In the ML7911A, monitor photodiodes is not installed in the laser package. Monitoring output is emitted from the back of package. Monitoring output is typically 1mW when the front light output is 25mW.

Fig. 9 Light output vs. monitoring output current



TYPE NAME

ML774A2F, ML7922

DESCRIPTION

ML7XX2 is a DFB (Distributed Feedback) laser diode which oscillates in a single wavelength with emission wavelength of 1310nm and standard continuos light output of 5mW.

ML7XX2 are hermetically sealed devices having the photodiode for optical output monitoring. This is a high-performance, high reliability, and long-life laser diode.

FEATURES

- Low threshold current typical 15mA
- High stable fundamental transverse mode oscillation
- High side mode suppression ratio typical 40dB ($T_C = 0 \sim +60$ ℃)
- High speed of response (Rise and fall time typically 0.2nsec)

APPLICATION

Long-distance, large-capacity optical communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	6	mW
V_{RL}	Reverse voltage (Laserdiode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case temperature	–	0～+60	℃
T_{stg}	Storage temperature	–	−40～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS ($T_C = 25$ ℃)

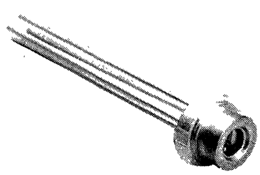
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	15	40	mA
I_{OP}	Operating current	CW, P_O = 5mW	–	30	80	mA
V_{OP}	Operating voltage (Laser diode)	CW, P_O = 5mW	–	1.2	1.8	V
η	Slope efficiency	CW, P_O = 5mW	–	0.4	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	–	1310	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	–	25	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	–	30	–	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 5mW, V_{RD} = 1V, R_L = 10 Ω (Note 1)	0.1	0.25	–	mA
t_r/t_f	Rise and fall times	$I_F = I_{th}$, P_O = 5mW, 10%～90%	–	0.2	0.4	ns
SMSR	Side mode suppression ratio	CW, P_O = 5mW, 0～+60℃	30	40	–	μA
P_m (Note 2)	Monitoring Light Output	CW, P_O = 5mW	–	0.5	–	mW

Note 1 : R_L is load resistance of the photodiode.
2 : P_m only apply to ML7922.

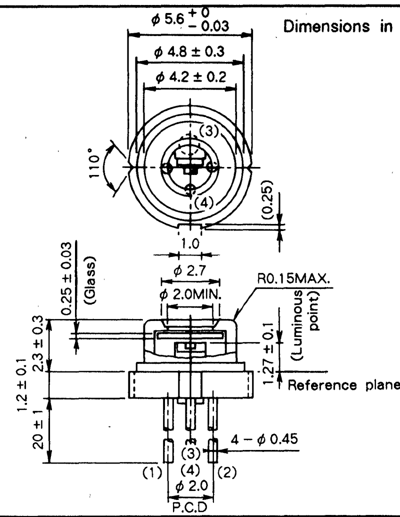
FOR OPTICAL COMMUNICATION

OUTLINE DRWINGS

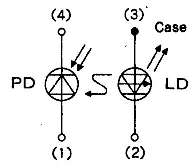
ML774A2F



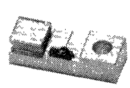
Dimensions in mm



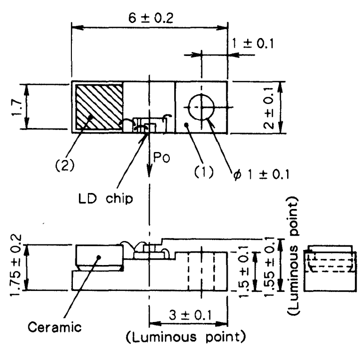
(φ 5.6mm 4pin with thick cap)



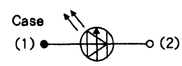
ML7922



Dimensions in mm



(Chip carrier type package)



MITSUBISHI ELECTRIC

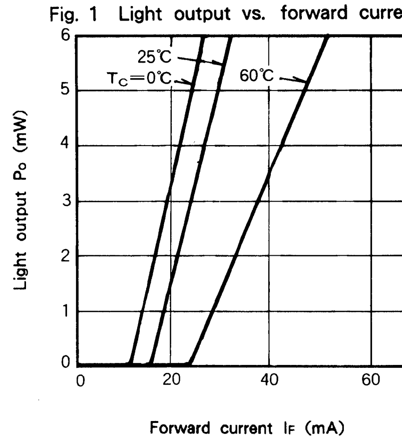
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 20mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 5mW is obtained at I_{th} + 13mA.

As can be seen in Fig. 1. I_{th} and slope efficiency η (dP_o / dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output of the built-in monitor PD becomes constant.)

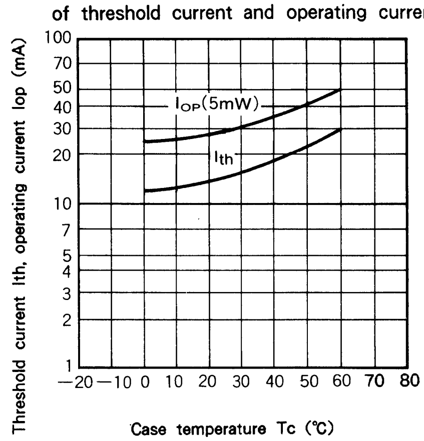
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th}), operating current (I_{op}) and slope efficiency. (η)

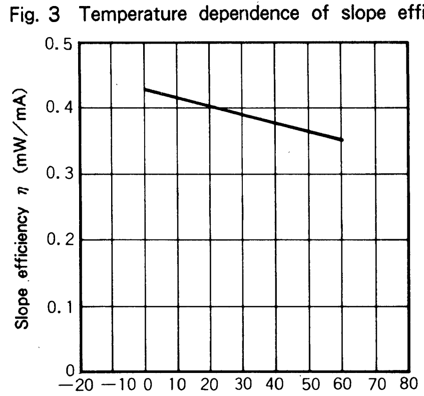
A typical temperature dependence of the threshold current and operating current (5mW) is shown in Fig. 2. The characateristic temperature T_0 of the threshold current is typically 60K in $T_c \leqq 40$℃, 55K in $T_c > 40$℃.

Fig. 2 Temperature dependence of threshold current and operating current



A typical temperature dependences of the slope efficiency η is shown in Fig. 3. The gradient is −0.0012mW/mA/℃.

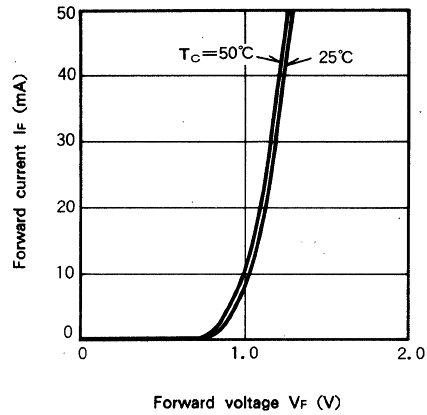
Fig. 3 Temperature dependence of slope efficiency



3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decrease slightly at a constant current I_F. V_F varies typically at a rate of −1.2mV/℃ and −1.1mV/℃ at I_F = 1mA and 10mA, respectively.

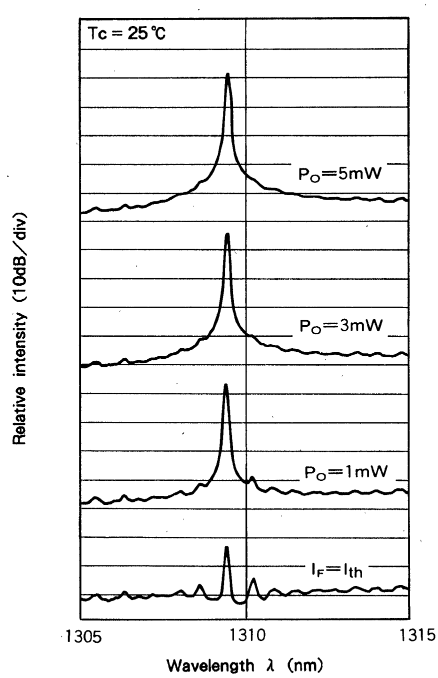
Fig. 4 Forward current vs. voltage



4 Optical output dependence of emission spectra

Typical emission spectra under CW operation are shown in Fig. 5.

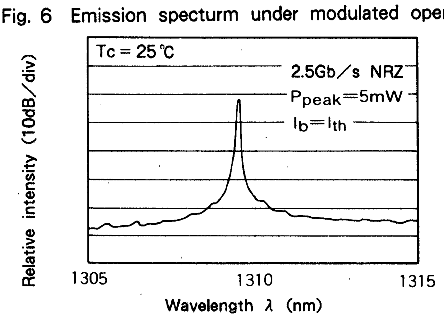
Fig. 5 Emission spectra under CW operation



Emission spectra under 2.5Gb/s (NRZ) modulation is shown in Fig.6.

Typical spectral width (Chirping) is about 0.15nm at −3dB, 0.45nm at −10dB and 0.60nm at −20dB.

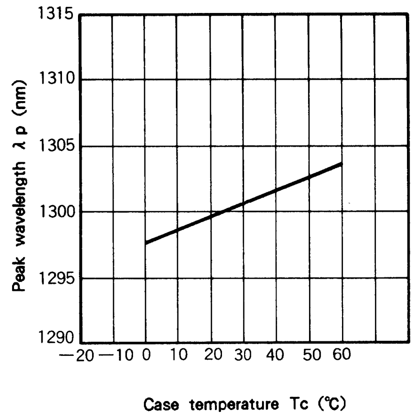
Fig. 6 Emission specturm under modulated operation



A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig. 7.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.1nm/℃.

Fig. 7 Temperature dependence of peak wavelength



5 Far-field pattern

The ML7XX2 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.0 × 1.25 μm².

Fig. 8 and 9 show the typical far-field patterns.

The full angles at half maximum points (FAHM) are typically 30deg. and 35deg., respectively.

Fig. 8 Far field pattern (parallel)

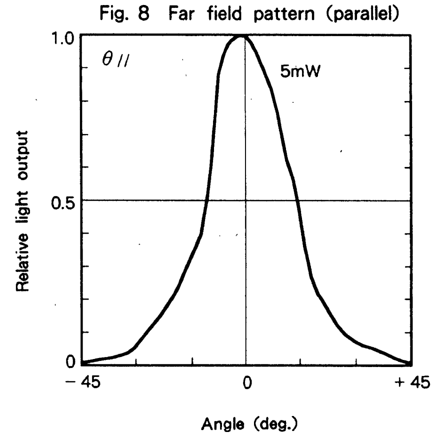
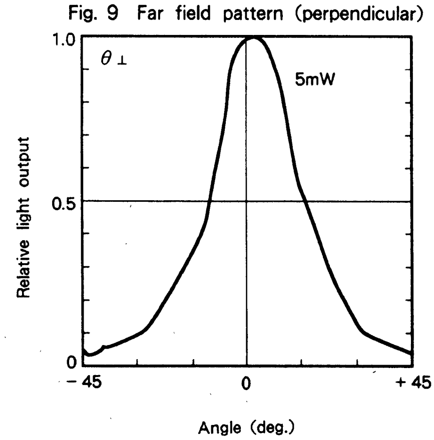


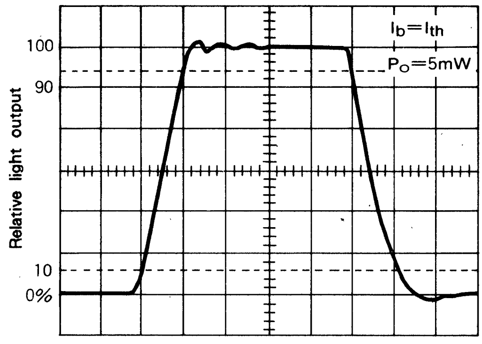
Fig. 9 Far field pattern (perpendicular)



6 Pulse response

In digital optical transmission systems, the response waveform and speed of the light output against the input pulse current waveform is a main concern. In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Fig. 10 shows a typical response waveform when a rectangular pulse current (rise/fall time is shorter than 0.1ns) is applied.
Rise/fall times is typically 0.2ns at $I_b = I_{th}$ and P_o = 5mW.

Fig. 10 Pulse response waveform

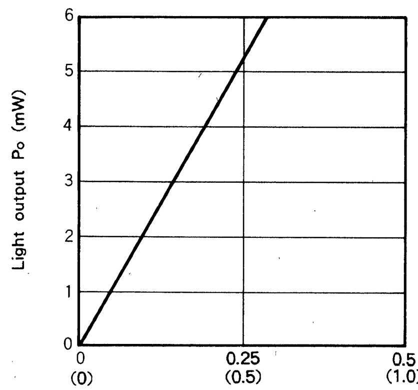


7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces (see the outline drawing). The rear beam can be used for monitoring the power of the front beam since the power of the rear beam is proportional to the front one. In the ML7XX2 series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 11 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring output current is typically 0.25mA when the front light output is 5mW.

In the ML7922, monitor photodiodes are not installed in the laser package. Monitoring output is emitted from the back of package. Monitoring output is typically 0.5mW when the front light output is 5mW.

Fig. 11 Light output vs. monitoring output current



TYPE NAME **ML7783F**

DESCRIPTION

ML7XX3 series are InGaAsP High Power laser diodes which provide a stabe, single transverse mode oscillation with emission wavelength of 1310nm and standard continuous light output of 25mW.

ML7XX3 are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such high-power applications as the light sources for OTDR systems and log-distance optical communication systems.

FEATURES

- High Power (CE 30mW, Pulse 200mW)
- 1310mm typical emission wavelength
- High speed of response
- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

OTDR systems, optical communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	30	mW
I_F	Forward current	Pulse (Note 1)	900	mA
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case temperature	–	+20～+30	℃
T_{stg}	Storage temperature	–	−40～+100	℃

Note 1 : Duty less than 1%, pulse width less than 1 μ s.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

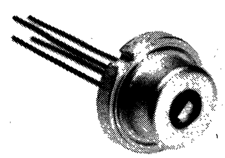
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	20	50	mA
I_{OP}	Operating current	CW, P_O = 25mW	–	80	150	mA
V_{OP}	Operating voltage	CW, P_O = 25mW	–	1.5	2.0	V
$P_{O(P)}$	Pulse light output	Pulse, I_F = 800mA (Note 2)	200	–	–	mW
λ_P	Peak wavelength	CW, P_O = 25mW	1280	1310	1330	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 25mW	–	8	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 25mW	–	25	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 25mW	–	30	–	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 25mW, 10%～90%	–	0.3	–	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 25mW, V_{RD} = 1V, R_L = 10Ω (Note 3)	0.1	0.2	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF

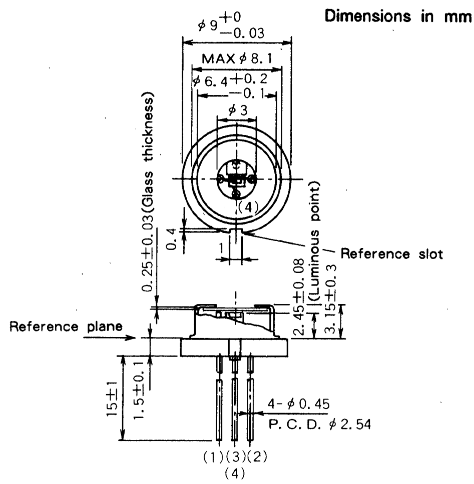
Note 2 : Duty cycle less than 1%, pulse width less than 1 μ s

3 : R_L is load resistance of photodiode.

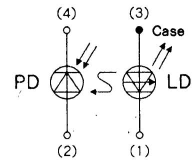
OUTLINE DRAWINGS

ML7783F





(φ 9mm 4pin
Low cap package)



SAMPLE CHARACTERISTICS

1 Light output vs. forward current characteristic

Fig. 1 shows the typical light output vs. forward current characteristic of ML7XX3. The threshold current I_{th} at room temperature is about 20mA.

Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical output of 25mW can be obtained at I_{th} + 60mA.

Fig. 1 Light output vs. forward current (CW)

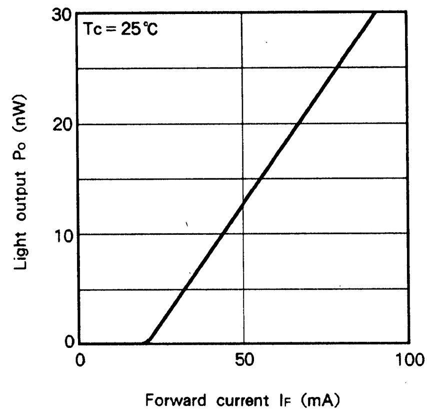
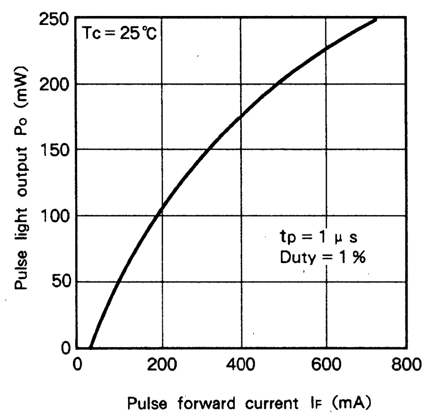


Fig. 2 shows the typical light output vs. forward current characteristic of ML7XX3 under pulse operation. Pulse conditions are pulse width t_p = 1 μsec and duty = 1 %. More than 200mW is obtained at I_F = 800mA.

Fig. 2 Pulse light output vs. forward current (Pulse)



TYPE NAME **ML7925**

DESCRIPTION

ML7XX5 series are DFB (Distributed Feedback) laser diodes emitting light beam around 1310nm.
They are well suited for light source in long–distance analog transmission system for example cable television (CATV).The ML7925 are specially designed for in fiber modules and mount on flat open packages.
Rear output can be used for automatic control of the operating current or case temperature of the laser.

FEATURES

- Excellent distortion characteristic
  42-channel transmission test
  CSO (composite second order) typical −65dBc
  CTB (composite triple beat) typical −70dBc
- Low relative intensity noise characteristic (typical −155dB/Hz)
- Low threshold current (typical 15mA)
- High-side mode suppression ratio (typical 40dB)
- High speed of response (typical 0.2ns)

APPLICATION

Long-distance analog transmission systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	20	mW
V_{RL}	Reverse voltage (Laser diode)	−	2	V
V_{RD}	Reverse voltage (Photodiode)	−	20	V
I_{FD}	Forward current (Photodiode)	−	2	mA
T_C	Case temperature	−	+20~+30	℃
T_{stg}	Storage temperature	−	−40~+100	℃

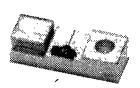
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	−	15	40	mA
I_{OP}	Operating current	CW, P_O = 10mW	−	45	80	mA
V_{OP}	Operating voltage	CW, P_O = 10mW	−	1.2	1.8	V
η	Slope efficiency	CW, P_O = 10mW	−	0.4	−	mW/mA
λ_P	Peak wavelength	CW, P_O = 10mW	−	1310	−	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 10mW	−	25	−	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 10mW	−	30	−	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 10mW, 10~90%	−	0.2	0.4	ns
SMSR	Side mode suppression ratio	CW, P_O = 10mW	30	40	−	dB
P_m	Monitoring output	CW, P_O = 10mW	−	1	−	mW
CSO	Composite second order	42-channel transmission test modulation depth ΔM = 0.035, average light output P_O = 10mW to 20mW	−	−65	−	dBc
CTB	Composite triple beat		−	−70	−	dBc
RIN	Relative intensity noise	CW, P_O = 10mW to 20mW, measuring frequency f_m = 550MHz.	−	−155	−	dB/Hz

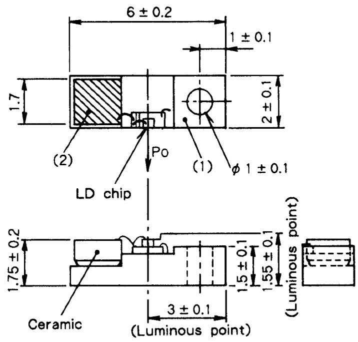
MITSUBISHI ELECTRIC

OUTLINE DRAWINGS

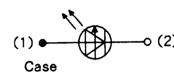
ML7925



Dimensions in mm



(Chip carrier type package)



TYPE NAME

ML8701, ML874A1F

DESCRIPTION

ML8XX1 series are InGaAsP laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1200nm and standard continuous light output of 5mW.

ML8XX1 are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such applications as the light source for multiple wavelength optical communication systems.

FEATURES

- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in photodiode
- High reliability, long operation life
- 1200nm typical emission wavelength
- High speed of response

APPLICATION

Digital communication systems, multiple wavelength communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	6	mW
		Pulse (Note 1)	10	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case temperature	–	−20～+70	℃
T_{stg}	Storage temperature	–	−40～+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	15	30	mA
I_{OP}	Operating current	CW, P_O = 5mW	–	30	60	mA
V_{OP}	Operating voltage	CW, P_O = 5mW	–	1.2	1.6	V
η	Slope efficiency	CW, P_O = 5mW	0.2	0.35	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	1180	1200	1230	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 5mW	–	3	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	–	25	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	–	30	–	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 5mW, 10%～90%	–	0.3	0.7	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 5mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.2	0.5	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF

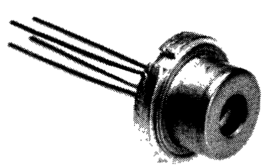
Note 2 : R_L is load resistance of the photodiode.

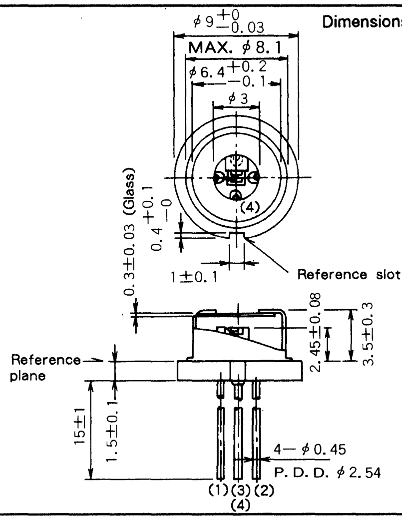
MITSUBISHI ELECTRIC

FOR OPTICAL COMMUNICATION

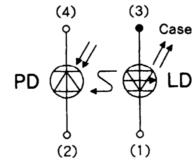
OUTPUT DRAWINGS

ML8701

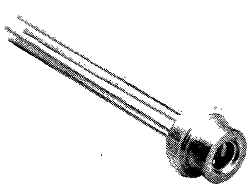


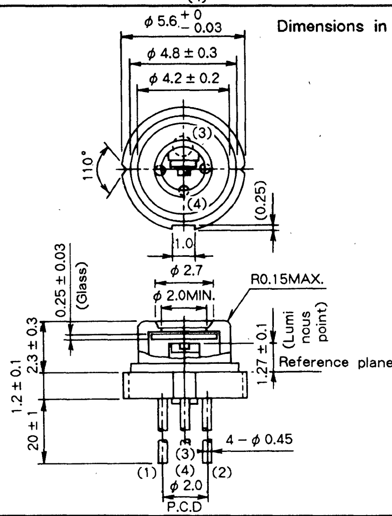


(ϕ 9mm 4pin Standard package)

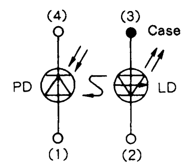


ML874A1F





(ϕ 5.6mm 4pin with thick cap)



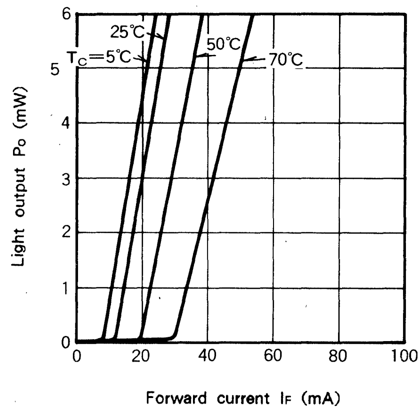
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 15mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 5mW is obtained at I_{th} + 15mA.

As can be seen in Fig.1 I_{th} and slope efficiency η (dPo/dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperature Tc or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

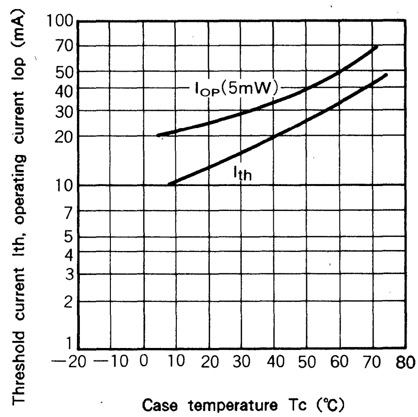
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th}), operating current (I_{op}) and slope efficiency (η)

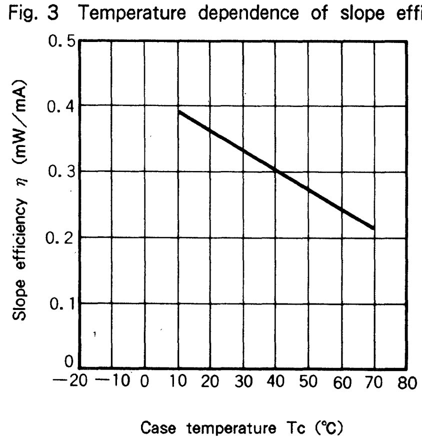
A typical temperature dependence of the threshold current and operating current is shown in Fig. 2. The characteristic temperature To of the threshold current is typically 45K in Tc≦40℃, 35K in Tc>40℃, where the definition of To is $I_{th} \propto \exp(Tc/To)$.

Fig. 2 Temperature dependence of threshold current and operating current



A typical temperature dependences of the slope efficiency η is shown in Fig. 3. The gradient is −0.003mW/mA/℃.

Fig. 3 Temperature dependence of slope efficiency

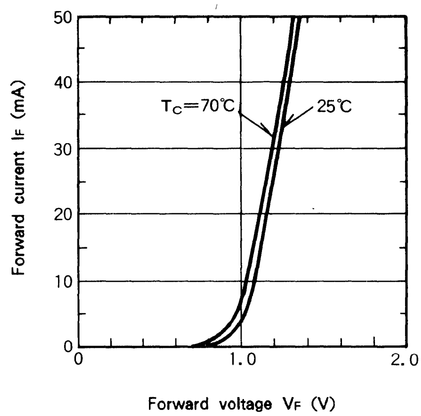


MITSUBISHI ELECTRIC

3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.3mV/℃$ and $-1mV/℃$ at $I_F = 1mA$ and 10mA, respectively.

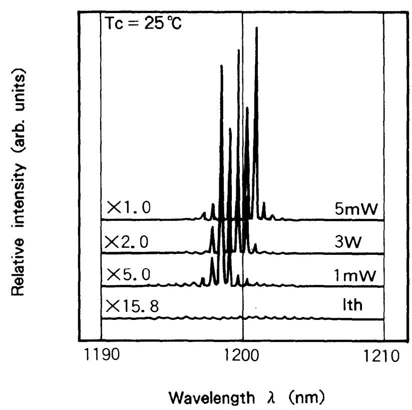
Fig. 4 Forward current vs. voltage



4 Emission spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 5mW, several modes are observed. Longitudinal mode spacings are typically 1nm and spectral width (FWHM) is typically 3nm at an output of 5mW. The peak wavelength depends on the operating case temperature and the forward current (output level).

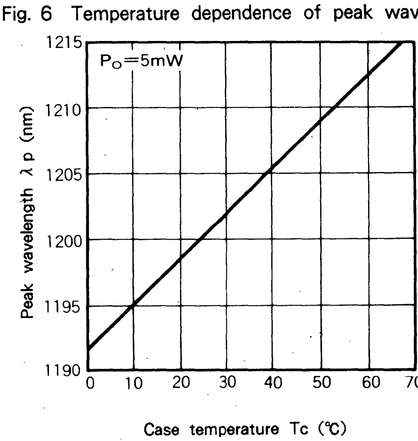
Fig. 5 Emission spectra under CW operation



A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.37nm/℃.

Fig. 6 Temperature dependence of peak wavelength



5 Far-field pattern

The ML8XX1 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.0 × 1.25 μm^2. Fig.7 and 8 show the typical far-field patterns. The full angles at half maximum points (FAHM) are typically 25deg. and 30deg., respectively.

Fig. 7 Far-field patterns
in plane parallel to heterojunctions $\theta_{//}$

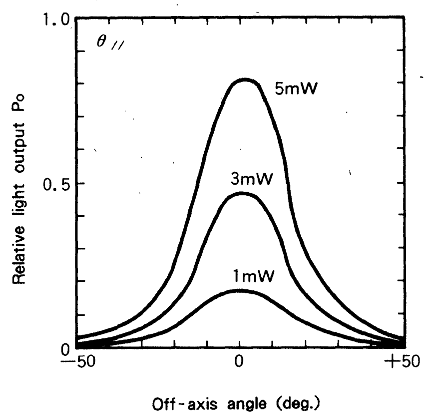
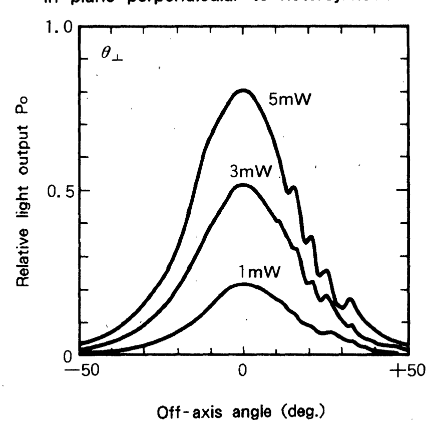


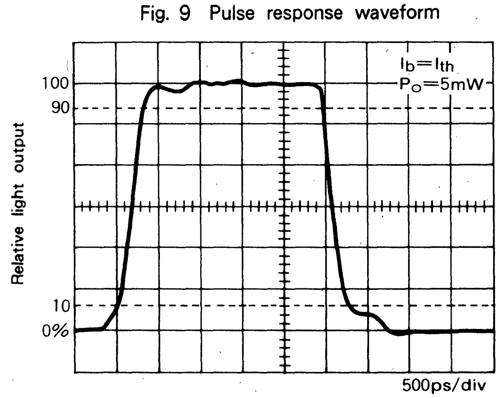
Fig. 8 Far-field patterns
in plane perpendicular to heterojunctions $\theta_{\perp}$



6 Pulse response

In digital optical transmission systems, the response waveform and speed of the light output against the input pulse current waveform is a main concern. In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Fig.9 shows a typical response waveform when a rectangular pulse current (rise/fall time is shorter than 0.2ns) is applied.
Rise/fall time is typically 0.3ns at $I_b = I_{th}$ and P_o = 5mW.

Fig. 9 Pulse response waveform



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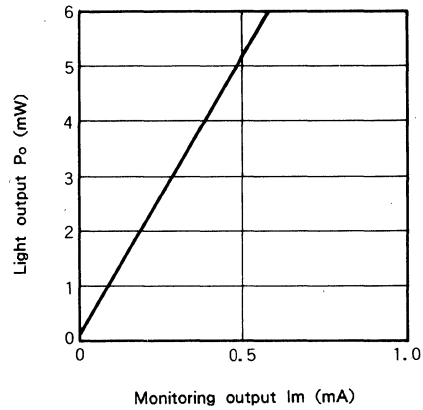
7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of the front beam since the power of the rear is proportional to the front one. In the ML8XX1 series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 10 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring output current is typically 0.5mA when the front light output is 5mW.

Fig. 10 Light output vs. monitoring output current



TYPE NAME

ML9701, ML974A1F, ML9911

DESCRIPTION

ML9XX1 series are InGaAsP laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1550nm and standard continuous light output of 5mW.

ML9XX1 are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such applications as the light source for long-distance optical communication systems.

FEATURES

- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in photodiode (ML9701, ML974A1F)
- High reliability, long operation life
- 1550nm typical emission wavelength
- High speed of response

APPLICATION

Long-distance communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	6	mW
		Pulse (Note 1)	10	
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case Temperature	–	−20~+60	℃
T_{stg}	Storage temperature	–	−40~+100	℃

Note 1 : Duty less than 50%, pulse width less than 1 μs.

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test Conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	15	35	mA
I_{OP}	Operating currrent	CW, P_O = 5mW	–	40	60	mA
V_{OP}	Operating voltage	CW, P_O = 5mW	–	1.3	1.7	V
η	Slope efficiency	CW, P_O = 5mW	–	0.2	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	1520	1550	1580	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 5mW	–	5	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	–	30	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	–	35	–	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 5mW, 10%~90%	–	0.3	0.7	ns
I_m	Monitoring output current	CW, P_O = 5mW, V_{RD} = 1V, R_L = 10 Ω (Note 2)	0.2	0.5	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF
P_m (Note 3)	Monitoring light output	CW, P_O = 5mW	–	1.0	–	mW

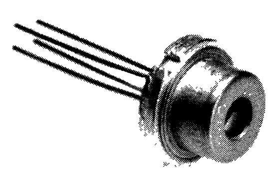
Note 2 : R_L is load resistance of the photodiode.
3 : P_m only apply to ML9911.

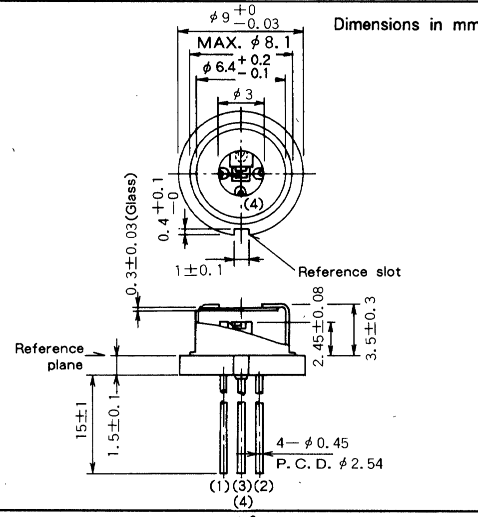
MITSUBISHI ELECTRIC

FOR OPTICAL COMMUNICATION

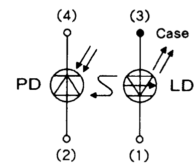
OUTLINE DRAWINGS

ML9701

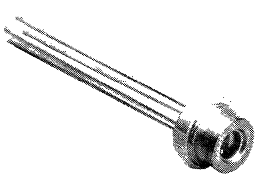


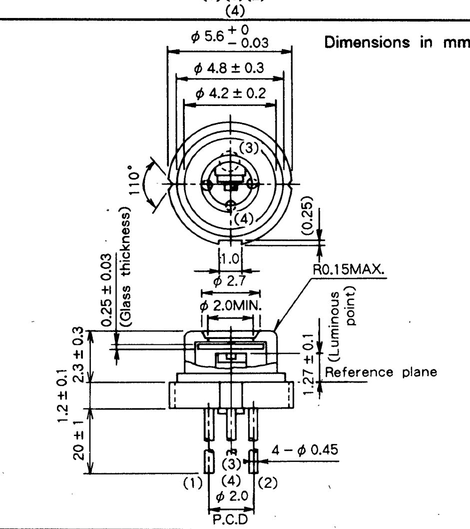


(φ 9mm 4pin Standard package)

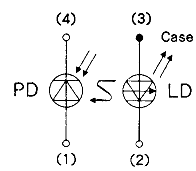


ML974A1F

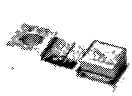


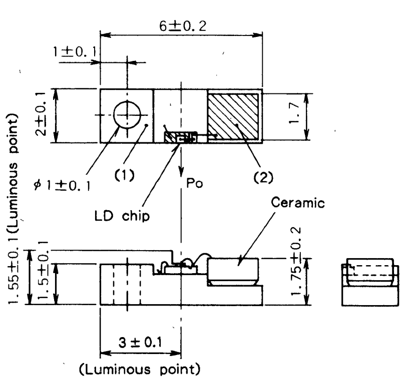


(φ 5.6mm 4pin with thick cap)

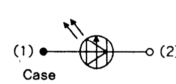


ML9911





(Chip carrier package)



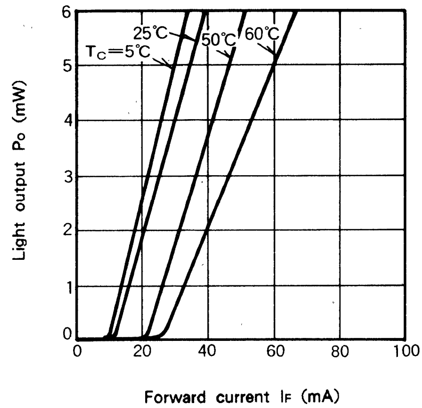
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 15mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 5mW is obtained at I_{th} + 25mA.

As can be seen in Fig. 1. I_{th} and slope efficiency η (dP_O / dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

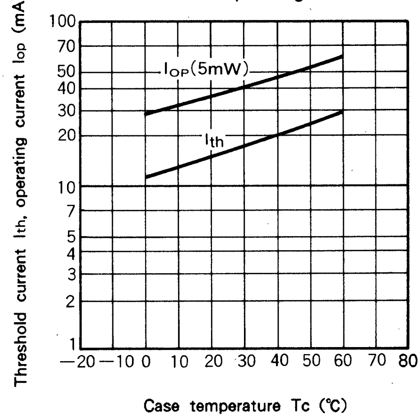
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th}), operating current (I_{op}) and slope efficiency (η)

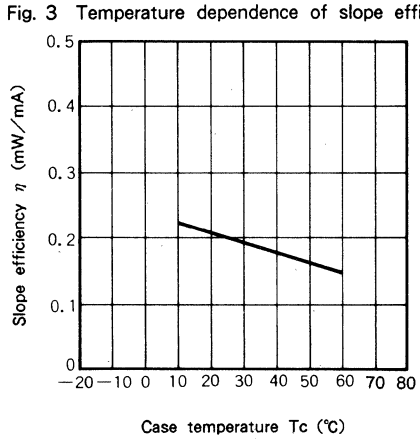
A typical temperature dependence of the threshold current and operating current (5mW) is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically 65k in $T_C \leqq 40$°C, 50k in $T_C > 40$°C.

Fig. 2 Temperature dependence of threshold current and operating current



A typical temperature dependences of the slope efficiency η is shown in Fig. 3. The gradient is − 0.0015mW/mA/°C typ.

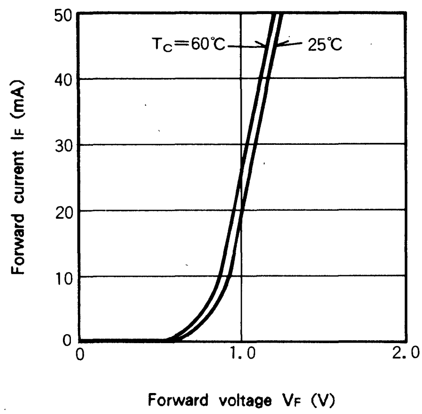
Fig. 3 Temperature dependence of slope efficiency



3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −1mV/℃ at I_F = 1mA and 10mA.

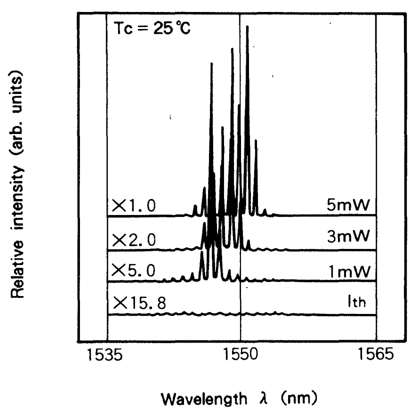
Fig. 4 Forward current vs. voltage



4 Emission Spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 5mW, several modes are observed. Longitudinal mode spacings are typically 1nm and spectral width (FWHM) is typically 5nm at an output of 5mW. The peak wavelength depends on the operating case temperature and the forward current (output level).

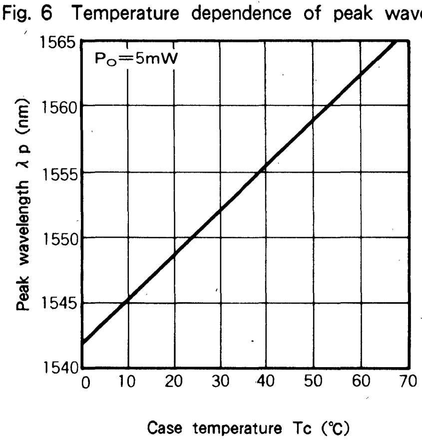
Fig. 5 Emission spectra under CW operation



A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.35nm/℃.

Fig. 6 Temperature dependence of peak wavelength



5 Far-field pattern

The ML9XX1 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.0X1.25 μm^2. Fig. 7 and 8 show the typical far-field patterns. The full angles at half maximum points (FAHM) are typically 30deg. and 35deg., respectively.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

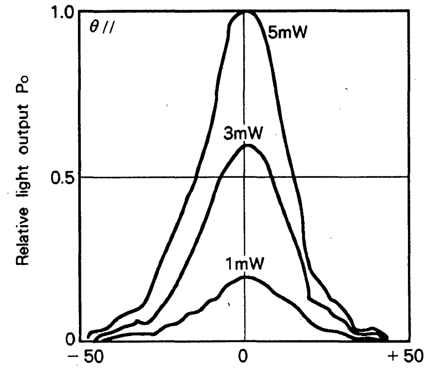
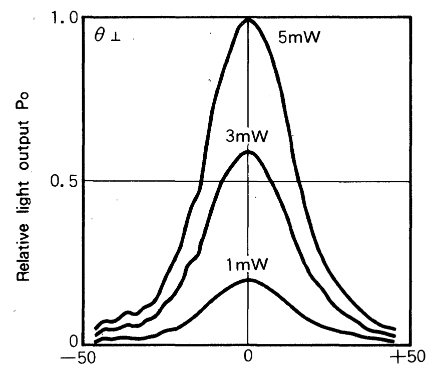


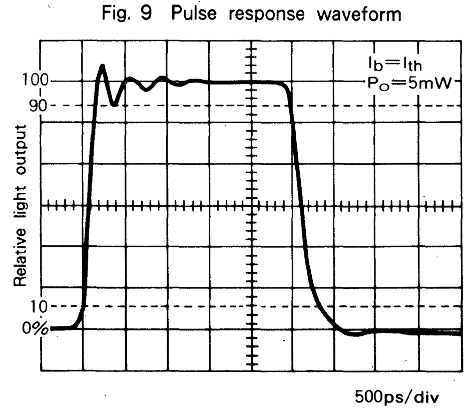
Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$



6 Pulse response

In digital optical transmission systems, the response waveform and speed of the light output against the input pulse current waveform is a main concern. In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Fig. 9 shows a typical response waveform when a rectangular pulse current (rise/fall time is shorter than 0.2ns) is applied. Rise/fall time is typically 0.3ns at $I_b = I_{th}$ and $P_o = 5mW$.

Fig. 9 Pulse response waveform



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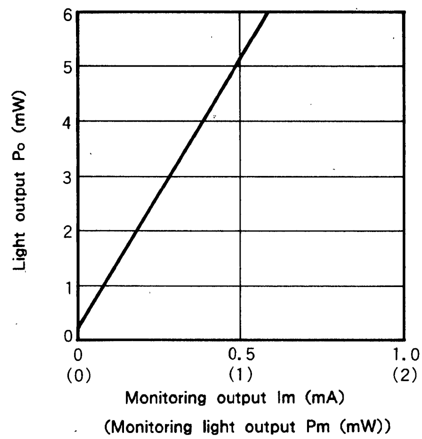
7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces (see the outline drawing). The rear beam can be used for monitoring power of the front beam since the power of the rear beam is proportional to the frontone. The rear-side beam is received by the built-in monitoring PD to be output as the monitoring current. Fig. 10 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring current is typically 0.5mA when the front light output is 5mW.

In the ML9911, monitor photodiodes is not installed in the laser package. Monitoring output is emitted from the back of package.

Monitoring output is typically 1mW when the front light output is 5mW.

Fig. 10 Light output vs. monitoring output current



TYPE NAME

ML9781A, ML9911A

DESCRIPTION

ML9XX1A series are InGaAsP High Power laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1550nm and standard continuous light output of 15mW.

ML9XX1A are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such applications as the light sources for OTDR systems and long-distance optical communication systems.

FEATURES

- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in photodiode (ML9781A)
- High reliability, long operation life
- High power (CW 15mW, Pulse 40mW)
- 1550nm typical emission wavelength
- High speed of response

APPLICATION

Digital communication systems, OTDR systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power (peak)	CW	20	mW
I_F	Forward current	Pulse (Note 1)	400	mA
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case Temperature	–	−20～+50	℃
T_{stg}	Storage temperature	–	−40～+100	℃

Note 1 : Duty less than 1%, pulse width less than 1 μs.

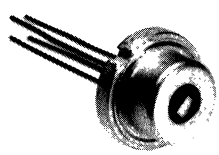
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

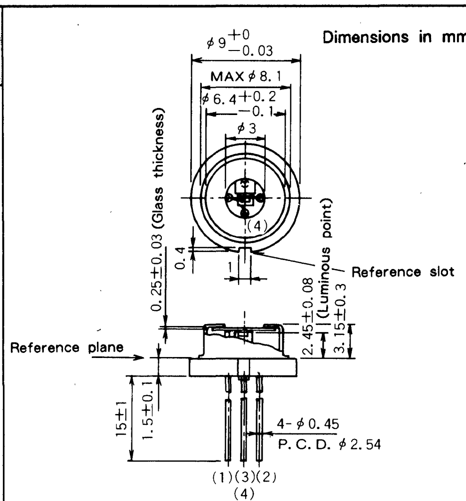
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	15	35	mA
I_{OP}	Operating current	CW, P_O = 15mW	–	75	120	mA
V_{OP}	Operating voltage	CW, P_O = 15mW	–	1.5	2.0	V
$P_{O(P)}$	Pulse light output	Pulse, I_F = 350mA (Note 4)	40	–	–	mW
λ_P	Peak wavelength	CW, P_O = 15mW	1520	1550	1580	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 15mW	–	8	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 15mW	–	30	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 15mW	–	35	–	deg.
t_r, t_f	Rise and fall times	$I_F = I_{th}$, P_O = 15mW, 10%～90%	–	0.3	0.7	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 15mW, V_{RD} = 1V, R_L = 10Ω (Note 2)	0.1	0.3	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF
P_m (Note 3)	Monitoring light output	CW, P_O = 15mW	–	0.6	–	mW

Note 2 : R_L is load resistance of the photodiode.
3 : P_m only apply to ML9911A.
4 : Duty cycle less than 1%, pulse width less than 1 μs.

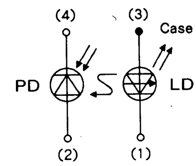
OUTLINE DRAWINGS

ML9781A

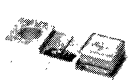


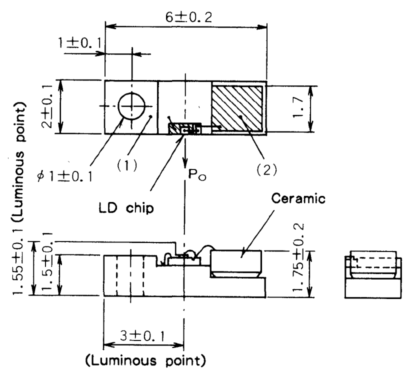


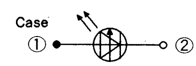
(φ 9mm, 4-pin, Low cap package)



ML9911A







SAMPLE CHARACTERISTICS

1 Light output vs. forward currrent

Typical light output vs. forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 15mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 15mW is obtained at I_{th} + 60mA.

As can be seen in Fig.1. I_{th} and slope efficiency η (dP_O / dI_F) depends on case temperature ; obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current.(control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

Fig. 1 Light output vs. forward current (CW)

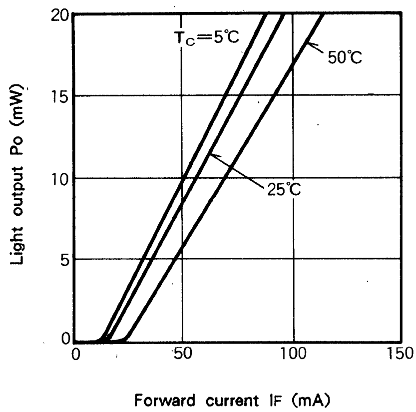
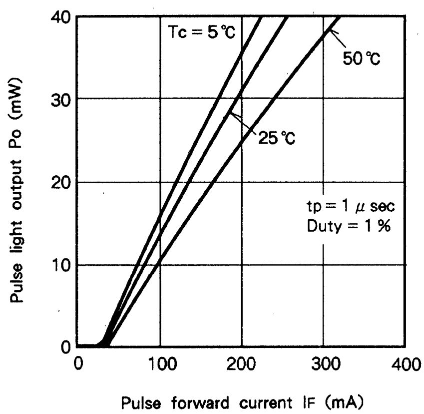


Fig. 2 shows a typical light output vs. forward current under pulse operation.

Pulse conditions are pulse width $t_P = 1\ \mu$sec and duty = 1 %. They emit light power of 40mW up to 50℃ on case temperature.

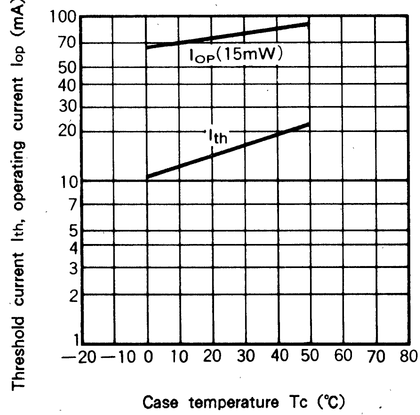
Fig. 2 Pulse light output vs. forward current (pulse)



2 Temperature dependence of I_{th}, I_{op}

Typical temperature dependence of the threshold and operating currents (15mW) is shown in Fig. 3. The characteristic temperature T_O of the threshold current is typically 65K for $T_C \leqq 50$℃ where the definition of T_O is $I_{th} \propto \exp(T_C/T_O)$.

Fig. 3 Temperature dependence of threshold and operating currents

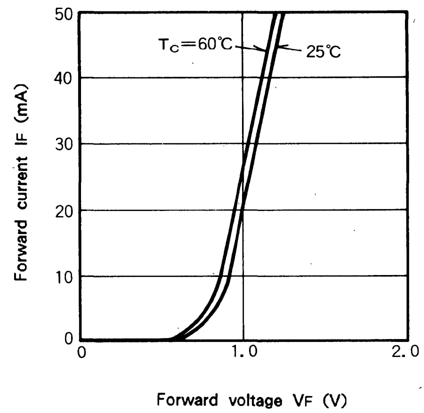


MITSUBISHI ELECTRIC

3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of −1mV/℃ at I_F = 1mA and 10mA.

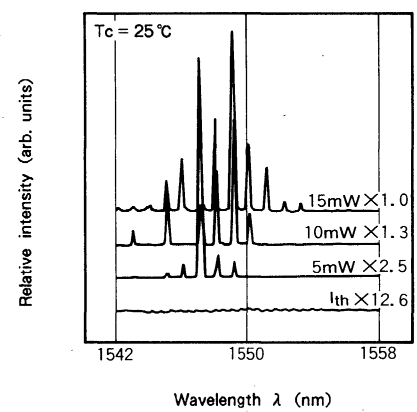
Fig. 4 Forward current vs. voltage



4 Emission spectra

Typical emission spectra under CW operation are shown in Fig. 5. In general, at an output of 15mW, several modes are observed. Longitudinal mode spacings are typically 1nm and spectral width (FWHM) is typically 8nm at an output of 15mW. The peak wavelength depends on the operating case temperature and the forward current (output level).

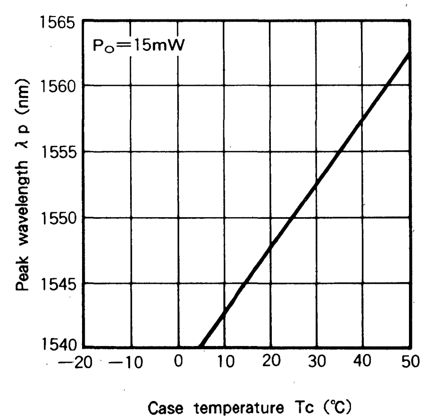
Fig. 5 Emission spectra under CW operation



A typical temperature dependence of the peak wavelength at an output of 15mW is shown in Fig. 6.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.5nm/℃.

Fig. 6 Temperature dependence of peak wavelength



5 Far-field pattern

The ML9XX1A laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have a typical emitting area (size of near-field pattern) of 1.0X1.25 μm^2. Figures 7 and 8 show the typical far-field patterns.

The full angles at half maximum points (FAHM) are typically 30deg. and 35deg., respectively.

Fig. 7 Far-field patterns in plane parallel to heterojunctions $\theta_{//}$

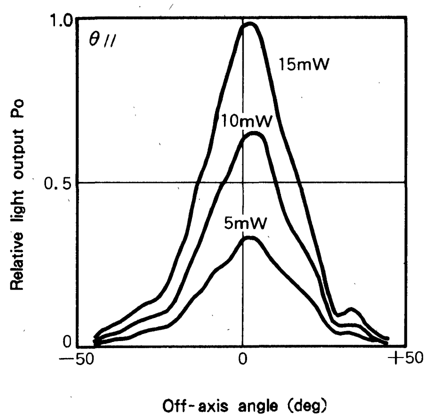
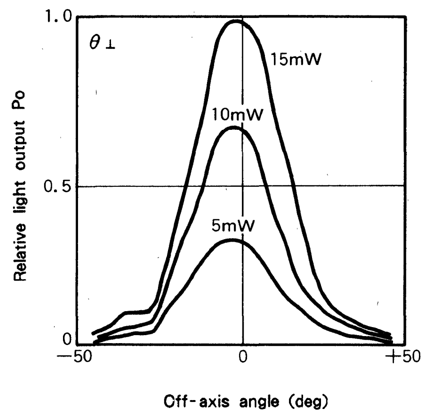


Fig. 8 Far-field patterns in plane perpendicular to heterojunctions $\theta_{\perp}$



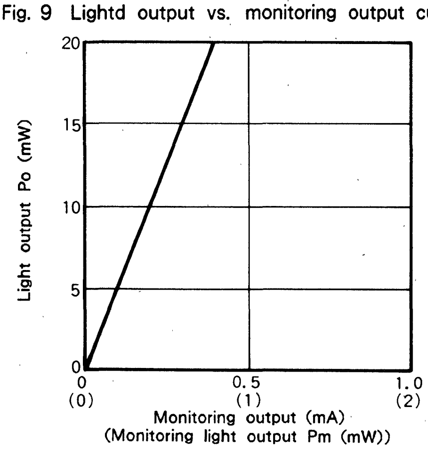
6 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces (see the outline drawing). The rear beam can be used for monitoring the power of the front beam since the power of the rear beam is proportional to the front one. In the ML9XX1A series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 9 shows typical light output vs. monitoring photocurrent characteristics. Above the threshold current, the monitoring photocurrent increases linearly with the front light output. The monitoring current is typically 0.3mA when the front light output is 15mW.

In the ML9911A, monitor photodiodes is not installed in the laser package. Monitoring output is emitted from the back of package.

Monitoring output is typically 0.6mW when the front light output is 15mW.

Fig. 9 Lightd output vs. monitoring output current



TYPE NAME

ML974A2F, ML9922

DESCRIPTION

ML9XX2 is a DFB (Distributed Feedback) laser diode which oscillates in a single wavelength with emission wavelength of 1550nm and standard continuos light output of 5mW.

ML9XX2 are hermetically sealed devices having the photodiode for optical output monitoring. This is a high-performance, high reliability, and long-life laser diode.

FEATURES

- Low threshold current typical 20mA
- High stable fundamental transverse mode oscillation
- High side mode suppression ratio typical 40dB (T_C = 0～+60℃)
- High speed of response (Rise and fall time typically 0.2nsec)

APPLICATION

Long-distance, large-capacity optical communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	6	mW
V_{RL}	Reverse voltage (Laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case Temperature	–	0～+60	℃
T_{stg}	Storage temperature	–	–40～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

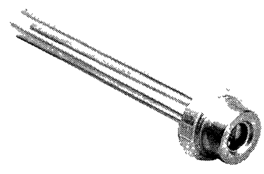
Symbol	Parameter	Test Conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	20	40	mA
I_{OP}	Operating current	CW, P_O = 5mW	–	45	90	mA
V_{OP}	Operating voltage	CW, P_O = 5mW	–	1.2	1.8	V
η	Slope efficiency	CW, P_O = 5mW	–	0.25	–	mW/mA
λ_P	Peak wavelength	CW, P_O = 5mW	–	1550	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 5mW	–	30	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 5mW	–	35	–	deg.
I_m	Monitoring output current (Photodiode)	CW, P_O = 5mW, V_{RD} = 1V, R_L = 10Ω (Note 1)	0.1	0.25	–	mA
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 5mW, 10～90%	–	0.2	0.4	ns
SMSR	Side mode suppression ratio	CW, P_O = 5mW, 0～+60℃	30	40	–	dB
P_m (Note 2)	Monitoring Light Output	CW, P_O = 5mW	–	0.5	–	mW

Note 1 : R_L is load resistance of the photodiode.
2 : P_m only apply to ML9922.

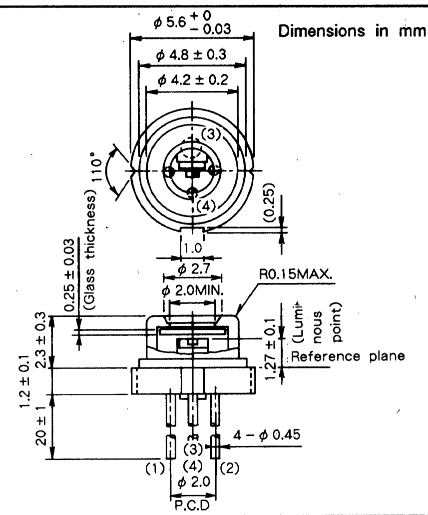
FOR OPTICAL COMMUNICATION

OUTLINE DRAWINGS

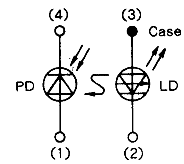
ML974A2F



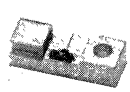
Dimensions in mm



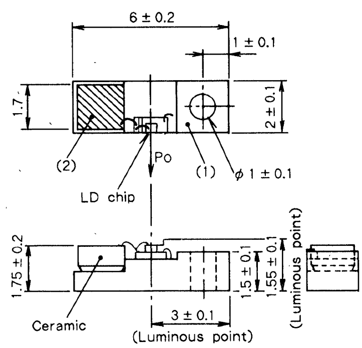
(φ 5.6mm, 4 pin, with thick cap)



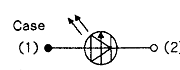
ML9922



Dimensions in mm



(Chip carrier type package)



MITSUBISHI ELECTRIC

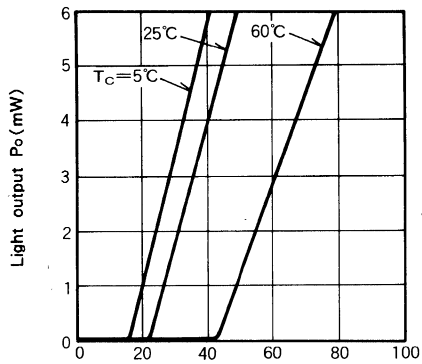
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical light output vs. forward current characteristics are shown in Fig. 1. The threshold current for lasing is typically 20mA at room temperature. Above the threshold, the light output increases linearly with current, and no kinks are observed in the curves. An optical power of about 5mW is obtained at I_{th} + 25mA.

As can be seen in Fig. 1. I_{th} and slope efficiency η (dP_O / dI_F) depends on case temperature, obtaining a constant output at varying temperatures requires to control the case temperature T_C or the laser current. (Control the case temperature or laser current such that the output current of the built-in monitor PD becomes constant.)

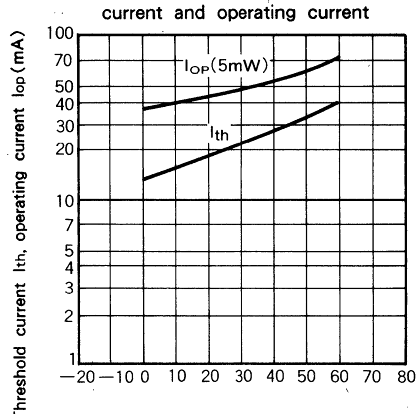
Fig. 1 Light output vs. forward current



2 Temperature dependence of threshold current (I_{th}), operating current (I_{op}) and slope efficiency (η)

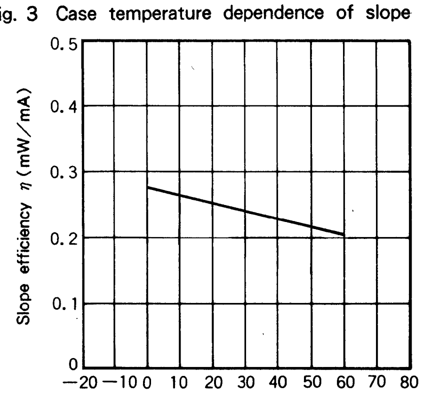
A typical temperature dependence of the threshold current and operating current (5mW) is shown in Fig. 2. The characteristic temperature T_O of the threshold current is typically 60k in $T_C \leq 40$℃, 50k in $T_C > 40$℃.

Fig. 2 Temperature dependence of threshold current and operating current



A typical temperature dependences of the slop efficiency η is shown in Fig. 3. The gradient is − 0.013mW/mA/℃

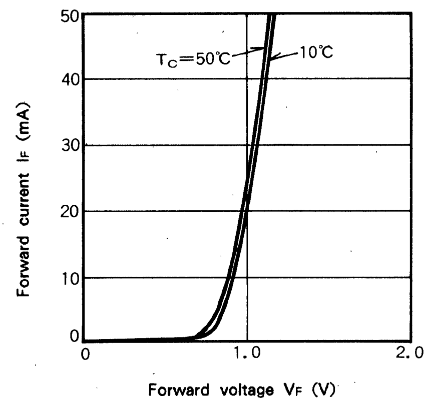
Fig. 3 Case temperature dependence of slope efficiency



3 Forward current vs. voltage

Typical forward current vs. voltage characteristics are shown in Fig. 4. In general, as the case temperature rises, the forward voltage V_F decreases slightly against the constant current I_F. V_F varies typically at a rate of $-1.0mV/°C$ and $-0.9mV/°C$ at $I_F = 1mA$ and $10mA$, respectively.

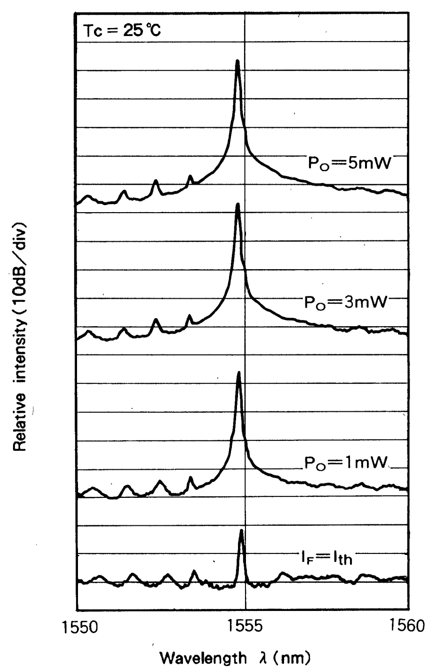
Fig. 4 Forward current vs. voltage



4 Emission spectra

Typical emission spectra under CW operation are shown in Fig. 5.

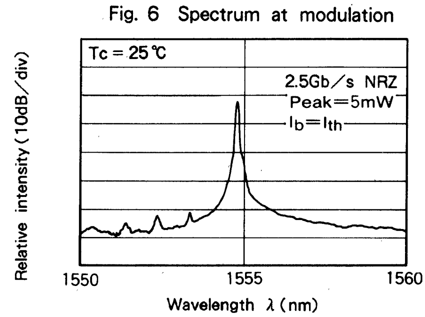
Fig. 5 Light output dependence of emission spectra



Emission spectrum under 2.5Gb/s (NRZ) modulation is shown in Fig. 6.

Typical spectral width (Chirping) is about 0.15nm at $-3dB$, 0.35nm at $-10dB$ and 0.80nm at $-20dB$.

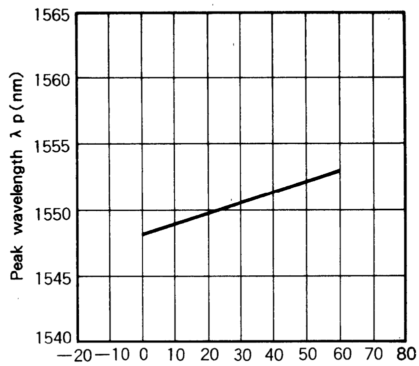
Fig. 6 Spectrum at modulation



A typical temperature dependence of the peak wavelength at an output of 5mW is shown in Fig. 7.

As the temperature rises, the peak wavelength shifts to the long-wavelength side at a rate of about 0.08nm/℃.

Fig. 7 Temperature dependence of peak wavelength



5 Far-field pattern

The ML9XX2 laser diodes lase in fundamental transverse (TE_{00}) mode and the mode does not change with the current. They have typical emitting area (size of near-field pattern) of 1.0 × 1.25 μm^2. Fig. 8. and 9 show the typical far-field patterns.

The full angles at half maximum points (FAHM) are typically 30deg. and 35deg., respectively.

Fig. 8 Far-field pattern (parallel)

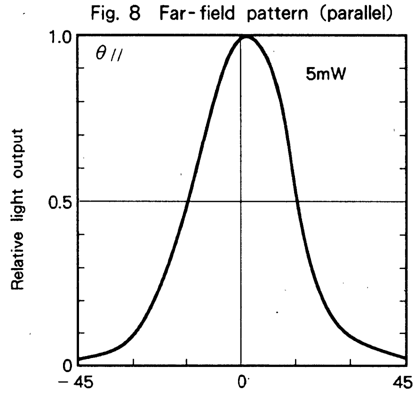
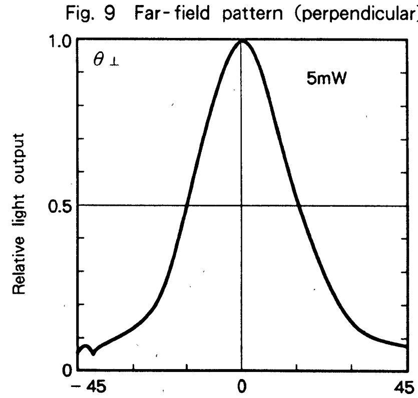


Fig. 9 Far-field pattern (perpendicular)

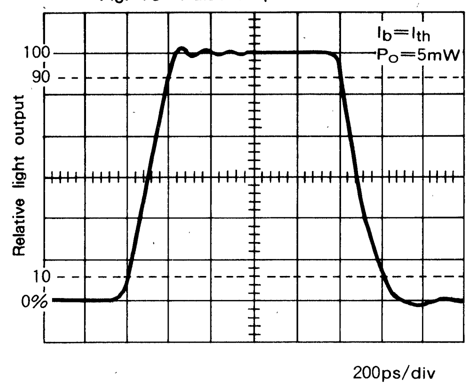


6 Pulse response

In digital optical transmission systems, the response wavelength and speed of the light output against the input pulse current waveform is a main concern.

In order to shorten the oscillation delay time, the laser diode is usually biased close to the threshold current. Fig. 10 shows a typical response waveform when a rectangular pulse current (rise/fall time is shorter than 0.1ns) is applied. Rise/fall time is typically 0.2ns at $I_b = I_{th}$ and $P_o = 5mW$.

Fig. 10 Pulse response waveform

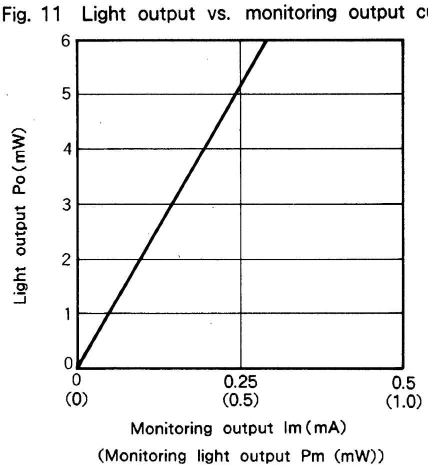


7 Monitoring output

The laser diodes emit beams from both of their mirror surfaces, front and rear surfaces. The rear beam can be used for monitoring power of the front beam since the power of the rear beam is proportional to the front one. In the ML9XX2 series, the rear beam power is changed into photocurrents by monitor photodiodes. Fig. 11 shows typical light output vs. monitoring photo-current characteristics.

Above the threshold current, the monitored photocurrent increases linearly with the front light output. The monitoring output current is typically 0.25mA when the front light output is 5mW. In the ML9922, monitor photodiodes are not installed in the laser package. Monitoring output is emitted from the back of package. Monitoring output is typically 0.5mW when the front light output is 5mW.

Fig. 11 Light output vs. monitoring output current



TYPE NAME
ML9783F

DESCRIPTION

ML9XX3 series are InGaAsP High Power laser diodes which provide a stable, single transverse mode oscillation with emission wavelength of 1550nm and standard continuous light output of 25mW.

ML9XX3 are hermetically sealed devices having the photodiode for optical output monitoring. This high-performance, high reliability, and long-life laser diode is suitable for such high-power applications as the light sources for OTDR systems and long-distance optical communication systems.

FEATURES

- High Power (CW 30mW, Pulse 120mW)
- 1550nm typical emission wavelength
- High speed of response
- Stable fundamental transverse mode oscillation
- Low threshold current, low operating current
- Built-in monitor photodiode
- High reliability, long operation life

APPLICATION

OTDR systems, optical communication systems.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	30	mW
I_F	Forward current	Pulse (Note 1)	900	mA
V_{RL}	Reverse voltage (laser diode)	–	2	V
V_{RD}	Reverse voltage (Photodiode)	–	20	V
I_{FD}	Forward current (Photodiode)	–	2	mA
T_C	Case temperature	–	+20～+30	℃
T_{stg}	Storage temperature	–	−40～+100	℃

Note 1 : Duty less than 1%, pulse width less than 1 μ s.

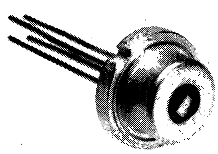
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

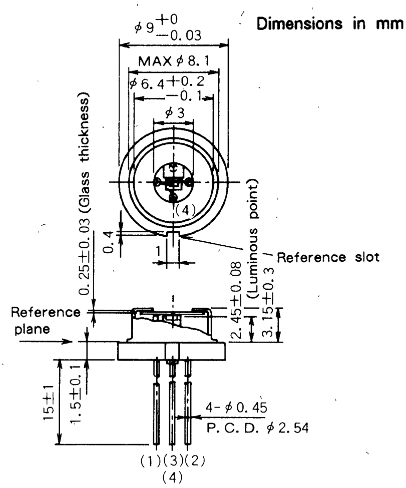
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	–	25	50	mA
I_{OP}	Operating current	CW, P_O = 25mW	–	120	180	mA
V_{OP}	Operating voltage	CW, P_O = 25mW	–	1.5	2.0	V
$P_{O(P)}$	Pulse light output	Pulse, I_F = 800mA (Note 2)	120	–	–	mW
λ_P	Peak wavelength	CW, P_O = 25mW	1520	1550	1580	nm
$\Delta\lambda$	Spectral half width	CW, P_O = 25mW	–	8	–	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 25mW	–	30	–	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 25mW	–	35	–	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 25mW, 10%～90%	–	0.3	–	ns
I_m	Monitoring output current (Photodiode)	CW, P_O = 25mW, V_{RD} = 1V, R_L = 10Ω (Note 3)	0.1	0.3	–	mA
I_D	Dark current (Photodiode)	V_{RD} = 10V	–	0.2	0.5	μA
C_t	Capacitance (Photodiode)	V_{RD} = 10V, f = 1MHz	–	8	20	pF

Note 2 : Duty cycle less than 1%, pulse width less than 1 μ s.
3 : R_L is load resistance of photodiode.

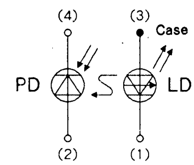
OUTLINE DRAWINGS

ML9783F





(φ 9mm, 4-pin, Low cap package)



SAMPLE CHARACTERISTICS

1 Light output vs. forward current characteristic

Fig. 1. shows the typical light output vs. forward current characteristic of ML9XX3. The threshold current I_{th} at room temperature is about 25mA.

Above the threshold, the light output increases linealy with current, and no kinks are observed in the curves. An optical output of about 25mw can be obtained at I_{th} + 95mA.

Fig. 1 Light output vs. forward current (CW)

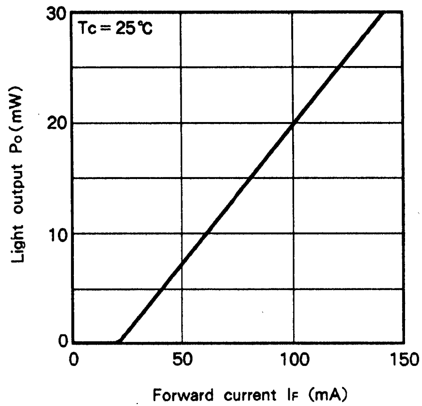
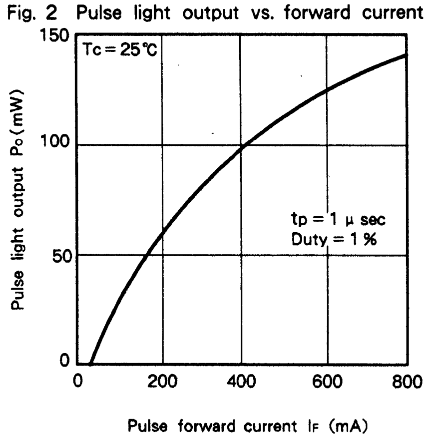


Fig. 2. shows the typical light output vs. forward current characteristic of ML9XX3 under pulse operation. Pulse conditions are pulse width t_p = 1 μ sec and duty = 1%. More than 120mW is obtained at I_F = 800mA.

Fig. 2 Pulse light output vs. forward current (Pulse)



TYPE NAME

ML9925

DESCRIPTION

ML9XX5 series are DFB (Distributed Feedback) laser diodes emitting light beam around 1550nm.

They are well suited for light source in long-distance analog transmission system for example cable television (CATV). The ML9925 are specially designed for in fiber modules and mount on flat open packages. Rear output can be used for automatic control of the operating current or case temperature of the laser.

FEATURES

- Excellent distortion characteristic.
  42-channel transmission test
  CSO (composite second order) typical −57dBc
  CTB (composite triple beat) typical −65dBc
- Low relative intensity noise characteristic (typical −155dB/Hz)
- Low threshold current (typical 20mA)
- High-side mode suppression ratio (typical 40dB)
- High speed of response (typical 0.2ns)

APPLICATION

Long-distance analog transmission systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
P_O	Light output power	CW	20	mW
V_{RL}	Reverse voltage (laser diode)	−	2	V
V_{RD}	Reverse voltage (Photodiode)	−	20	V
I_{FD}	Forward current (Photodiode)	−	2	mA
T_C	Case temperature	−	+20～+30	℃
T_{stg}	Storage temperature	−	−40～+100	℃

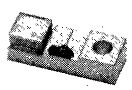
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
I_{th}	Threshold current	CW	−	20	40	mA
I_{OP}	Operating current	CW, P_O = 10mW	−	45	90	mA
V_{OP}	Operating voltage	CW, P_O = 10mW	−	1.2	1.8	V
η	Slope efficiency	CW, P_O = 10mW	−	0.25	−	mW/mA
λ_P	Peak wavelength	CW, P_O = 10mW	−	1550	−	nm
$\theta_{//}$	Beam divergence angle (parallel)	CW, P_O = 10mW	−	30	−	deg.
$\theta_{\perp}$	Beam divergence angle (perpendicular)	CW, P_O = 10mW	−	35	−	deg.
t_r, t_f	Rise and fall times	I_F = I_{th}, P_O = 10mW, 10～90%	−	0.2	0.4	ns
SMSR	Side mode suppression ratio	CW, P_O = 10mW	30	40	−	dB
P_m	Monitoring output	CW, P_O = 10mW	−	1	−	mW
CSO	Composite second order	42−channel transmission test modulation depth ΔM = 0.035, average light output = 10mW to 20mW	−	−57	−	dBc
CTB	Composite triple beat		−	−65	−	dBc
RIN	Relative intensity noise	CW, P_O = 10mW to 20mW, measuring frequency f_m = 550MHz	−	−155	−	dB/Hz

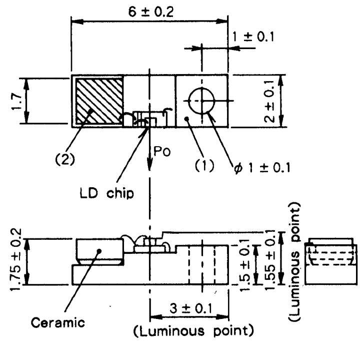
MITSUBISHI ELECTRIC

OUTLINE DRAWINGS

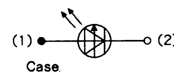
ML9925



Dimensions in mm



(Chip carrier type package)



LIGHT EMITTING DIODES

3

TYPE NAME

ME1013

DESCRIPTION

ME1XX3 are AlGaAs double heterostructure light emitting diodes (LED) emitting light beams around 850nm wavelength. A spherical micro-lens is mounted on the light emitting area to provide a highly optical coupling efficiency from LED to fiber.

ME1XX3 is suitable for such applications as the light sources for data links and optical communication systems.

FEATURES

- Low operating current (50mA)
  * Easy drive with conventional transistors and IC's
- With ϕ 100 μm spherical lens
- High radiance and narrow beam angle
  * High optical coupling efficiency from LED to fiber
- High speed response and high modulation frequency (30MHz, − 1.5dB)
- High linearity in light output vs. current characteristic

APPLICATION

Optical data link, optical communication systems, and other optical information systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Conditions	Ratings	Unit
I_F	Forward current (Note 1)	DC	$T_c \leq 50$ ℃	75	mA
		Pulse (Note 2)	$T_c \leq 50$ ℃	120	
V_R	Reverse voltage		−	3	V
T_c	Case temperature		−	−40〜+100	℃
T_{stg}	Storage temperature		−	−55〜+125	℃

Note 1 : Forward current derating ($T_c > 50$ ℃) : $I_F\ (T_c) = I_{Fmax}\left(\frac{T_{cmax} - T_c}{T_{cmax} - 50}\right)$

2 : Duty ratio ≦ 50 %, repetition ≧ 100kHz

ELECTRICAL/OPTICAL CHARACTERISTICS (T_c = 25 ℃)

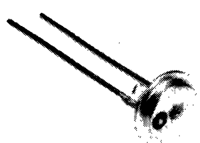
Symbol	Parameter		Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
λ_P	Peak wavelength		I_F = 50mA	820	850	880	nm
$\Delta\lambda$	Spectral half width		I_F = 50mA	−	45	−	nm
P_O	Light output	DC	I_F = 50mA	1.0	1.5	−	mW
		Pulse (Note 3)	I_F = 100mA	2.0	3.0	−	
θ	Beam diverging angle		I_F = 50mA	−	40	−	deg.
fc	Cut-off frequency		I_F = 25mA, I_{RF} = 4mA$_{P-P}$, − 1.5dB (optical signal)	15	30	−	MHz
V_F	Forward voltage		I_F = 50mA	−	1.6	2.2	V
I_R	Reverse current		V_R = 3V	−	−	10	μA

Note 3 : Duty ratio = 50 %, repetition = 100kHz.

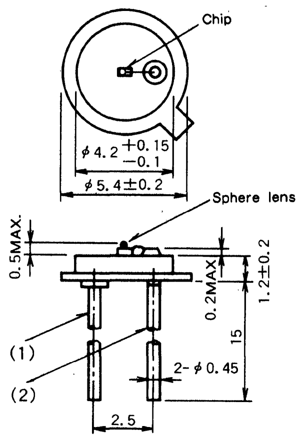
FOR OPTICAL COMMUNICATION

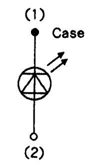
OUTLINE DRAWINGS

ME1013



Dimensions in mm





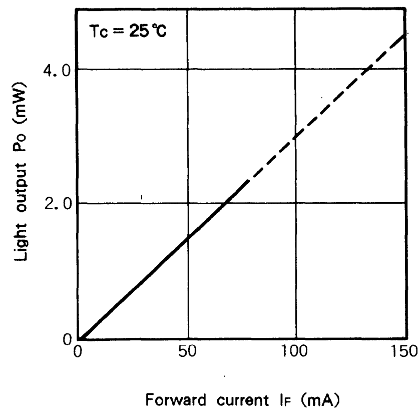
MITSUBISHI ELECTRIC

SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Typical current dependence of the light output is shown in Fig.1. Light power of typical 1.5mW is obtained at 50mA. Over the forward current of 10mA, excellent linearity in light output vs. current is obtained and enables the LED to be applicable in analog systems.

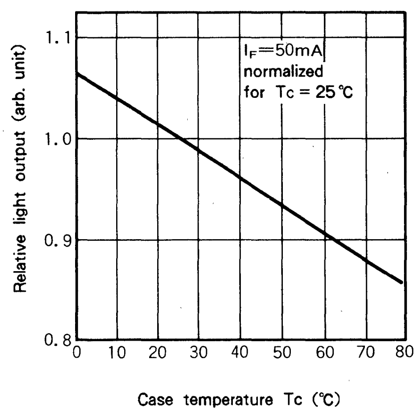
Fig. 1 Light output vs. forward current



2 Temperature dependence of light output

Fig.2 shows typical relative light output vs. case temperature characteristics when the light output is normalized for Tc = 25℃. As the case temperature rises, the relative light output decreases at a rate of −0.015dB/℃.

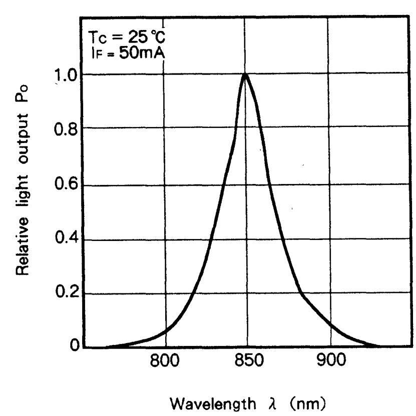
Fig. 2 Temperature dependence of light output



3 Emission spectra

Typical emission spectra is shown in Fig.3. The spectral half width is typically 45nm. Peak wavelength are in a range from 820 to 880nm depending on production lots at room temperature.

Fig. 3 Typical emission spectra

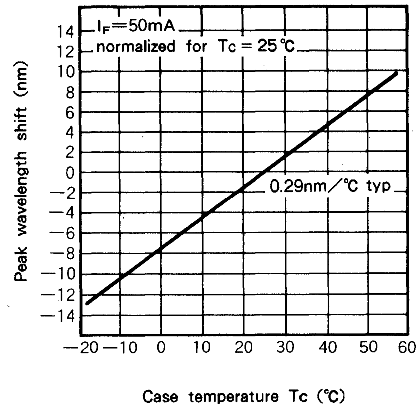


4 Case temperature dependence of the peak wave-length shift

Fig. 4. shows typical case temperature dependence of the peak wavelength shift with the light emitting peak wavelength being 0 at forward current of 50mA and case temperature of 25℃.

As the case temperature rises, the peak wavelength shift to the long wavelength side at a rate of about 0.29nm/℃.

Fig. 4 Temperature dependence of peak wavelength shift

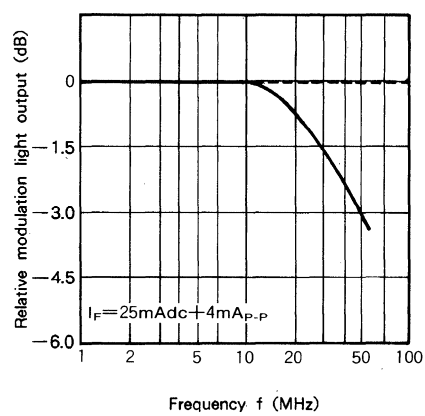


5 Modulation characteristics

Typical frequency modulation characteristics are shown in Fig.5. A bandwidth of 30MHz is typically obtained when it is defined as the frequency range with in which the modulated light output does not drop to the − 1.5dB level.

In pulsed operation, response time of the light output is typically 12ns.

Fig. 5 Typical frequency modulatin characteristics

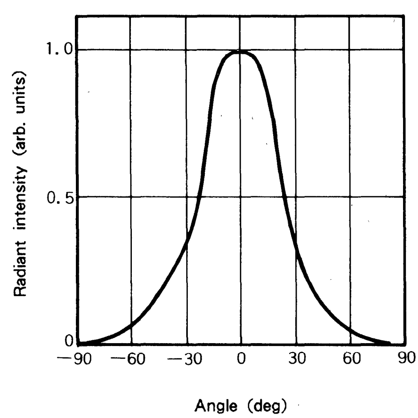


6 Far-field pattern

Typical far-field pattern is shown in Fig.6. Full angle of the beam at half maximum intensity is typically 40 deg.

Diameters of the light emitting region and the lens are 35 μ m and 100 μ m respectively.

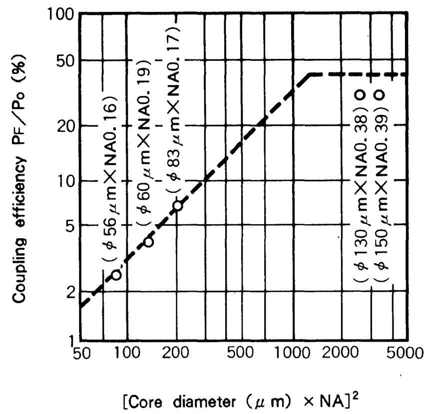
Fig. 6 Typical far-field radiation pattern



7 Coupling efficiency

The coupling efficiency depends on the product of core diameter and numerical aperture (NA) of a fiber. Typical efficiency and light power coupled into various step index fibers are plotted in Fig.7. The dashed line shows the theoretical limit. For example, with a fiber having a core diameter of 150 μ m and NA = 0.39, the coupling efficiency is about 30%. At a low operating current of 50mA, about 500 μ W is obtained.

Fig. 7 Coupling characterstics of the LED to various step index optical fibers.



8 Allowance in fiber aligning

The ME1013 release you from difficult and troublesome aligning of fibers because of their excellent radiation patterns. Fig.8. shows variation of coupling loss due to offset of the optical axis. Fig.9. shows the coupling loss due to distance d between the top of the lens and the fiber end.

The allowable range by fiber couple has been enhanced, making handling much easier.

Fig. 8 Coupling loss due to offset of the fiber axis. This data is for step index fibers.

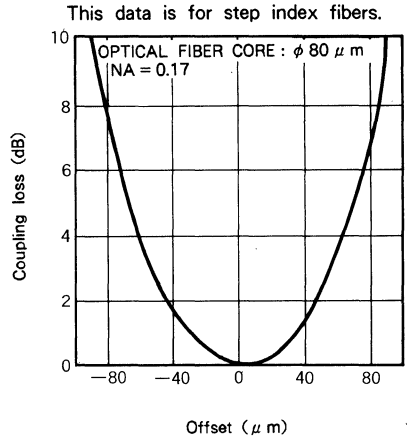
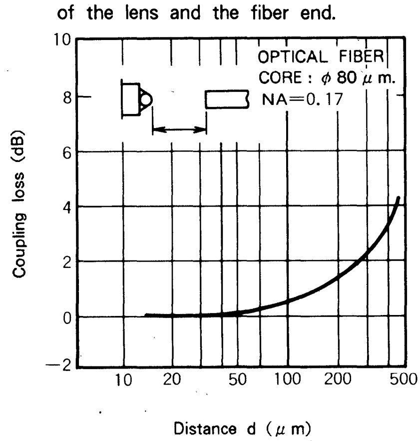


Fig. 9 Coupling loss due to the distance between top of the lens and the fiber end.



TYPE NAME

ME1504, ME1514

DESCRIPTION

ME1XX4 are AlGaAs double heterostructure light emitting diodes (LED) emitting light beams around 850nm wavelength. A spherical micro-lens is mounted on the light emitting area to provide a highly optical coupling efficiency from LED to fiber.

ME1XX4 provides a high radiance, narrow beam angle characteristic. ME1XX4 series are hermetically sealed devices, resulting in high reliability and long operating life. It is suitable for such applications as the light sources for data links and optical communication systems.

FEATURES

- LOW operating current (50mA)
  * Easy drive with conventional transistors and IC's
- With ϕ 200 μm spherical lens
- High radiance and narrow beam angle
  * High optical coupling efficiency from LED to fiber
- High speed response and high modulation frequency (30MHz, − 1.5dB)
- High linearity in light output vs. current characteristic

APPLICATION

Optical data link, optical communication systems, and other optical information systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Conditions	Ratings	Unit
I_F	Forward current (Note 1)	DC	$T_c \leqq 50$℃	75	mA
		Pulse (Note 2)	$T_c \leqq 50$℃	120	
V_R	Reverse voltage		−	3	V
T_c	Case temperature		−	−40〜+100	℃
T_{stg}	Storage temperature		−	−55〜+125	℃

Note 1 : Forward current derating ($T_c > 50$℃) : $I_F (T_c) = I_{Fmax} \left(\frac{T_{cmax} - T_c}{T_{cmax} - 50}\right)$

2 : Duty ratio ≦ 50 %, repetition ≧ 100kHz

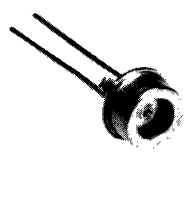
ELECTRICAL/OPTICAL CHARACTERISTICS ($T_c = 25$℃)

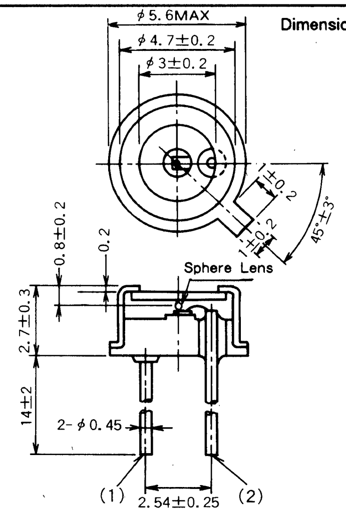
Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
λ_P	Peak wavelength		$I_F = 50$mA	820	850	880	nm
$\Delta\lambda$	Spectral half width		$I_F = 50$mA	−	45	−	nm
P_o	Light output	DC	$I_F = 50$mA	0.5	1.5	−	mV
		Pulse (Note 3)	$I_F = 100$mA	1.0	3.0	−	
θ	Beam diverging angle		$I_F = 50$mA	−	20	−	deg.
fc	Cut-off frequency		$I_F = 25$mA, $I_{RF} = 4$mA$_{P-P}$, − 1.5dB (optical signal)	10	30	−	MHz
V_F	Forward voltage		$I_F = 50$mA	−	1.6	2.2	V
I_R	Reverse current		$V_R = 3$V	−	−	10	μA

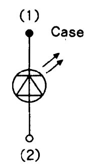
Note 3 : Duty ratio = 50 %, repetition = 100kHz.

OUTLINE DRAWINGS

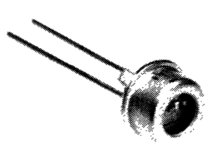
ME1504

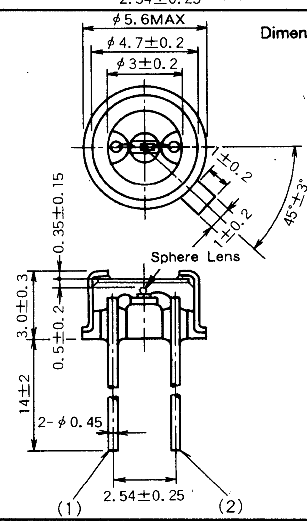


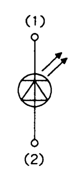




ME1514







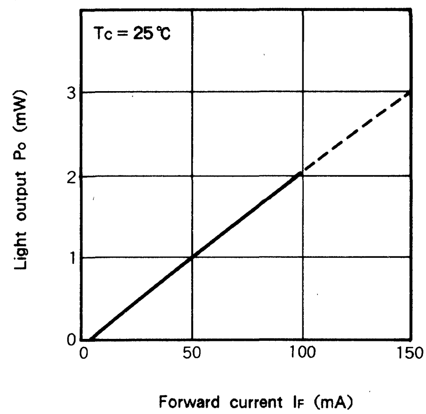
SAMPLE CHARACTERISTICS

1 Light output vs. forward current

Fig. 1. shows the typical light output vs. forward current of ME1504 and ME1514.

Light power of typical 1.0mW is obtained at 50mA. Over the forward current of 10mA, excellent lineality in light output vs. current is obtained and enables the LED to be applicable in analog systems.

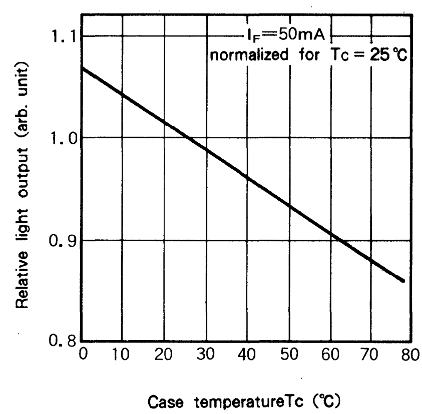
Fig. 1 Light output vs. forward current



2 Temperature dependence of light output

Fig.2. shows typical relative light output vs. case temperature characteristics when the light output is normalized for $T_c = 25$℃. As the case temperature rises, the relative light output decreases at a rate of −0.015dB/℃.

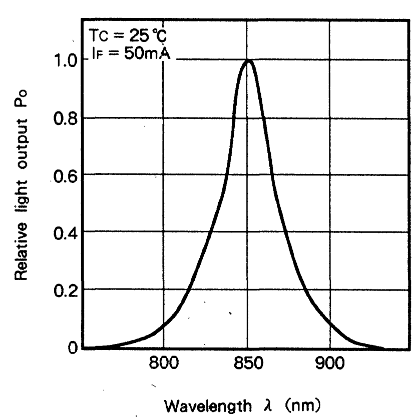
Fig. 2 Temperature dependence of light output



3 Emission spectra

Typical emission spectra is shown in Fig. 3. The spectral half width is 45nm. Peak wavelength are in a range from 820～880nm depending on production lots at room temperature.

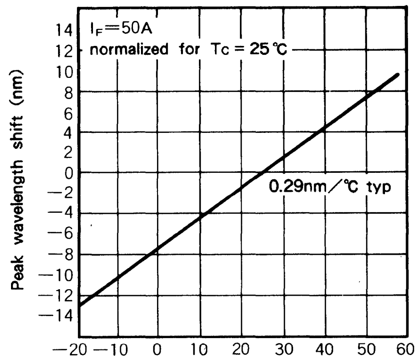
Fig. 3 Typical emission spectra



4 Case temperature dependence of the peak wavelength shift

Fig. 4. shows the case temperature dependence of the peak wavelength shift with the light emitting peak wavelength being 0 at forward current of 50mA and a case temperature of 25℃.
As the case temperature rises, the peak wavelength shifts to the long wavelength side at a rate of about 0.29nm/℃.

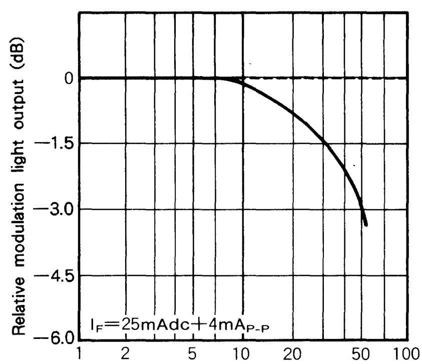
Fig. 4 Temperature dependence of peak wavelength shift



5 Modulation characteristics

Typical frequency modulation characteristics are shown in Fig. 5. A bandwidth of 30MHz is typically obtained when it is defined as the frequency range with in which the modulated light output does not drop to the 1.5dB level.
In pulsed operation, response time of the light output is typically 12ns.

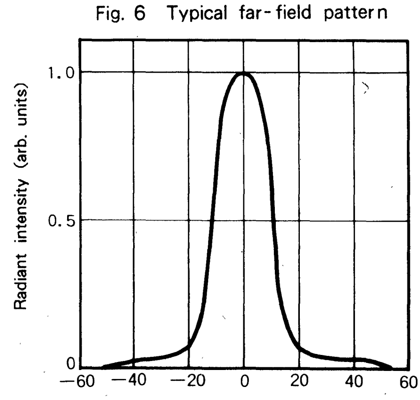
Fig. 5 Typical frequency modulation characteristics



6 Far-field pattern

Typical far-field pattern is shown in Fig. 6.
Full angle of the beam at half maximum intensity is typically 20 deg.
Diameters of the light emitting region and the lens are 35 μm and 200 μm respectively.

Fig. 6 Typical far-field pattern



TYPE NAME

ME7022, ME7032

DESCRIPTION

ME7XX2 are InGaAsP／InP double heterostructure light emitting diodes (LED) emitting light beam around 1310nm.

A spherical micro-lens is mounted on the light emitting area to provide a highly optical coupling efficiency from LED to fiber.

ME7XX2 provides a high radiance, narrow beam angle characteristic. Providing ring grooves from the P-side area to the junction to form the mesa-shaped light emitting area, thus reducing the parasitic capacitance and realizing a high speed response. ME7022 and ME7032 have high reliability and long operating life and are suitable for such short-distance communication systems as LAN and data links.

FEATURES

- High cut-off frequency, typically 150MHz
- High coupling power, typically −17dBm
- Pulse rise and fall times : typical 3ns and 4ns

APPLICATION

Fiber-optic communication systems, local area networks, CATV trunks, industrial control, data link

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
I_F	Forward current	−	120	mA
V_R	Reverse voltage	−	2.0	V
T_C	Case temperature	−	−30～+80	℃
T_{stg}	Storage temperature	−	−40～+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (Tc = 25℃)

Symbol	Parameter	Test conditions	Limits						Unit
			ME7022			ME7032			
			Min.	Typ.	Max.	Min.	Typ.	Max.	
λ_P	Peak wavelength	I_F = 100mA	1280	1310	1340	1280	1310	1340	nm
$\Delta\lambda$	Spectral half width	I_F = 100mA	−	130	160	−	130	160	nm
P_f	Fiber coupled power (Note 1)	I_F = 100mA, GI50/125, NA = 0.2	15	20	−	10	14	−	μW
fc	Cut-off frequency	I_F = 100mA, I_{RF} = 4mAP-P, −1.5dB	−	150	−	−	150	−	MHz
t_r/t_f	Rise and fall times	I_P = 100mA, V_F = 1V, 10%～90%	−	3/4	−	−	3/4	−	ns
V_F	Forward voltage	I_F = 100mA	−	1.5	2.0	−	1.5	2.0	V

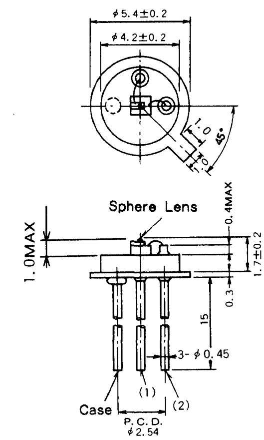
Note1 : P_f is the maximum available power coupled into a fiber (GI50／125, NA = 0.2)
- ME7022 optimum distance between the top of the spherical micro-lens and the fiber end is d≃200 μm
- ME7032 optimum distance between the top of the cap lens and the fiber end is d≃1mm

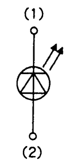
MITSUBISHI ELECTRIC

OUTLINE DRAWINGS

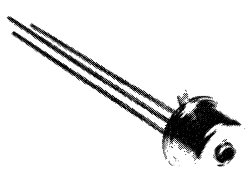
ME7022

Dimensions in mm

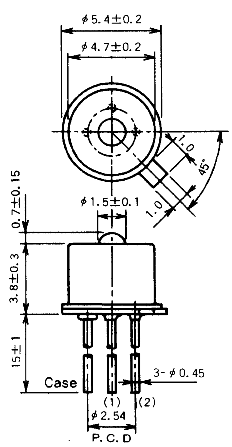


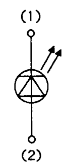


ME7032



Dimensions in mm



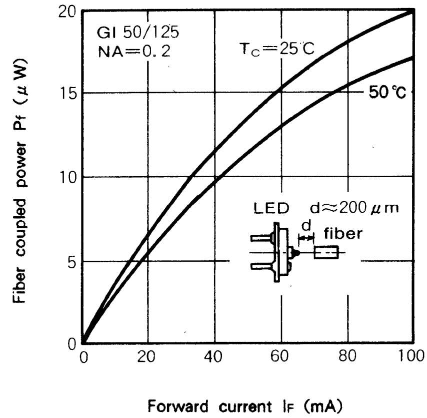


SAMPLE CHARACTERISTICS

1 Fiber coupled power vs. current

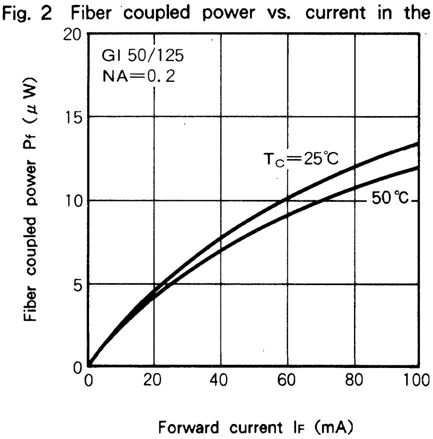
Typical current dependence of the fiber output in the ME7022 is shown in Fig.1. when the fiber of GI50/125, NA = 0.2 is used. The optimum distance between the top of the spherical micro-lens and the fiber end is about 200 μm. At a case temperature of 25℃, fiber coupled power is 20 μW at 100mA. At a case temperature 50℃, it is typically 17 μW.

Fig. 1 Fiber coupled power vs. current in the ME7022



Typical current dependence of the fiber output in the ME7032 shown in Fig.2. when the fiber of GI50/125, NA = 0.2 is used. Light output from the fiber is typically 14 μW and 12 μW at 100mA and case temperature of 25℃ and 50℃, respectively.

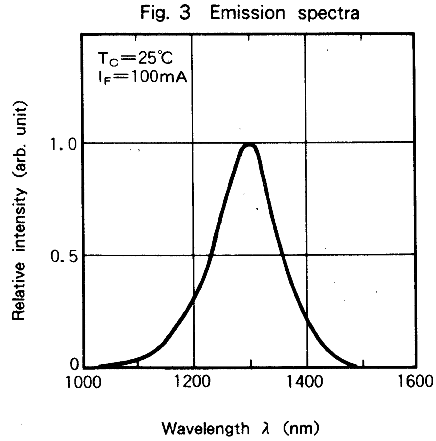
Fig. 2 Fiber coupled power vs. current in the ME7032



2 Emission spectra

Typical emission spectra of the ME7XX2 is shown in Fig.3. The spectral width at half maximum at room temperature and a forward current of 100mA is about 130nm. The peak wavelength depends on the light output and the operating case temperature. The peak wavelength ranges from 1280 to 1340nm at room temperature.

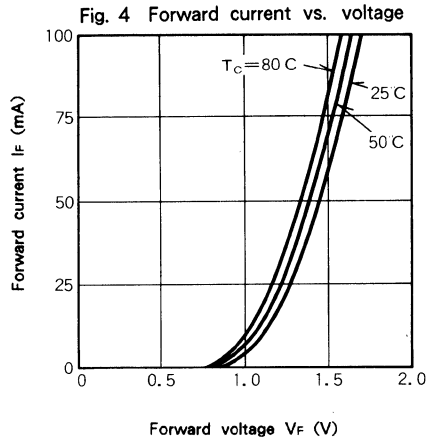
Fig. 3 Emission spectra



3 Temperature dependence of I-V

Typical temperature dependence of the forward current vs. voltage characteristics is shown in Fig. 4. In general, the voltage V_F decreases slightly for the constant I_F when the case temperature rises. As the case temperature rises, V_F decreases typically at a rate of −1.1mV/℃ and −0.7mV/℃ for I_F = 5mA and 50mA, respectively.

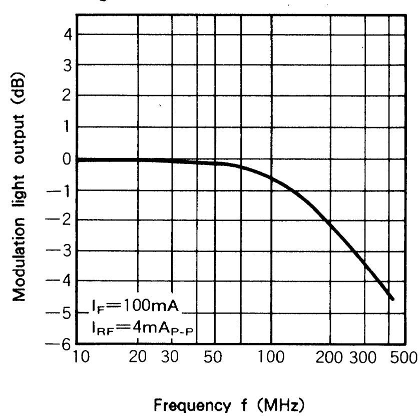
Fig. 4 Forward current vs. voltage



4 Modulation characteristics

Typical frequency modulation characteristics are shown in Fig.5. A bandwidth of 150MHz is typically obtained when it is defined as the frequency range within which the modulated light output does not drop to the −1.5dB level.

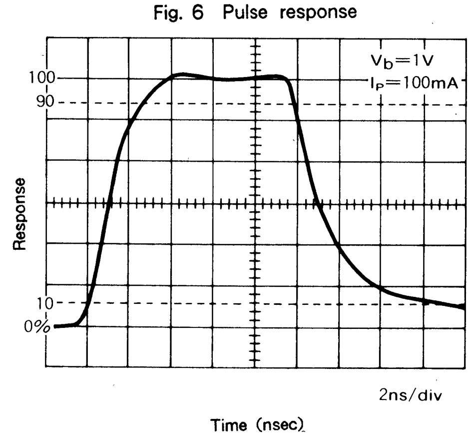
Fig. 5 Modulation characteristics



5 Pulse response characteristics

Typical pulse response characterisics at an input pulse current of 100mA and 1V pre-bias are shown in Fig.6. The rise and fall times are as quick as about 3ns and 4ns respectively.

Fig. 6 Pulse response



PHOTODIODES

PD2XX1 SERIES

FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

TYPE NAME **PD2101**

DESCRIPTION

PD2XX1 is a silicon pin photodiode having a light receiving area of 500 μm square suitable for the light reception of 800nm wavelength band. They are well suited for optical communication systems.

They provide high speed response and small dark current.

FEATURES

- High speed response
- Small dark current
- Operating with low voltage
- Floating package
- High reliability, long operating life
- Active area 500 μm□

APPLICATION

Light receiving elements for optical fiber communication systems, instrumentation, POS, and others, POS systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V_R	Reverse voltage	$T_{opr} \leqq 80$℃, $I_R = 10\ \mu A$	30	V
I_F	Forward current	$T_{opr} \leqq 80$℃	10	mA
T_C	Case temperature	–	−40～+110	℃
T_{stg}	Storage temperature	–	−55～+150	℃

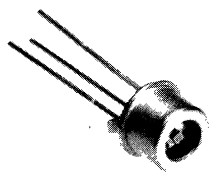
ELECTRICAL/OPTICAL CHARACTERISTICS ($T_c = 25$℃)

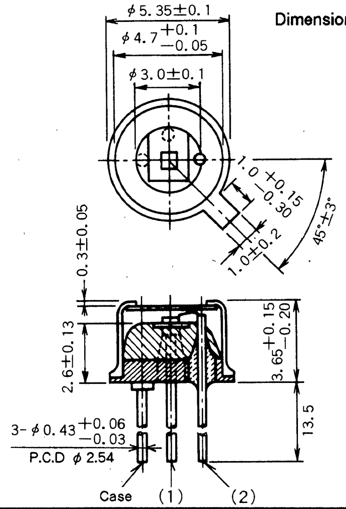
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
R	Responsivity	$V_R = 10V$, $\lambda = 850nm$	0.40	0.45	–	A/W
C_t	Total capacitance	$V_R = 5V$	–	5	10	pF
I_D	Dark current	$V_R = 10V$	–	0.5	4	nA
λ	Wavelength range	–	600～900			nm
t_r	Rise time	$V_R = 5V$	–	2	–	ns

FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

OUTLINE DRAWINGS

PD2101





PD1XX2 SERIES

FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

TYPE NAME **PD1002, PD1032**

DESCRIPTION

PD1XX2 is a silicon avalanche photodiode (Si-APD) having a light receiving area of 200 μ m in diameter. Mitsubishi Si-APD realizes the P-side incidence method having a deep junction of planar mesa structure, increasing the gain band width area and decreasing the noise generated by the multiplication mechanism.

FEATURES

- High speed response (pulse rise time 150ps)
- Flat frequency characteristics (cutoff frequency 2GHz)
- High gain-bandwidth product (800GHz)
- Low noise index in multiplication process ($< M^{0.3}$)
- Active diameter 200 μ m

APPLICATION

Light receiving element for optical fiber communication systems and optical telemetry systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
I_R	Reverse current	$T_{opr} \leqq 80$ ℃	200	μ A
I_F	Forward current		10	mA
Tc	Case temperature	–	−40～+110	℃
T_{stg}	Storage temperature	–	−55～+150	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (Tc = 25 ℃)

Symbol	Parameter	Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
$V_{(BR)R}$	Breakdown voltage	$I_D = 100\ \mu$ A	100	150	200	V
β	Temp.coeff.of $V_{(BR)R}$		–	0.12	–	%/℃
Ct	Total capacitance	$V_R = 0.9V_{(BR)R}$	–	1.5	2	pF
I_D	Dark current	$V_a = 50V$	–	0.3	1	nA
R	Responsivity	$V_a = 50V$, $\lambda = 800nm$	0.4	0.45*	–	A/W
Mmax	Maximum multiplication rate	$I_{PO} = 10nA$, $R_L = 1k\Omega$	–	1000	–	–
fc	Cutoff frequency	$M = 100$, $R_L = 50\Omega$, −3dB	–	2	–	GHz
NEP	Noise equivalent power	$\lambda = 800nm$	–	1×10^{-14}	–	W/Hz
F	Excess noise factor	M = 100	–	$M^{0.25}$	–	–

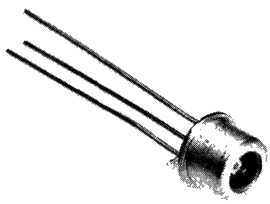
With PD1032, the minimum coupling response is 0.3A/W and the typical coupling response is 0.4A/W against GI50/125 outgoing light.

MITSUBISHI ELECTRIC

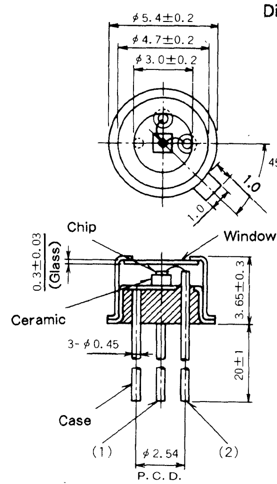
FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

OUTLINE DRAWINGS

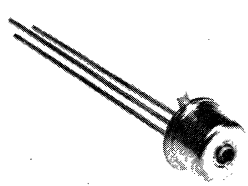
PD1002



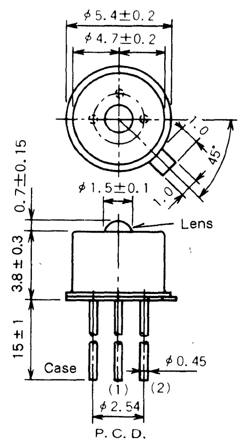
Dimensions in mm

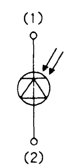


PD1032



Dimensions in mm





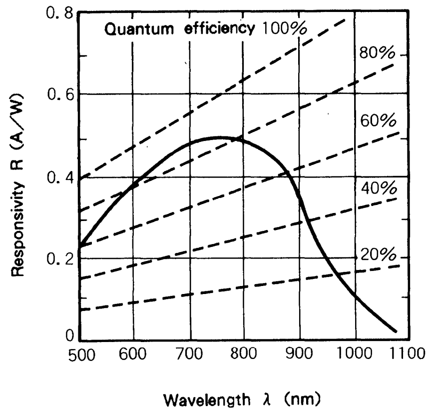
MITSUBISHI ELECTRIC

SAMPLE CHARACTERISTICS

1 Responsivity under no multiplication condition

Figure 1 shows PD1XX2's typical response characteristic against wavelength at a 50Vbias. PD1XX2 is a PIN structure APD suitable for receiving the lights having a wavelength band of 600 to 900nm like He－Ne laser (633nm) and AlGaAs laser (750 to 900nm). At a wavelength of 750nm, the response becomes about 0.5A/W at peak. The dashed lines indicate quantum efficiency levels.

Fig. 1 Spectral response



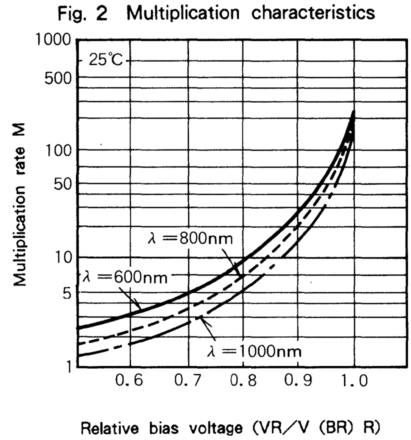
2 Multiplication characteristics

Typical voltage dependence of the multiplication rate at various wavelengths is shown in Fig. 2. Multiplicaiton rate as high as 1000 is obtainable when the output voltage (product of multiplied photocurrent and load resistance) is smaller than 100mV.

Practically available responsivity is a product of the value in Fig.1 and the multiplication rate M.A value as high as 300A/W can be easily obtained.

Because of the PIN structure, the PD1XX2 have much amaller scattering of the multiplication rate from device sto device, more uniform multiplication rate throughout the detecting area as compared with reach through devices.

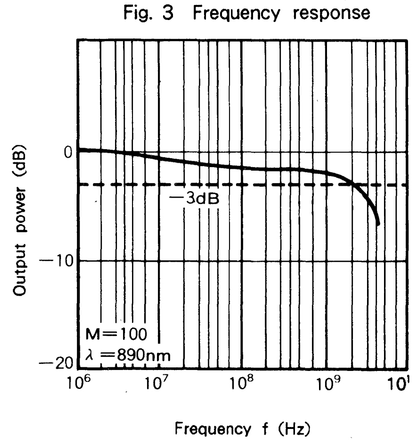
Fig. 2 Multiplication characteristics



3 Frequency response

Figure 3 shows PD1XX2's typical frequency response characteristic. The cutoff frequency (the frequency at output being －3dB) at a 50-ohm load is 2GHz or higher.

Fig. 3 Frequency response



4 Gain-bandwidth product

The gain-bandwidth product of an APD is a product of the multiplication rate and the cutoff frequency, GB. It increases with M and approaches an asymptote which is determined by the GB of multiplication process. Fig. 4. shows the GB of the PD1XX2. The multiplication limited GB of the devices is approximately 800GHz. Such a large GB is required particularly in detection of very weak and very wideband signals.

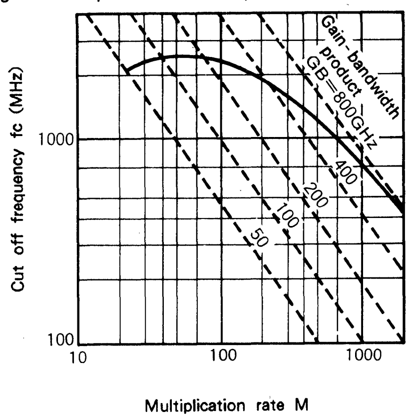


Fig. 4 Multiplication rate dependence of cutoff frequency

5 Noise characteristics

Excess noise factor of the multiplication process depends on the multiplication rate M. It is generally approximated by an expression M^x. Fig. 5 shows the noise characteristics of the PD1XX2. They depend slightly on wavelength of incident light signals. The constant, x, of the PD1XX2 is approximately 0.25. The PD1XX2 can be low noise detectors even in the high multiplication region since their noise increment is so small.

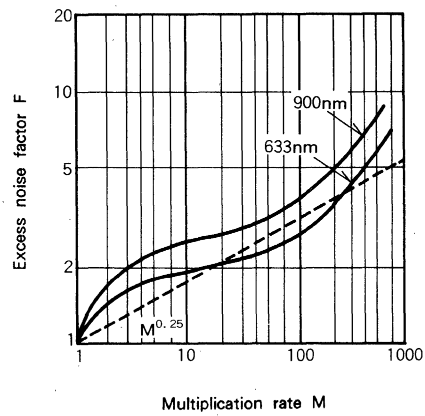
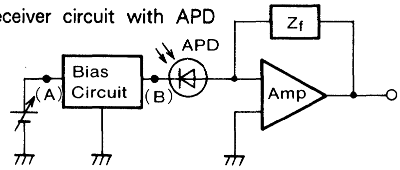


Fig. 5 Excess noise factor of multiplication process

6 Bias circuit

Fig. 6 shows an example of APD receiver circuit. Because the multiplication rate obtained when a constant reverse bias is added changes with temperature, a stable operation for long time requires the compensation of the temperature dependence of the multiplication rate. Figure 7 shows an example of the bias circuit for temperature compensation which uses an avalanche diode (AD1000) for temperature compensation.

Fig. 6 Receiver circuit with APD



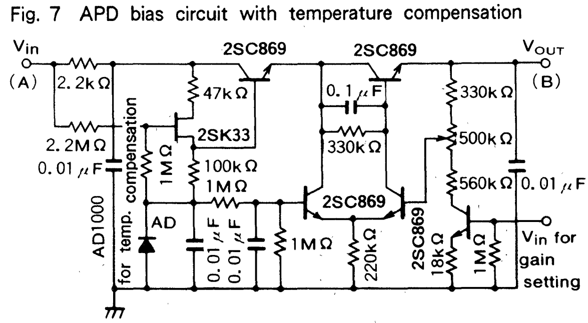


Fig. 7 APD bias circuit with temperature compensation

FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

TYPE NAME **PD1005**

DESCRIPTION

PD1XX5 is a silicon avalanche photodiode (Si-APD) having a light receiving area of 500 μm in diameter. Mitsubishi Si-APD realizes the P-side incidence method having a deep junction of planar mesa structure, increasing the gain band width area and decreasing the noise generated by the multiplication mechanism.

FEATURES

- High speed response (pulse rise time 750ps)
- Very low multiplication noise (< $M^{0.3}$)
- Flat frequency characteristic (cutoff frequency 400MHz)
- Very high gain-bandwidth product (400GHz)
- Active diameter 500 μm

APPLICATION

Light receiving element for optical fiber communication systems and optical telemetry systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
I_R	Reverse current	T_{opr} ≦ 80℃	200	μA
I_F	Forward current		10	mA
T_C	Case temperature	–	−40～+110	℃
T_{stg}	Storage temperature	–	−55～+150	℃

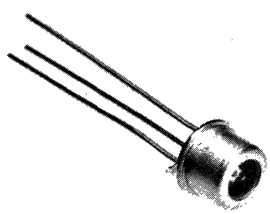
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$V_{(BR)R}$	Breakdown voltage	I_R = 100 μA	100	150	200	V
β	Temp. coeff. of $V_{(BR)R}$		–	0.12	–	%/℃
C_t	Total capacitance	$V_R = 0.9V_{(BR)R}$	–	5	7	pF
I_D	Dark current	V_R = 50V	–	0.3	1	nA
R	Responsivity	V_R = 50V, λ = 800nm	0.4	0.45	–	A/W
Mmax	Maximum multiplication rate	I_{PO} = 10nA, R_L = 1kΩ	–	1000	–	–
fc	Cutoff frequency	M = 100, R_L = 50Ω, −3dB	–	0.4	–	GHz
NEP	Noise equivalent power	λ = 800nm	–	1×10^{-14}	–	W/Hz
F	Excess noise factor	M = 100	–	$M^{0.25}$	–	–

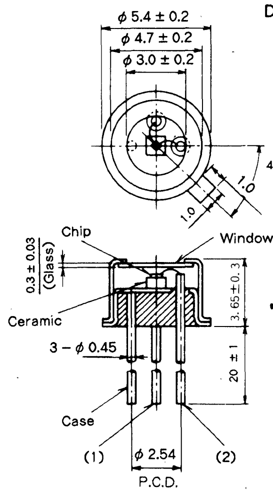
FOR OPTICAL COMMUNICATION AND RADAR SYSTEMS

OUTLINE DRAWINGS

PD1005



Dimensions in mm



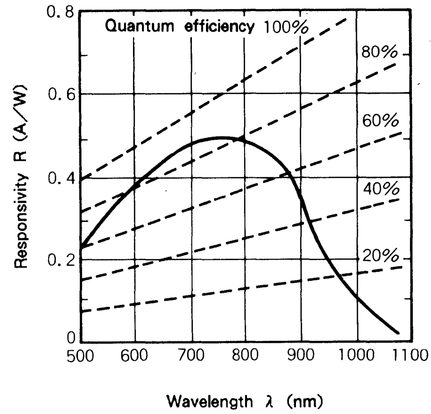
MITSUBISHI ELECTRIC

SAMPLE CHARACTERISTIC

1 Responsivity under no multiplication condition

Figure 1 shows PD1XX5's typical response characteristic against wavelength at a 50V bias. PD1XX5 is a PIN structure APD suitable for receiving the lights having a wavelength band of 600 to 900nm like He-Ne laser (633nm) and AlGaAs laser (750 to 900nm). At a wavelength of 750nm, the response becomes about 0.5A/W at peak. The dashed lines indicate quantum efficiency levels.

Fig. 1 Spectral response



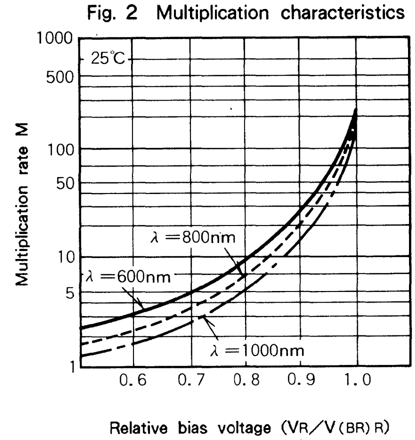
2 Multiplication characteristics

Typical voltage dependence of the multiplication rate at various wavelengths is shown in Fig. 2. Multiplication rate as high as 1000 is obtainable when the output voltage (product of multiplied photocurrent and load resistance) is smaller than 100mV.

Practically available responsivity is a product of the value in Fig. 1 and the multiplication rate M. A value as high as 300A/W can be easily obtained.

Because of the PIN structure, the PD1XX5 have much smaller scattering of the multiplication rate from device to device, more uniform multiplication rate throughout the detecting area as compared with reach through devices.

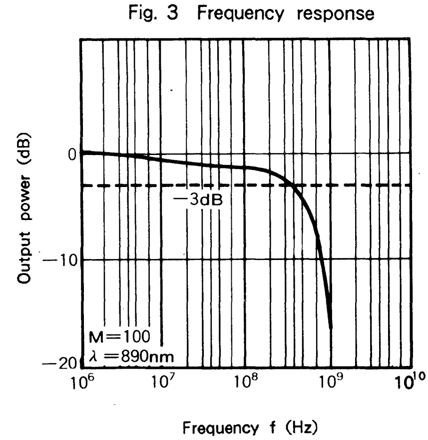
Fig. 2 Multiplication characteristics



3 Frequency response

Figure 3 shows PD1XX5's typical frequency response characteristic. The cutoff frequency (the frequency at output being −3dB) at a 50-ohm load is 400MHz or higher.

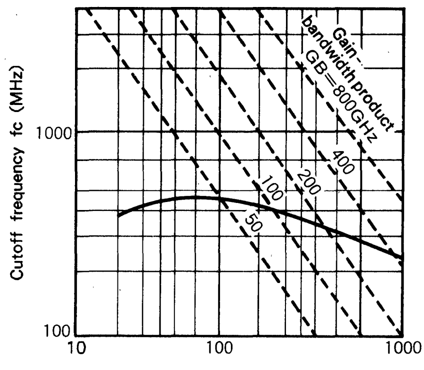
Fig. 3 Frequency response



4 Gain-bandwidth product

The gain-bandwidth product of an APD is a product of the multiplication rate and the cutoff frequency, GB. It increases with M and approaches an asymptote which is determined by the GB of multiplication process. Fig. 4. shows the GB of the PD1XX5. The multiplication limited GB of the devices is approximately 400GHz. Such a large GB is required particularly in detection of very weak and very wideband signals.

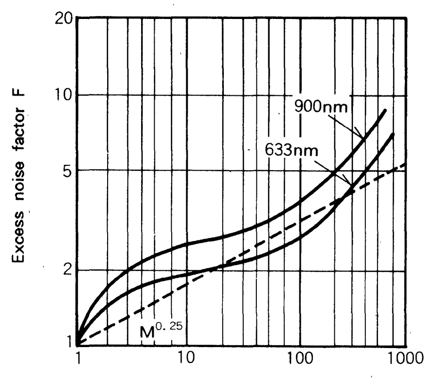
Fig. 4 Multiplication rate dependence of cutoff frequency



5 Noise characteristics

Excess noise factor of the multiplication process depends on the multiplication rate, M. It is generally approximated by an expression M^x. Fig. 5 shows the noise characteristics of the PD1XX5. They depend slightly on wavelength of incident light signals. The constant, x, of the PD1XX5 is approximately 0.25. The PD1XX5 can be low noise detectors even in the high multiplication region since their noise increment is so small.

Fig. 5 Excess noise factor of multiplication process



6 Bias circuit

Fig. 6 shows an example of APD receiver circuit. Because the multiplication rate obtained when a constant reverse bias is added changes with temperature, a stable operation for long time requires the compensation of the temperature dependence of the multiplication rate. Figure 7 shows an example of the bias circuit for temperature compensation which uses an avalanche diode (AD1000) for temperature compensation.

Fig. 6 Receiver circuit with APD

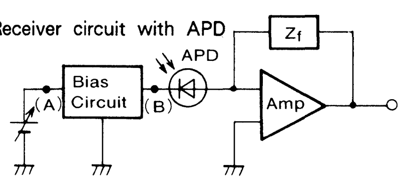
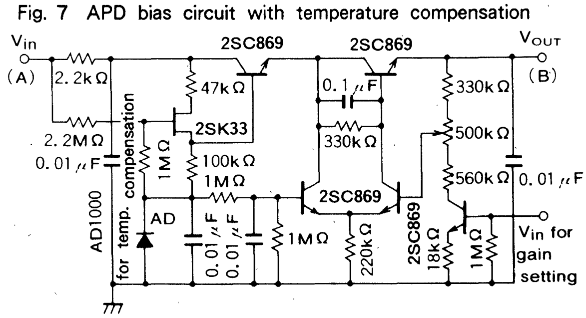


Fig. 7 APD bias circuit with temperature compensation



TYPE NAME

PD7005, PD7035

DESCRIPTION

PD7XX5 is an InGaAs pin photodiode having a light receiving diameter of 80 μm, which is suitable for receiving the light having a wavelength band of 1000 to 1600nm. This photodiode features a high quantum efficiency and a very small dark current is suitable for the light receiving element for long-distance optical communications.

FEATURES

- High quantum efficiency
- Very small dark current
- High speed response
- Active diameter 80 μm
- Wavelength range 1000~1600nm
- High reliability, long operation life

APPLICATION

Fiber-optic communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V_R	Reverse voltage	–	20	V
I_R	Reverse current	–	500	μA
I_F	Forward current	–	2	mA
T_C	Case temperature	–	−30~+80	℃
T_{stg}	Storage temperature	–	−40~+100	℃

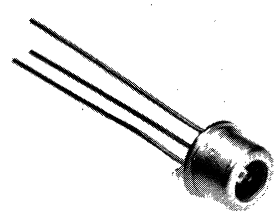
ELECTRICAL/OPTICAL CHARACTERISTICS (T_c = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
C_t	Total capacitance	V_R = 10V, f = 1MHz	–	1	2	pF
I_D	Dark current	V_R = 10V	–	0.05	1	nA
R	Responsivity	V_R = 10V, λ = 1300nm	0.6	0.9 *	–	A/W
fc	Cutoff frequency	V_R = 10V, λ = 1300nm, R_L = 50 Ω, −3dB	1	–	–	GHz
t_r, t_f	Rise and fall time	V_R = 10V, λ = 1300nm, R_L = 50 Ω	–	0.3	–	ns

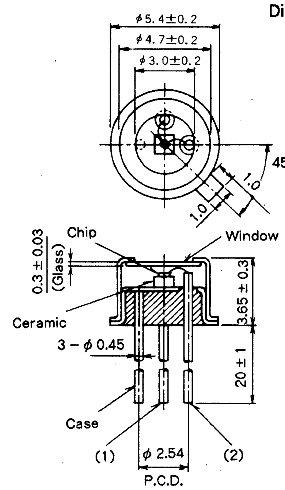
* Coupling response is typical 0.7A/W to light output (GI 50/125) about PD7035.

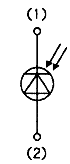
OUTLINE DRAWINGS

PD7005

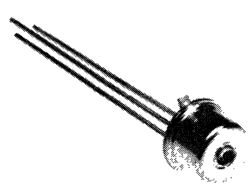


Dimensions in mm

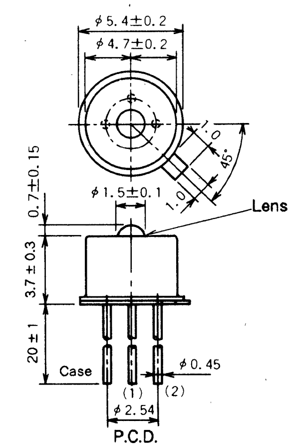


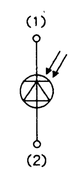


PD7035



Dimensions in mm





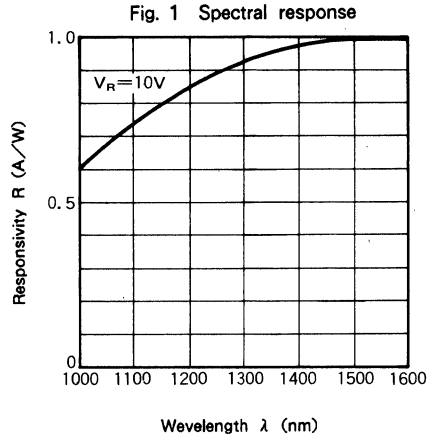
MITSUBISHI ELECTRIC

SAMPLE CHARACTERISTIC

1 Spectral response

Typical spectral response at $V_R = 10V$ is shown in Fig. 1. The PD7XX5 are suitable for detection of the spectral region between 1000 and 1600nm. At a wavelength of 1300nm, the responsivity is typically about 0.9A/W.

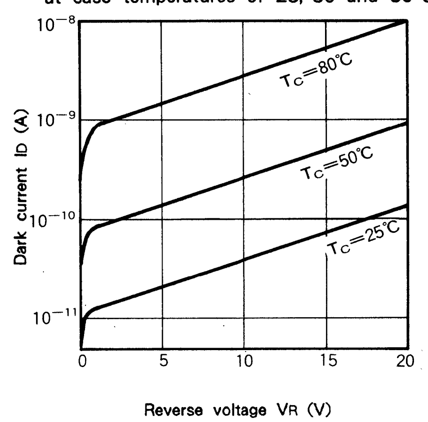
Fig. 1 Spectral response



2 Dark current

Figure 2 shows PD7XX5's typical dark current vs. reverse voltage characteristics at $T_C = 25°C, 50°C$, and 80°C. The dark current at $V_R = 10V, T_C = 25°C$ is typically 50pA.

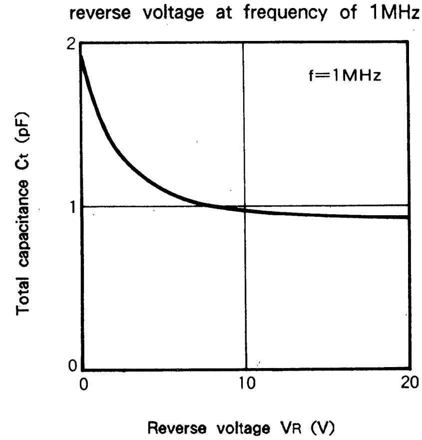
Fig. 2 Dark current vs. reverse voltage at case temperatures of 25, 50 and 80°C



3 Total capacitance

Typical capacitance vs. reverse bias characteristics are shown in Fig. 3. The total capacitance is typically 1pF at $V_R = 10V$.

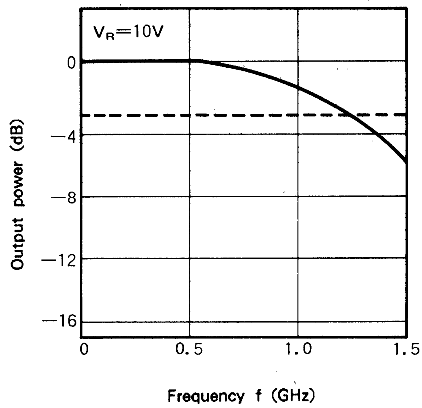
Fig. 3 Total capacitance vs. reverse voltage at frequency of 1MHz



4 Frequency response

Typical frequency response is shown in Fig. 4. For the light source, ML7XX1 (λ = 1300nm) was used. The cutoff frequency (− 3dB) is higher than 1GHz.

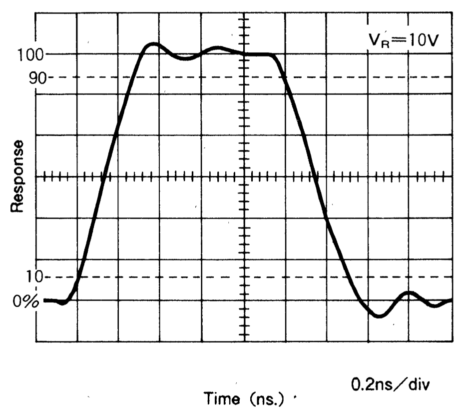
Fig. 4 Frequency response



5 Pulse response

Typical pulse response is shown in Fig. 5. The ML7XX1 series (wavelength : 1300nm, rise/fall time : 0.3ns) are used as light sources. Rise and fall times of about 0.3ns are typically obtained.

Fig. 5 Pulse response



TYPE NAME

PD7006

DESCRIPTION

PD7XX6 is an InGaAs pin photodiode having a light receving diameter of 300 μm, which is suitable for receiving the light having a wavelength band of 1000 to 1600nm. This photodiode features a high quantum efficiency and a very small dark current and is suitable for the light receiving elements for monitor and long-distance optical communications.

FEATURES

- High quantum efficiency
- Very small dark current
- Active diameter 300 μm
- Wavelngth range 1000~1600nm
- High reliability, long operation life
- Wide effective area

APPLICATION

Fiber-optic communication systems. Light receiving element for monitor.

ABSOLUTE MAXIMUM RATINGS

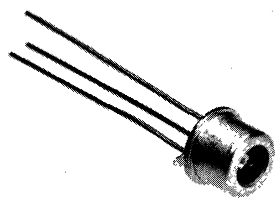
Symbol	Parameter	Conditions	Ratings	Unit
V_R	Reverse voltage	–	20	V
I_R	Reverse current	–	3000	μA
I_F	Forward current	–	2	mA
T_c	Case temperature	–	−30~+80	℃
T_{stg}	Storage temperature	–	−40~+100	℃

ELECTRICAL/OPTICAL CHARACTERISTICS (Tc = 25℃)

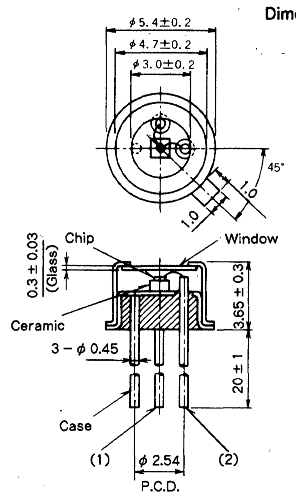
Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
C_t	Total capacitance	V_R = 10V, f = 1MHz	–	10	15	pF
I_D	Dark current	V_R = 10V	–	0.2	3	nA
R	Responsivity	V_R = 10V, λ = 1300nm	0.6	0.9	–	A/W
fc	Cutoff frequency	V_R = 10V, λ = 1300nm, R_L = 50 Ω, −3dB	0.2	0.4	–	GHz
t_r, t_f	Rise and fall times	V_R = 10V, λ = 1300nm, R_L = 50 Ω	–	1	–	ns

OUTLINE DRAWINGS

PD7006



Dimensions in mm

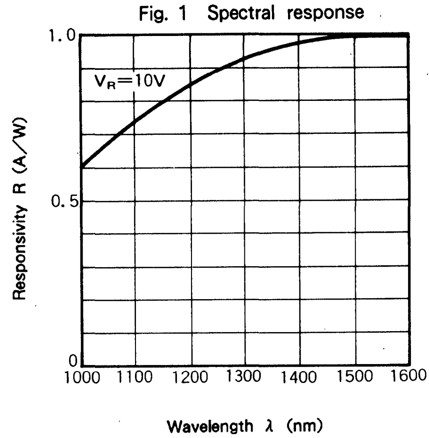


SAMPLE CHARACTERISTICS

1 Spectral response

Typical spectral response at $V_R = 10V$ is shown in Fig. 1. The PD7XX6 are suitable for detection of the spectral region between 1000 and 1600nm. At a wavelength of 1300nm, the responsivity is typically about 0.9A/W.

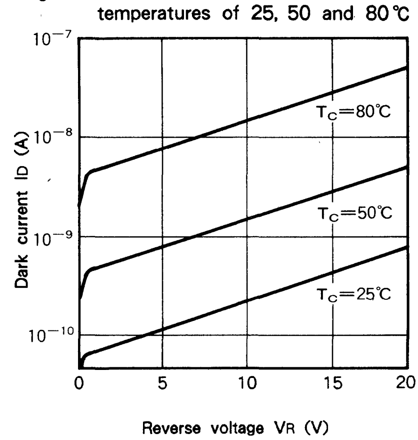
Fig. 1 Spectral response



2 Dark current

Figure 2 shows PD7XX6's typical dark current vs. reverse voltage characteristics at $T_c = 25°C, 50°C$, and 80°C. The dark current at $V_R = 10V, T_c = 25°C$ is typically 0.2nA.

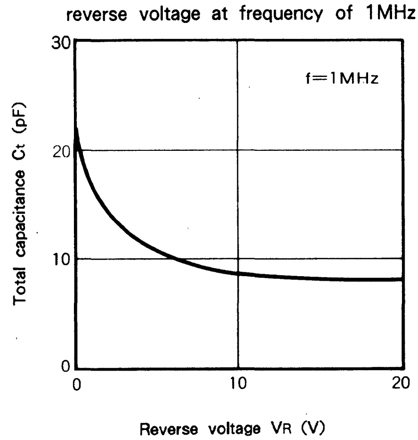
Fig. 2 Dark current vs. reverse voltage at case temperatures of 25, 50 and 80°C



3 Total capacitance

Typical capacitance vs. reverse bias characteristics are shown in Fig. 3. The total capacitance is typically 6pF at $V_R = 10V$.

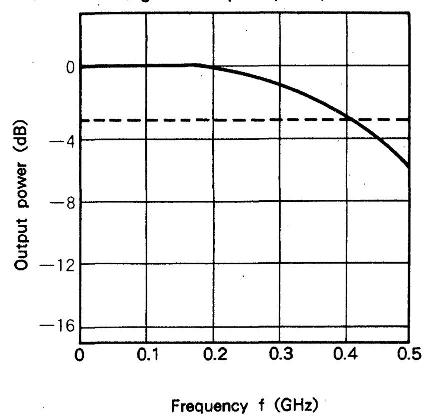
Fig. 3 Total capacitance vs. reverse voltage at frequency of 1MHz



4 Frequency response

Typical frequency response is shown in Fig. 4. The ML7XX1 (wavelength : 1300nm) are used as light sources. The cutoff frequency (−3dB) is higher than 0.4GHz.

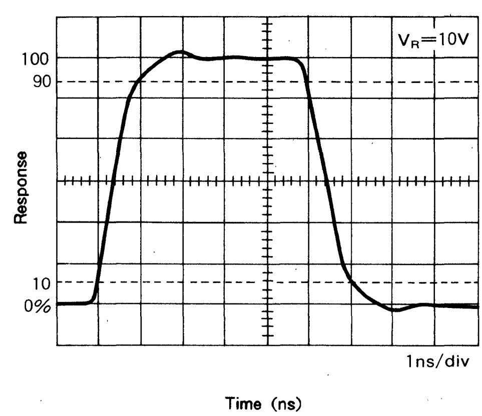
Fig. 4 Frequency response



5 Pulse response

Typical pulse response is shown in Fig. 5. The ML7XX1 (wavelength : 1300nm, rise/fall time : 0.3ns) are used as light sources. Rise and fall times of about 1ns are typically obtained.

Fig. 5 Pulse response



TYPE NAME

PD700A7

DESCRIPTION
PD7XX7 is an InGaAs pin photodiode having a light receiving diameter of 40 μm, which is suitable for receiving the light having a wavelength band of 1000 to 1600nm. This photodiode features a high quantum efficiency and a very small dark current is suitable for the light receiving element for long -distance optical communications.

FEATURES
- High quantum efficiency
- Very small dark current
- High speed response
- Active diameter 40 μm
- Wavelength range 1000~1600nm
- High reliability, long operation life

APPLICATION
Fiber-optic communication systems

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V_R	Reverse voltage	–	20	V
I_R	Reverse current	–	500	μA
I_F	Forward current	–	2	mA
T_C	Case temperature	–	−30~+80	℃
T_{stg}	Storage temperature	–	−40~+100	℃

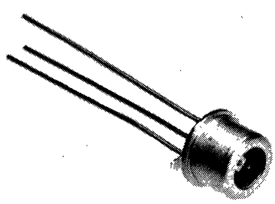
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
C_t	Total capacitance	V_R = 5V, f = 1MHz	–	0.6	1	pF
I_D	Dark current	V_R = 5V	–	0.05	0.3	nA
R	Responsivity	V_R = 5V, λ = 1300nm	0.6	0.9	–	A/W
fc	Cutoff frequency	V_R = 5V, λ = 1300nm, R_L = 50 Ω, −3dB	1.5	3	–	GHz
t_r, t_f	Rise and fall time	V_R = 5V, λ = 1300nm, R_L = 50 Ω	–	0.1	0.3	ns

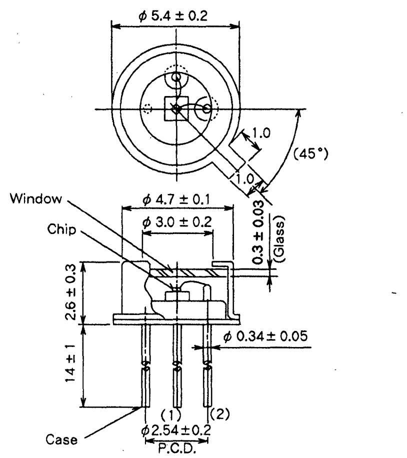
FOR OPTICAL COMMUNICATION

OUTLINE DRAWINGS

PD700A7



Dimensions in mm

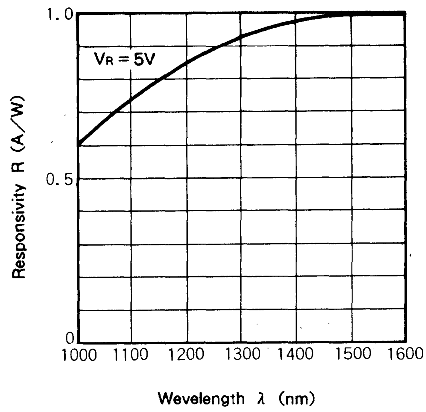


SAMPLE CHARACTERISTIC

1 Spectral response

Typical spectral response at $V_R = 5V$ is shown in Fig. 1. The PD7XX7 are suitable for detection of the spectral region between 1000 and 1600nm. At a wavelength of 1300nm, the responsivity is typically about 0.9A/W.

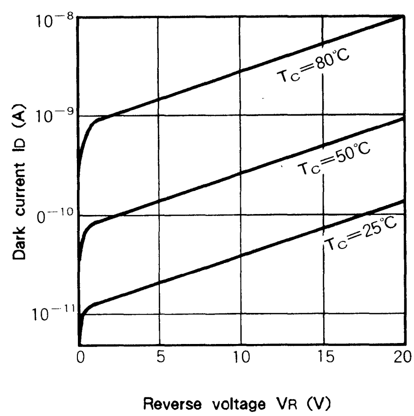
Fig. 1 Spectral response



2 Dark current

Figure 2 shows PD7XX7's typical dark current vs. reverse voltage characteristics at $T_C = 25°C, 50°C,$ and 80°C. The dark current at $V_R = 5V, T_C = 25°C$ is typically 50pA.

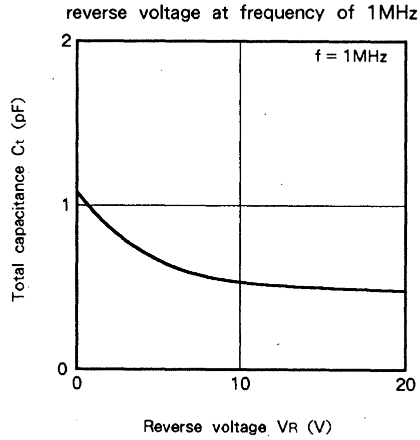
Fig. 2 Dark current vs. reverse voltage at case temperatures of 25, 50 and 80°C



3 Total capacitance

Typical capacitance vs. reverse bias characteristics are shown in Fig. 3. The total capacitance is typically 0.6pF at $V_R = 5V$.

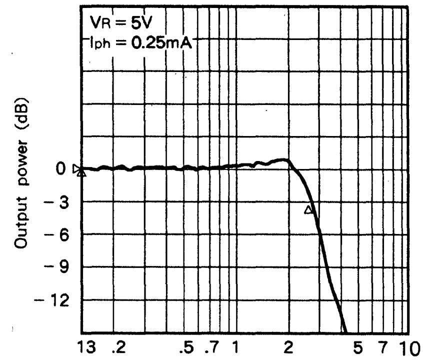
Fig. 3 Total capacitance vs. reverse voltage at frequency of 1MHz



4 Frequency response

Typical frequency response is shown in Fig. 4. For the light source, ML7XX1 (λ = 1300nm) was used. The cutoff frequency (− 3dB) is typically 3GHz.

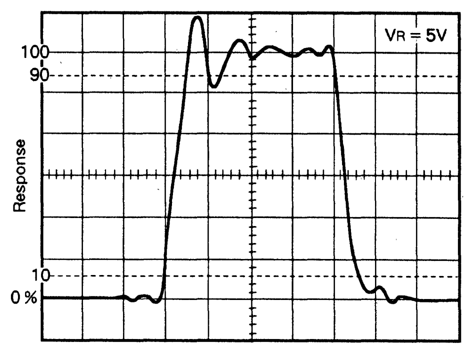
Fig. 4 Frequency response



5 Pulse response

Typical pulse response is shown in Fig. 5. Rise and fall times of about 0.1ns are typically obtained.

Fig. 5 Pulse response



MITSUBISHI ELECTRIC

TYPE NAME

PD805A2

DESCRIPTION

PD8XX2 is an InGaAs avalanche photodiode suitable for receiving the light having a wavelength band of 1000 to 1600nm. This photodiode features a high quantum efficiency and a very small dark current and is suitable for the light receiving element for long-distance optical communications.

FEATURES

- High quantum efficiency
- Very small dark current
- High speed response
- Active diameter 50 μm
- Low noise

APPLICATION

Fiber-optic communication systems

ABSOLUTE MAXIMUM RATINGS

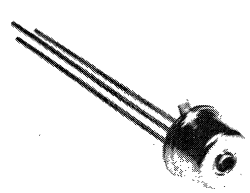
Symbol	Parameter	Conditions	Ratings	Unit
I_R	Reverse current	–	500	μA
I_F	Forward current	–	2	mA
T_C	Case temperature	–	–30～+80	℃
T_{stg}	Storage temperature	–	–40～+100	℃

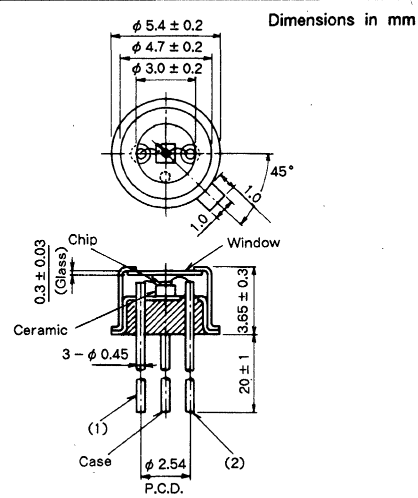
ELECTRICAL/OPTICAL CHARACTERISTICS (T_C = 25℃)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$V_{(BR)R}$	Breakdown voltage	I_R = 100 μA	40	70	90	V
C_t	Total capacitance	V_R = 0.9$V_{(BR)R}$, f = 1MHz	–	0.7	0.9	pF
I_D	Dark current	V_R = 0.9$V_{(BR)R}$	–	10	30	nA
η	Quantum efficiency	M = 1, λ = 1300nm	–	80	–	%
fc	Cutoff frequency	M = 10, R_L = 50 Ω, –3dB	1	3	–	GHz
F	Excess noise factor	M = 10	–	$M^{0.7}$	–	–

OUTLINE DRAWINGS

PD805A2



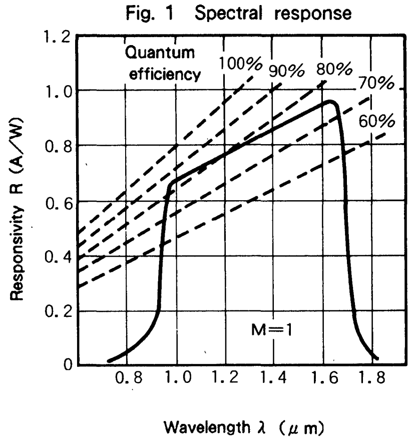


SAMPLE CHARACTERISTICS

1 Spectral response

Figure 1 shows PD8XX2's typical spectral response. Dashed curves indicate quantum efficiency levels. PD8XX2 is suitable for receiving the light having a wavelength of 1000 to 1600nm. The typical quantum efficiency in this area is 80%.

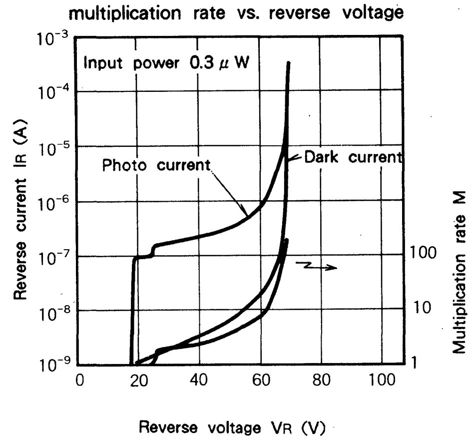
Fig. 1 Spectral response



2 Multiplication

Figure 2 shows PD8XX2's typical dark current, photo current, and multiplication rate vs. reverse voltage characteristic. The dark current at $0.9V_{(BR)R}$ is about 10nA and the multiplication rate is about 10.

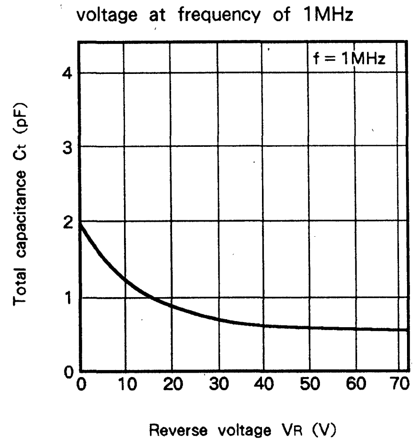
Fig. 2 Dark current, photo current, and multiplication rate vs. reverse voltage



3 Total capacitance vs. reverse voltage characteristic

Typical capacitance vs. reverse bias characteristics are shown in Fig. 3. The capacitance at $0.9V_{(BR)R}$ is about 0.7pF.

Fig. 3 Total capacitance vs. reverse voltage at frequency of 1MHz



CANCELED PRODUCTS

5

PRODUCTS TO BE DISCONTINUED

LIST OF PRODUCTS TO BE DISCONTINUED

Year in data book	Product to be discontinued	Replacement	Remarks
'90	ML3401	ML3411	Package "40" → "41", same chip
	ML4014C	ML40115C	Same package, chip improved.
	ML4014R	ML40115R	Same package, chip improved.
	ML4016N	–	To be out of production.
	ML4016C	–	To be out of production.
	ML4016R	–	To be out of production.
	ML4406	–	To be out of production.
	ML4446N	–	To be out of production.
	ML4708N	–	To be out of production.
	ML40110C	ML40110R	Pin connection "C" → "R", same package.
	ML40115N	ML40115R	Pin connection "N" → "R", same package.
	ML40117C	ML44114C	Package "01" → "41", chip improved.
	ML40117R	ML40114R	Same package, chip improved.
	ML5704F	ML5784F	Package "70" → "78", same chip.
	ML6701A	ML6411A	Package "70" → "41", same chip.
	ML6705N	–	To be out of production.
	ML6706N	–	To be out of production.
	ML6418N	–	To be out of production.
	ML6418R	–	To be out of production.
	ML6418C	–	To be out of production.
	ML6708E	–	To be out of production.
	ML7701A	ML7781A	Package "70" → "78", same chip.
	ML7761	ML776B1F	Package "76" → "76B", same chip.
	ML7702	ML774A2F	Package "70" → "74A", same chip.
	ML7912	ML7922	Package "91" → "92", same chip.
	ML9701A	ML9781A	Package "70" → "78", same chip.
	ML9702	ML974A2F	Package "70" → "74A", same chip.
	ML9912	ML9922	Package "91" → "92", same chip.
	ME7522	ME7032	Package "52" → "03", same chip.
	PD7935	PD7035	Package "93" → "03", same chip.
	PD7936	PD7006	Package "93" → "00", same chip.
	PD8001	PD805A2	Package "00" → "05A", chip improved.
	PD8931	PD805A2	Package "93" → "05A", chip improved.
	PD8002	PD805A2	Package "00" → "05A", same chip.
	PD8932	PD805A2	Package "93" → "05A", same chip.

Note : The user is recommended not to use the products to be discontinued in new designs.

OPTICAL-FIBER COMPONENTS GUIDANCE

6

LD Module for Singlemode Fiber (Receptacle Type)

Parts Number	Light emission Wavelungth (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-011SLD-N2	780	0.4	Receptacle	–	FC	ML40116R	7 – 3
FU-16SLD-N1	1300	1.5	Receptacle	–	FC	ML776BIF	7 – 5
FU-16SLD-N3	1300	0.2	Receptacle	–	FC	ML776BIF	7 – 8
FU-17SLD-N1	1300	1.5	Receptacle	–	FC	ML776BIF	7 – 5
FU-17SLD-N3	1300	0.2	Receptacle	–	FC	ML776BIF	7 – 8

LD Module for Singlemode Fiber (Coaxial Type)

Parts Number	Light emission Wavelungth (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-411SLD	1300	1.8	Coaxial	10/125	–	ML776BIF	7 – 11
FU-411SLD-20	1300	20	Coaxial	10/125	–	ML7XX1A	7 – 14
FU-611SLD	1550	1.5	Coaxial	10/125	–	ML9XX1	7 – 16
DU-611SLD-15	1550	15	Coaxial	10/125	–	ML9XX1A	7 – 19

LD Module for Singlemode Fiber (DIP Type/Butterfly Type)

Parts Number	Light emission Wavelungth (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-43SLD-1	1300	2	DIP	10/125	–	ML7701	7 – 21
FU-43SLD-2	1300	0.2	DIP	10/125	–	ML7701	7 – 24
FU-44SLD-1	1300	2	DIP w/cooler	10/125	–	ML7XX1	7 – 27
FU-44SLD-7	1300	10mW, Pulsed	DIP w/cooler	10/125	–	ML7XX1 Screened	7 – 30
FU-45SLD	1300	2	Butterfly, w/cooler	10/125	–	ML7XX1	7 – 33
FU-64SLD-1	1550	1.5	DIP w/cooler	10/125	–	ML9XX1	7 – 36
FU-64SLD-7	1550	10mW, Pulsed	DIP w/cooler	10/125	–	ML9XX1 Sccreened	7 – 39

DFB-LD Module for Singlemode Fiber (DIP Type/Butterfly Type)

Parts Number	Light emission Wavelungth (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-41SDF	1300	1.5	DIP w/cooler	10/125	–	ML7XX2	7 – 42
FU-44SDF	1300	1.5	Butterfly, w/cooler	10/125	–	ML7XX2	7 – 42
FU-45SDF-38	1300	3.6	Butterfly, w/isolator cooler	10/125	–	ML7XX2 Screened	7 – 45
FU-45SDF-4	1300	2	Butterfly, w/isolator cooler	10/125	–	ML7XX2	7 – 48
FU-48SDF-1	1300	3.5	Butterfly, w/isolator cooler	10/125	–	ML7XX2	7 – 51
FU-61SDF	1550	1.5	DIP w/cooler	10/125	–	ML9XX2	7 – 54
FU-64SDF	1550	1.5	Butterfly, w/cooler	10/125	–	ML9XX2	7 – 54
FU-65SDF-3	1550	2	Butterfly, w/isolator cooler	10/125	–	ML9XX2 Screened	7 – 57
FU-65SDF-4	1550	2	Butterfly, w/isolator cooler	10/125	–	ML9XX2	7 – 60
FU-68SDF-2	1550	3.5	Butterfly, w/isolator cooler	10/125	–	ML9XX2	7 – 63

LD Module for Multimode Fiber

Parts Number	Light emission Wavelength (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-01LD-N(0.78)	780	1.8	Receptacle	–	FC	ML4402A	7 – 66
FU-27LD(0.78)	780	1.8	Coaxial	50/125	–	ML4402A	7 – 66
FU-01LD-N(0.85)	850	1.8	Receptacle	–	FC	ML3401	7 – 69
FU-27LD(0.85)	850	1.8	Coaxial	50/125	–	ML3401	7 – 69
FU-23LD	850	4	DIP w/cooler	50/125	–	ML2XX1	7 – 72
FU-11LD-N	1300	5	Receptacle	–	FC	ML7701	7 – 75
FU-33LD	1300	2.5	DIP w/cooler	50/125	–	ML7XX1	7 – 77

LED Module

Parts Number	Light emission Wavelungth (nm)	Optical output power (mW)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-02LE-N	840	65	Receptacle	–	FC	ME1514	7 – 80
FU-23LE	840	65	Coaxial	50/125	–	ME1514	7 – 80
FU-13LE-N	1300	15	Receptacle	–	FC	ME7XX3	7 – 83
FU-34LE	1300	15	Coaxial	50/125	–	ME7XX3	7 – 83

PD Module

Parts Number	Detection Band (nm)	Responsivity (A/W)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-04PD-N	430-1060	0.6	Receptacle	–	FC	NA	7 – 86
FU-21PD	430-1060	0.6	Coaxial	50/125	–	NA	7 – 86
FU-15PD-N	1000-1600	0.8	Receptacle	–	FC	PD7035	7 – 89
FU-16PD-N	1000-1600	0.8	Receptacle	–	FC	PD7035	7 – 89
FU-35PD	1000-1600	0.8	Coaxial	50/125	–	PD7035	7 – 91

APD Module

Parts Number	Detection Band (nm)	Responsivity (A/W)	Package type	Fiber	Connector Type	Discrete Device Type No.	Page
FU-05AP-N	500-1000	0.4	Receptacle	–	FC	PD1XX2	7 – 94
FU-25AP	500-1000	0.4	Coaxial	50/125	–	PD1XX2	7 – 94
FU-12AP-N	800-1550	0.7	Receptacle	–	FC	NA	7 – 97
FU-32AP	800-1550	0.7	Coaxial	50/125	–	NA	7 – 97
FU-13AP-N	1000-1600	0.8	Receptacle	–		PD8001	7 – 100
FU-310AP	1000-1600	0.8	Coaxial	50/125	–	PD8XX1	7 – 102

Digital-Optical Transceiver Module (3R Type)

Parts Number	Wavelength (nm)	Data Rate (Mb/s) NRZ (max)	Transmission Distance (Km)	Logic	Opt. Source & Detector	Connector Type	Page
MF-125DS-TR113-006	1300	125	4	ECL	LED, PD	FC	7 – 105
MF-156DS-TR124-002/003	1300	155.52	40/15	ECL	LD APD	FC	7 – 108
MF-622DF-T12-007~011	1300/1550	622.08	15/40/60	ECL	LD, DFB LD	FC	7 – 112
MF-622DS-R13-002 R14-002/003	1300/1550	622.08	15 40/60	ECL	PD, APD	FC	7 – 115

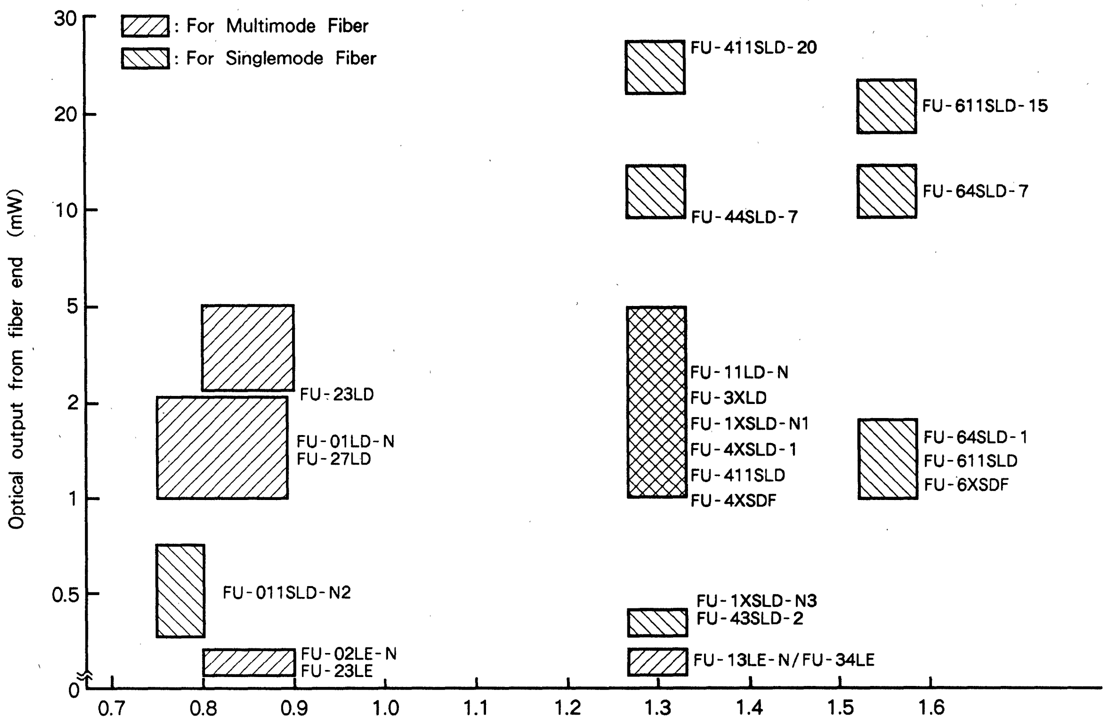
Digital-Optical Transceiver Module (2R Type)

Parts Number	Wavelungth (nm)	Data Rate (Mb/s) NRZ (max)	Transmission Distance (Km)	Logic	Opt. Source & Detector	Connector Type	Page
MF-20DF-TR014-002	850	20	1	TTL	LED/APD	FC	7 – 117
MF-32DF-T01/R03	840	32	4	ECL	LED/PD	FC	7 – 119

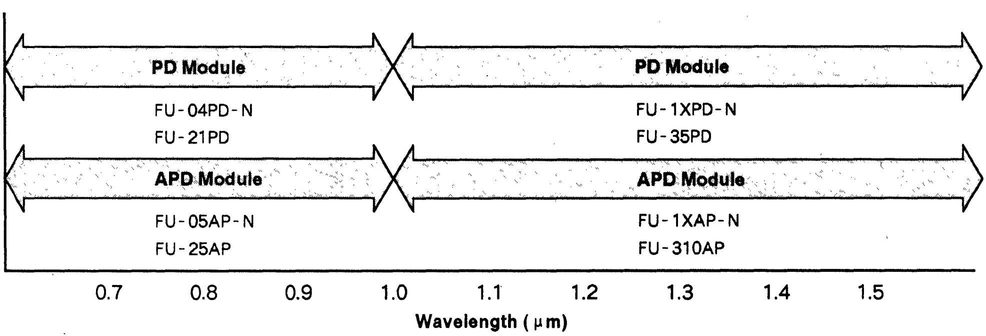
Optical-Fiber Connector

Parts Name	Model No.	Coupling loss	Optical Fiber Type	Page
Optical-fiber connector plug (Singlemode fiber)	FC-01PN-(L)-SMF	0.5dB Typ.	Silica fiber (singlemode fiber 10/125)	7 – 121
	FC-01PNW-(L)-SMF			
	FC-01PN-(L) • PC-SMF	0.3dB Typ.		
	FC-01PNW-(L) • PC-SMF			
	FC-01PN-(L) • SPC-SMF	0.3dB Typ.		
	FC-01PNW-(L) • SPC-SMF			
Optical-fiber connector plug (Multimode fiber)	FC-01PN-(L)	0.3dB Typ.	Silica fiber (GI 50/125)	7 – 123
	FC-01PNW-(L)			
	FC-01PN-(L) • PC	0.05dB Typ.		
	FC-01PNW-(L) • PC			
	FC-01PN-(L) • SPC	0.05dB Typ.		
	FC-01PNW-(L) • SPC			
Adaptor	FC-01RN(S)	–	for singlemode fiber	7 – 121
	FC-01RN		for multimode fiber	7 – 123

LD/LED Module



PD/APD Module



PRODUCT DESIGNATION CODE

LD, LED, PD, APD MODULE

F U - 4 2 S L D - D

- F — Fiber
- U — Module
- 4 — Wavelength & Package

	Wavelength	Package
0 :	0.78μm or 0.85μm Band	Receptacle
1 :	1.3μm Band	Receptacle
2 :	0.78μm or 0.85μm Band	Pigtail(MMF)
3 :	1.3μm Band	Pigtail(MMF)
4 :	1.3μm Band	Pigtail(SMF)
6 :	1.55μm Band	Pigtail(SMF)

- 2 — Development rank
- S — S : For Singlemode Fiber
  NO MARK : For Multimode Fiber
- LD — Device LD : Laser Diode
  DF : DFB Laser Diode
  LE : Surface Emitting Light Emitting Diode
  PD : Photo Diode
  AP : Avalanche Photo Diode
- D — In Case of Receptacle type,
  Connector Type N : NTT-FC Type In Case of Pigtail type,
  Optical power rank

METHOD FOR ORDERING OTHER THAN STANDARD PRODUCTS
(ONLY FOR FU-42SLD TYPE LD MODULE)

Please, advise whether with sheath of optical fiber, for optical connector, and the length of optical fiber, as shown below.

FU-42LD-D — □ — □ — □

- Sheath of optical fiber
  A--- φ 0.9mm(Nylon jacket)
  B--- φ 3mm(PVC code)
- Optical connector
  0---Without connector
  1---With FC-01PN
- Optical fiber length
  L----L(m)

SAFETY CONSIDERATION FOR LD MODULE

(1) The maximum rating of LD module is based on optical output. For LD module application, it should be handled carefully in order that the output from the optical-fiber cable will not exceed the maximum rating.

(2) As a laser diode is delicate, it can be damaged by surge current caused when power is supplied or interrupted. To prevent generation of surge current, for example, a slow-starter unit shown in Fig. 1 should be used.

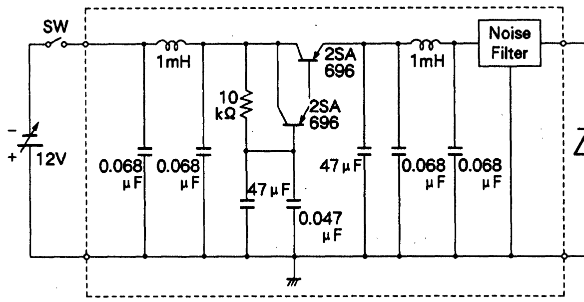


Fig. 1 Example of Circuit for Slow Starter

(3) As a laser diode can be damaged by static electricity, appropriate precautions should be taken to prevent static electricity.

(4) When the LD module is driven constantly, if the temperature varies, the optical output varies inversely. If the temperature lowers, the optical output of LD module may exceed the maximum rating. For obtaining stabilized optical output, and at the same time for protecting a laser diode, using an APC (Automatic Power Control) circuit for example as shown in Fig. 2 is strongly recommended.

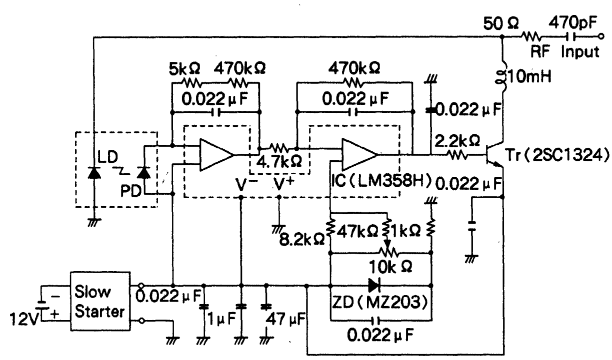


Fig. 2 Example of Circuit for APC Circuit

(5) The beam emitted from the laser diode is invisible and may be harmful to the human eye. Avoid any possibility of looking into the laser package or the collimated beam along its optical axis when the device is in operation. Operation over the maximum ratings may cause failure of the device or a safety hazard. Power supplies for the device must be such that the maximum rating of the right output cannot be exceeded. Because of the size of each module, the labels shown below are attached to the individual laser container. They are illustrated to comply with the requirements of DHHS standards under the Radiation Control for Health and Safety Act of 1968.

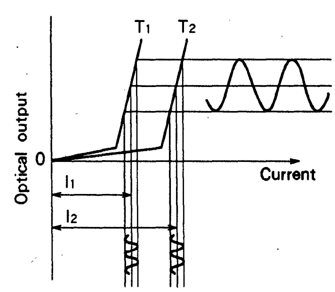
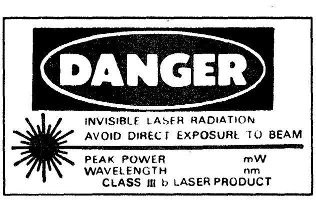
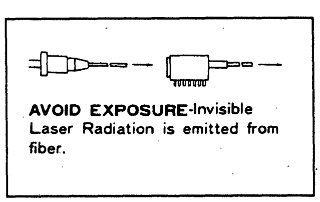


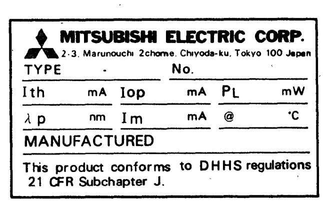
Fig. 3 Optical Output for APC Drive



Warning Label



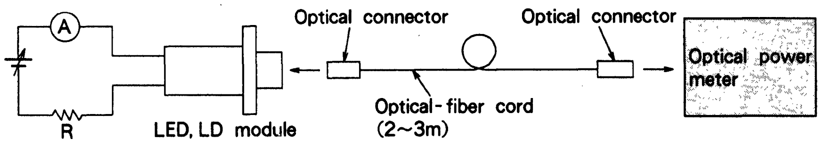
Aperture Label



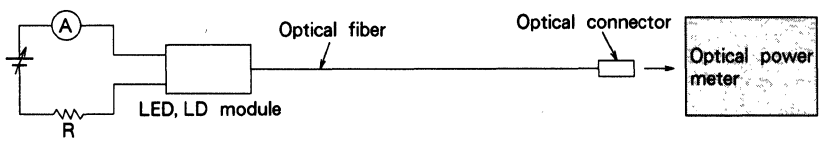
Certification Label

1. Optical Output of Light-emission Module (LED, LD Modules)

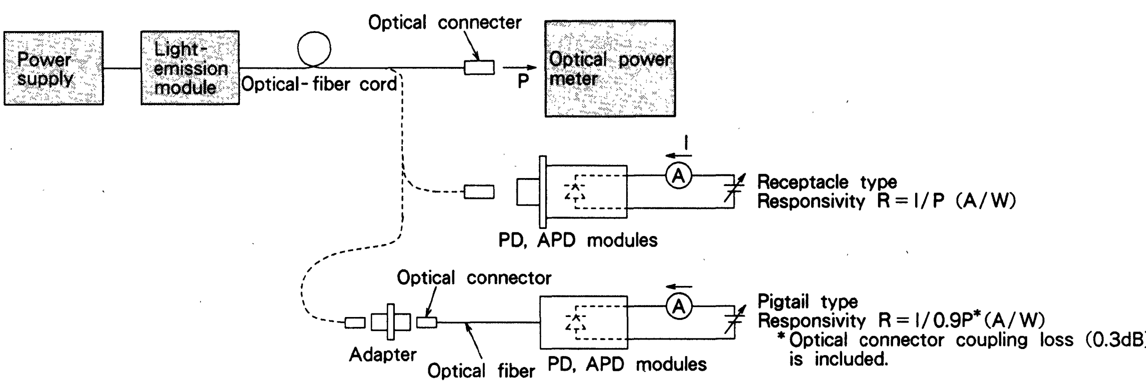
(1) Receptacle type



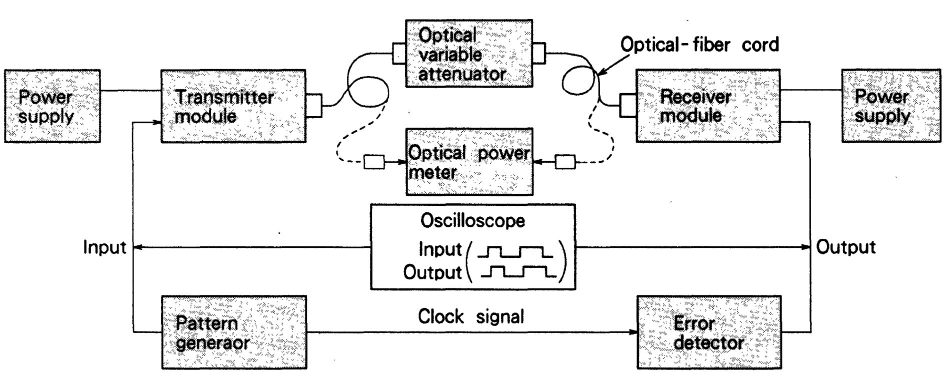
(2) Pigtail type



2. Responsivity of Light-receiving Module (PD, APD Modules)

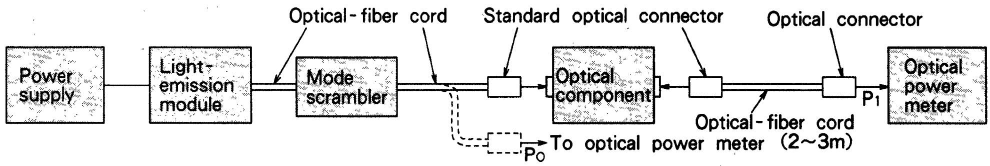


3. Digital Optical Transceiver Module



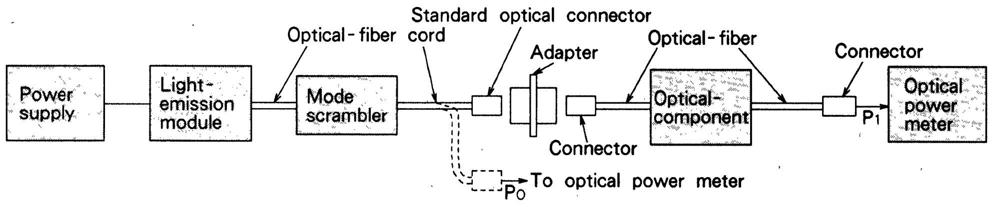
4. Insertion Loss of Optical Compornents

(1) Receptacle type



$$\text{Insertion loss} = -10\log\frac{P_1}{P_0}\ \text{(dB)}$$

(2) Pigtail type



$$\text{Insertion loss} = -10\log\frac{P_1}{P_0}\ \text{(dB)}$$

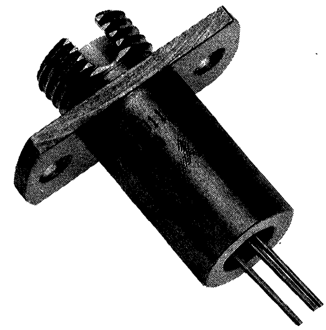
OPTICAL-FIBER COMPONENTS DATA SHEET

7

FU-011SLD-N2

0.78μm Connectorized LD Module for Singlemode Fiber

LD module type FU-011SLD-N2 contains self-pulsation AlGaAs LD (Laser diode) for 0.78μm band and is used as light source for use in intermediate and high speed local area network systems.



FU-011SLD-N2

FEATURES

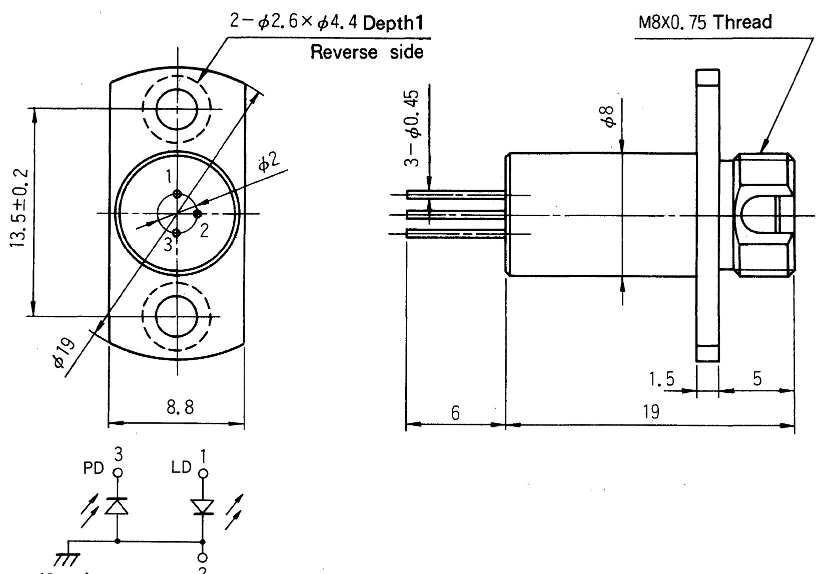
- High-speed response
- Emission wavelength is in 0.78μm wavelength band
- Connectorized package for FC connector
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	1	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	10	mA
Operating case temperature		T_C	–	−20~60	℃
Storage temperature		T_{stg}	–	−40~70	℃

Note 1) Singlemode fiber master plug with mode field diameter 10μm

OUTLINE DRAWINGS Unit (mm)



FU-011SLD-N2

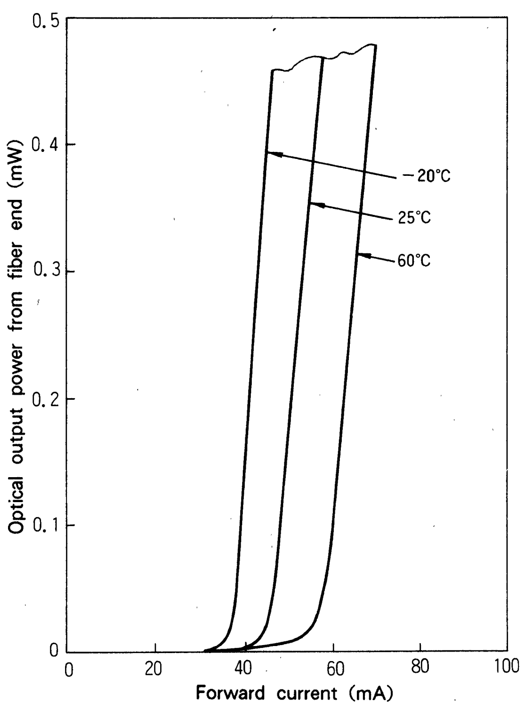
0.78 μm Connectorized LD Module for Singlemode Fiber

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

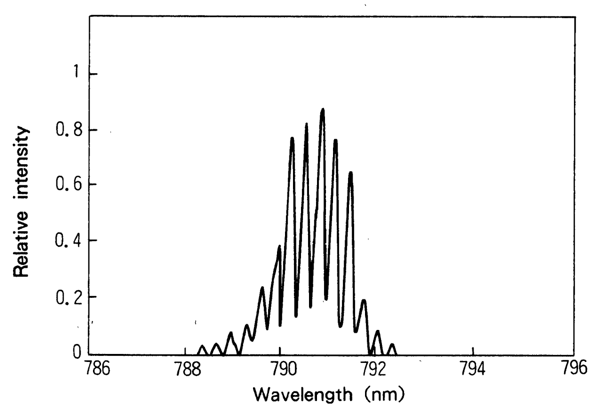
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	45	70	mA
Operating current	I_{op}	CW	–	55	85	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.8	2.3	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	0.25	0.4	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	765	780	800	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	0.5	–	ns
Tracking error (Note 4)	E_r	Tc = – 20~60℃, APC	–	0.5	–	dB
Differential efficiency (Note 2)	η	–	–	0.04	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.4	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	–	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	7	–	pF
Optical connector type	–	–	FC			–

Note 1) I_F : Forward current (LD)
Note 2) Singlemode fiber master plug with mode field diameter 10μm
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

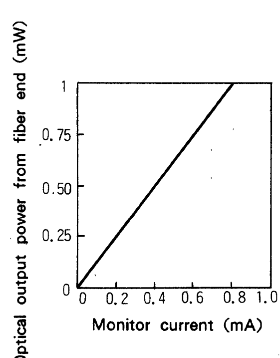
EXAMPLE OF CHARACTERISTICS



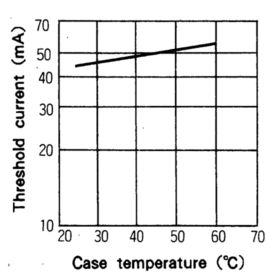
Forward current vs. Optical output power



Light-emission spectrum



Monitor current vs. Optical output power from fiber end



Case temperature vs. Threshold current

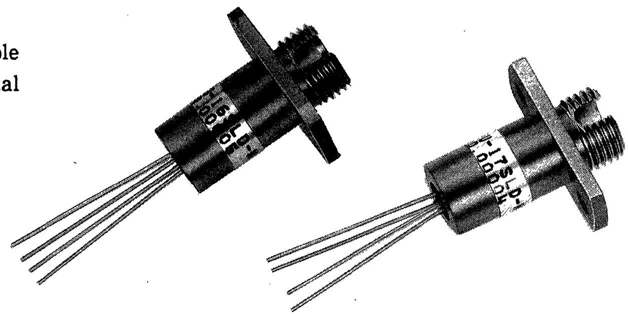
MITSUBISHI ELECTRIC

FU-16SLD-N1, FU-17SLD-N1

1.3μm Connectorized LD Module for Singlemode Fiber

Module type FU-16SLD-N1 and FU-17SLD-N1 have been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).

FU-16SLD-N1 and FU-17SLD-N1 are suitable to light source for use in medium haul digital optical communication systems.



FU-16SLD-N1 **FU-17SLD-N1**

FEATURES

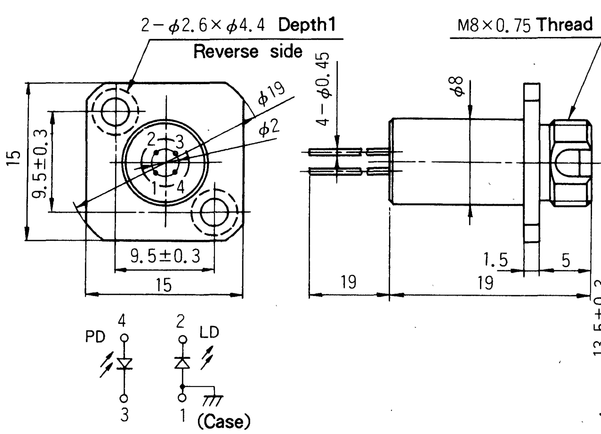
- High optical output
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Connectorized package for FC connector
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

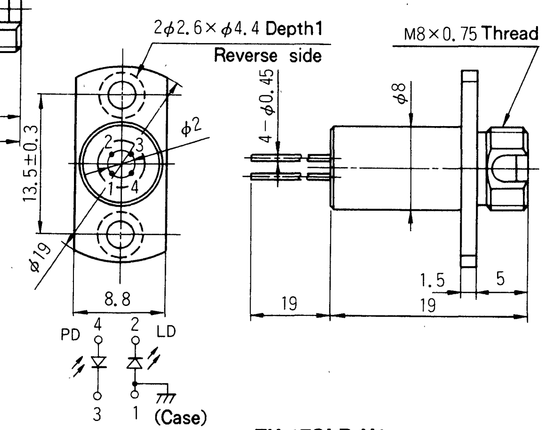
Items		Symbols	Conditions	Ratings		Units
				FU-16SLD-N1	FU-17SLD-N1	
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	2.5	2.5	mW
	Reverse Voltage	V_{RL}	−	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	−	15	15	V
	Forward current	I_{FD}	−	2	2	mA
Operating case temperature		T_C	−	−20~65	−20~65	℃
Storage temperature		T_{stg}	−	−40~85	−40~85	℃

Note 1) Singlemode fiber master plug with mode field diameter 10μm

OUTLINE DRAWINGS Unit (mm)



FU-16SLD-N1



FU-17SLD-N1

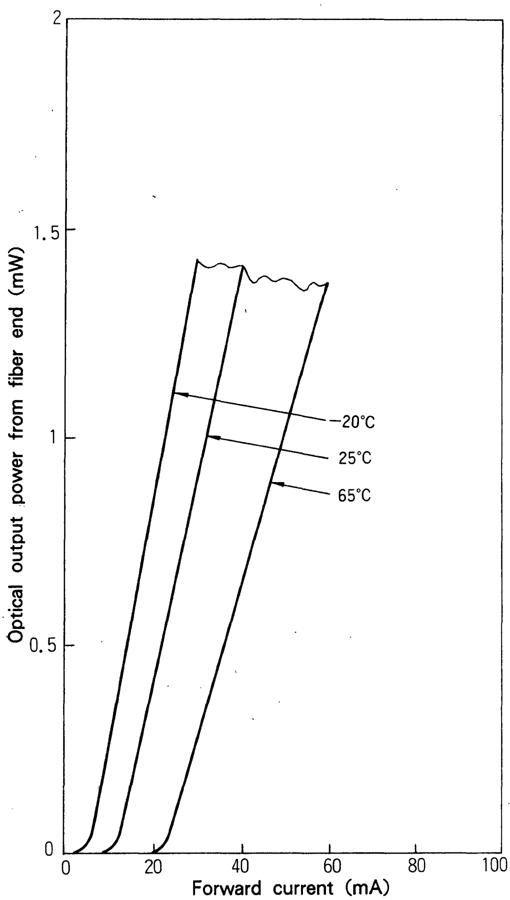
CHARACTERISTICS (T_c=25°C, unless otherwise noted)

Items	Symbols	Conditions	FU-16SLD-N1			FU-17SLD-N1			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	10	20	–	10	20	mA
Operating current	I_{op}	CW	–	30	65	–	30	65	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	–	1.2	1.6	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	1	1.5	–	1	1.5	–	mW
Central wavelength	λ_C	CW, $I_F = I_{op}$	1270	1300	1330	1270	1300	1330	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90%(Note 3)	–	0.3	–	–	0.3	–	ns
Tracking error (Note 4)	E_r	T_C = – 20~65°C, APC	–	0.5	–	–	0.5	–	dB
Differential efficiency (Note 2)	η	–	–	0.07	–	–	0.07	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.25	1	–	0.25	1	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	–	10	–	pF
Optical connector type	–	–		FC			FC		–

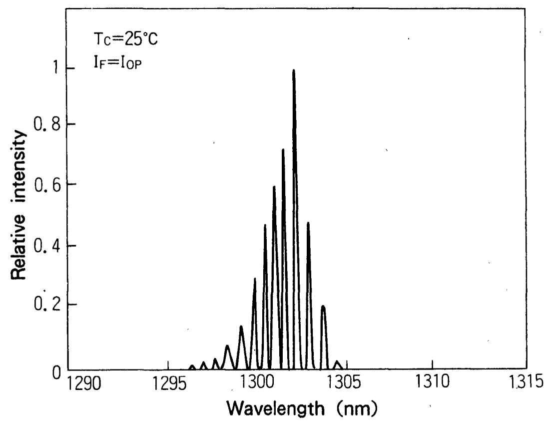
Note 1) I_F : Forward current (LD)
Note 2) Singlemode fiber master plug with mode field diameter 10μm
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX \left| 10 \cdot \log \frac{P_F}{P_F\ (25°C)} \right|$

MITSUBISHI ELECTRIC

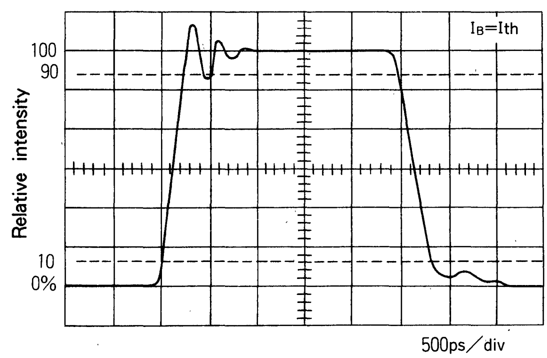
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



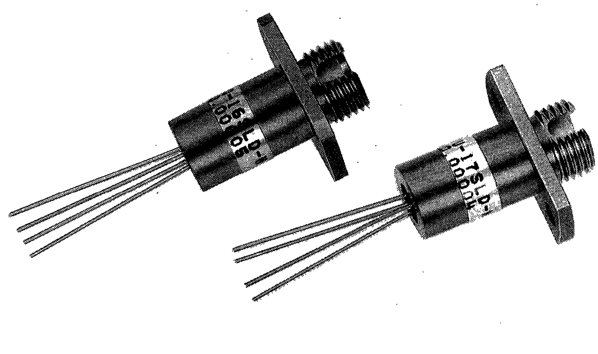
Pulse response

FU-16SLD-N3, FU-17SLD-N3

1.3μm Connectorized LD Module for Singlemode Fiber

Module type FU-16SLD-N3 and FU-17SLD-N3 have been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).

FU-16SLD-N3 and FU-17SLD-N3 are suitable to light source for use in medium haul digital optical communication systems.



FU-16SLD-N3 **FU-17SLD-N3**

FEATURES

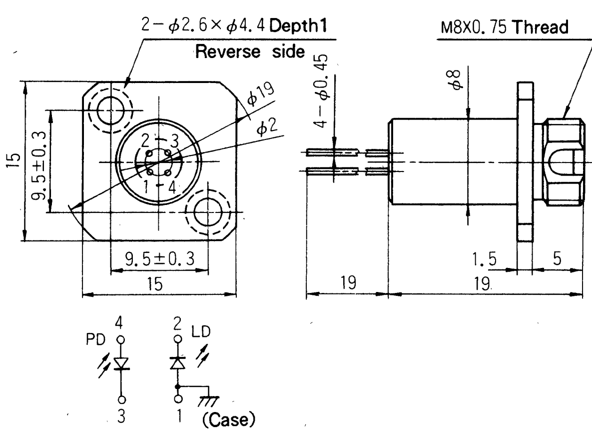
- Wide operating temperature range
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Connectorized package for FC connector
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

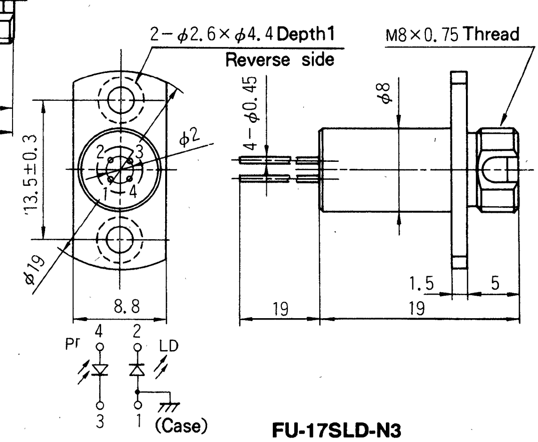
Items		Symbols	Conditions	Ratings		Units
				FU-16SLD-N3	FU-17SLD-N3	
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	0.5	0.5	mW
	Reverse Voltage	V_{RL}	–	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	15	V
	Forward Current	I_{FD}	–	2	2	mA
Operating case temperature		T_C	–	−30～85	−30～85	℃
Storage temperature		T_{stg}	–	−40～85	−40～85	℃

Note 1) Singlemode fiber master plug with mode field diameter 10μm

OUTLINE DRAWINGS Unit (mm)



FU-16SLD-N3



FU-17SLD-N3

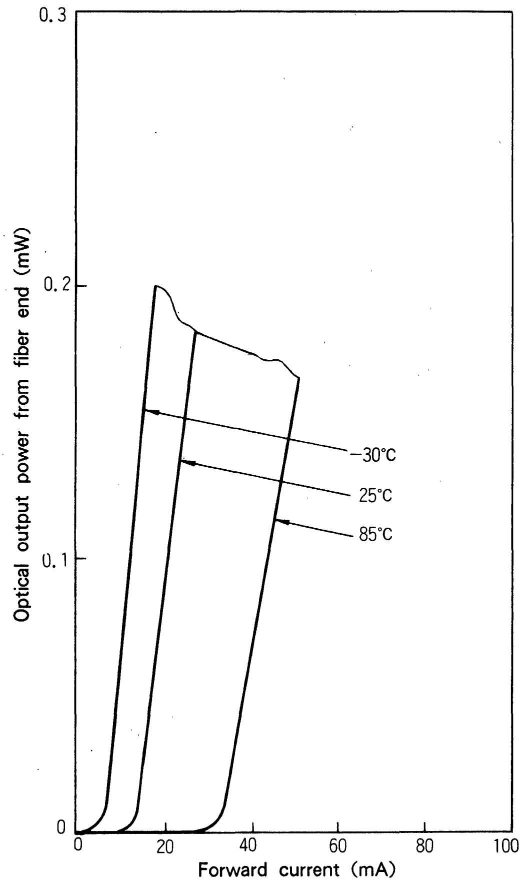
MITSUBISHI ELECTRIC

CHARACTERISTICS (Tc=25 °C, unless otherwise noted)

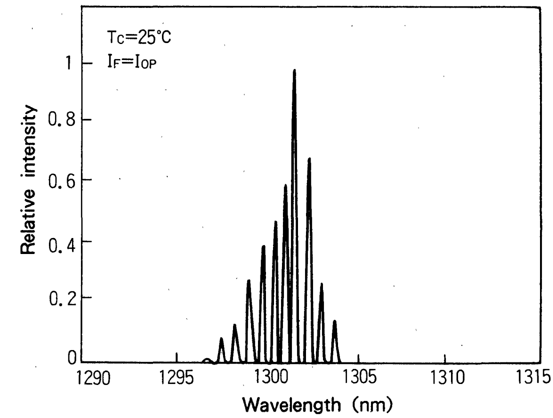
Items	Symbols	Conditions	FU-16SLD-N3			FU-17SLD-N3			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	10	20	–	10	20	mA
Operating current	I_{op}	CW	–	30	65	–	30	65	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	–	1.2	1.6	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	0.1	0.2	–	0.1	0.2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	1270	1300	1330	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90 %(Note 3)	–	0.3	–	–	0.3	–	ns
Tracking error (Note 4)	E_r	$T_C = -30 \sim 85$ ℃, APC	–	0.5	–	–	0.5	–	dB
Differential efficiency (Note 2)	η	–	–	0.01	–	–	0.01	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, $V_{RD} = 5V$	0.1	0.6	–	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	$V_{RD} = 5V$	–	0.1	1	–	0.1	1	μA
Capacitance (Photodiode)	C_t	$V_{RD} = 5V$, f = 1MHz	–	10	–	–	10	–	pF
Optical connector type	–	–	FC			FC			–

Note 1) I_F : Forward current (LD)
Note 2) Singlemode fiber master plug with mode field diameter 10μm
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX \left| 10 \cdot \log \frac{P_F}{P_F (25℃)} \right|$

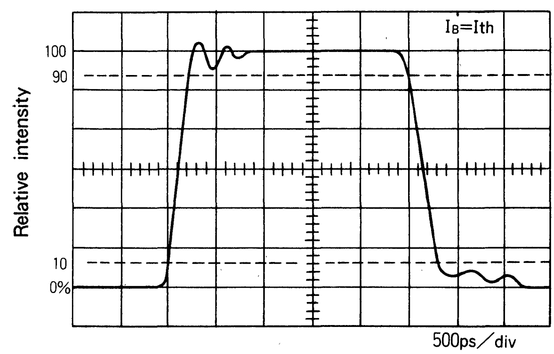
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum

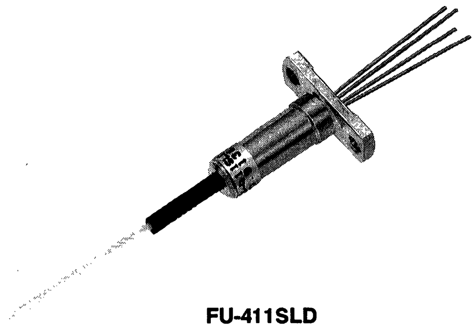


Pulse response

FU-411SLD

1.3μm LD Module with Singlemode Fiber Pigtail

Module type FU-411SLD has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).
FU-411SLD is suitable to light source for high-speed long haul digital optical communication systems and measuring instruments.



FU-411SLD

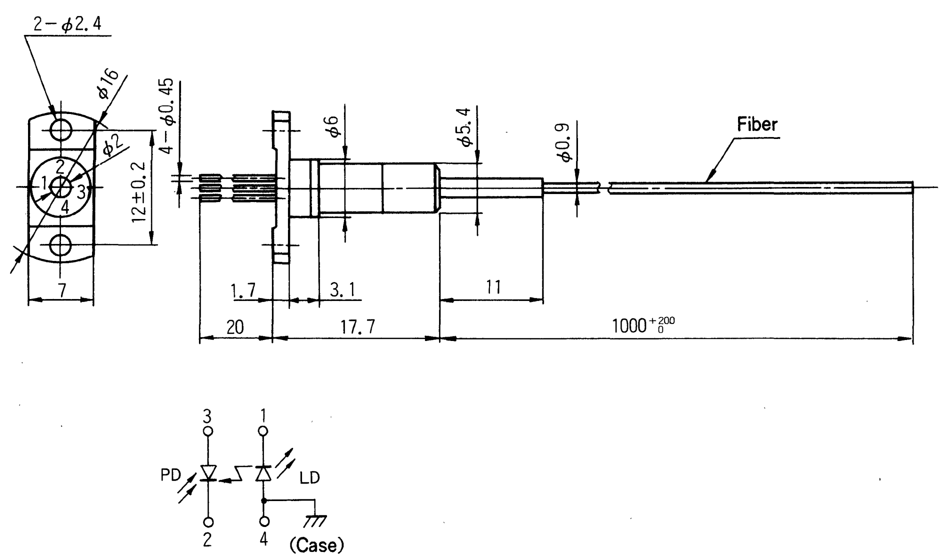
FEATURES

- High-speed response
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	3	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	0~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-411SLD

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral width (FWHM)	$\Delta\lambda$	CW, $I_F = I_{OP}$	–	3	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 3)	E_r	T_C = 0~65℃, APC	–	0.4	–	dB
Differential efficiency	η	–	–	0.13	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

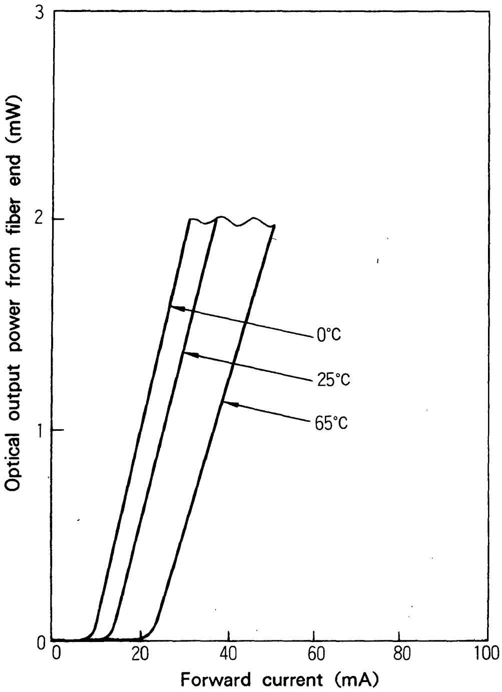
Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = \mathrm{MAX}\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

* Module up to 85℃ in operating case temperature (Tc) is also available.
Please consult with sales office about specification and so on, if necessary.

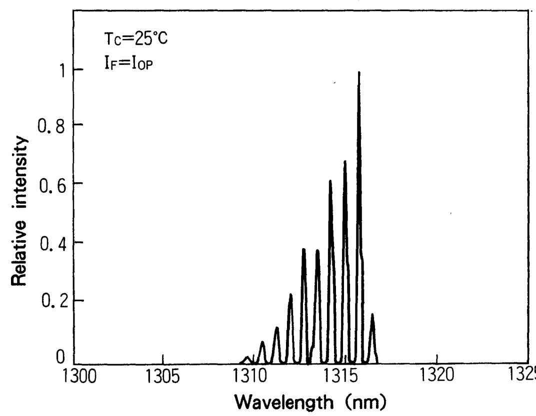
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

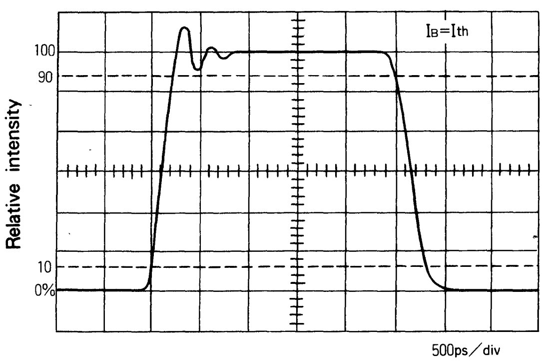
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



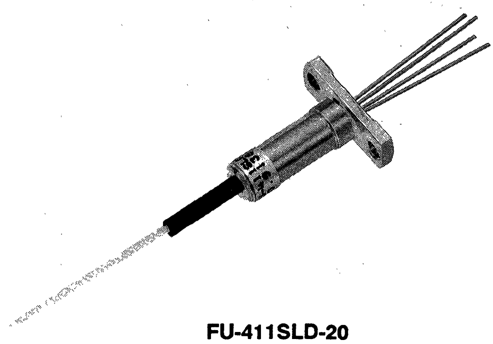
Pulse response

FU-411SLD-20

1.3μm LD Module with Singlemode Fiber Pigtail

Module type FU-411SLD-20 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP high power LD (Laser diode).

FU-411SLD-20 is suitable to light source for measuring instruments.(especially, OTDR)



FU-411SLD-20

FEATURES

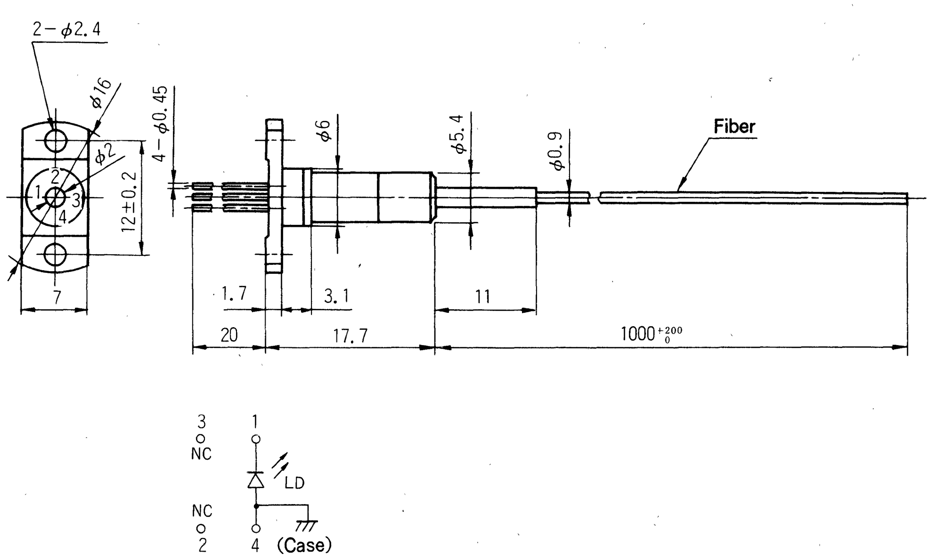
- High optical output power
- Emission wavelength is in 1.3μm band
- Laser diode are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Forward Current	I_{FL}	CW	150	mA
			Pulse (Note1)	700	
	Reverse Voltage	V_{RL}	–	2	V
Operating case temperature		Tc	–	0~60	℃
Storage temperature		T_{stg}	–	–40~70	℃

Note 1) Pulse condition : Pulse width ≦ 10μs, Duty ratio ≦ 5%

OUTLINE DRAWINGS Unit (mm)



FU-411SLD-20

CHARACTERISTICS (T_c=25°C, unless otherwise noted)

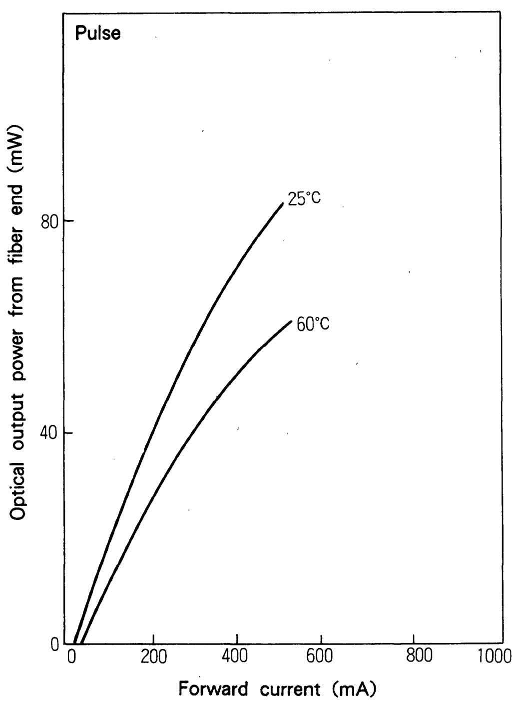
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	–	–	25	100	mA
Operating current	I_{op}	Pulse (Note 1)	–	500	650	mA
Operating voltage	V_{op}	$I_F = I_{op}$, Pulse (Note 1, 2)	–	1.8	3.5	V
Optical output power from fiber end	P_F	$I_F = I_{op}$, Pulse (Note 1, 2)	20	80	–	mW
Central wavelength	λc	$I_F = I_{op}$, Pulse (Note 1, 2)	1270	1300	1330	nm
Spectral width (FWHM)	$\Delta\lambda$	$I_F = I_{op}$, Pulse (Note 1, 2)	–	6	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	–	3	ns

Note 1) Pulse condition : Pulse width ≦ 10μs, Duty ratio ≦ 5%
Note 2) I_F : Forward current (LD)
Note 3) I_B : Bias current (LD)

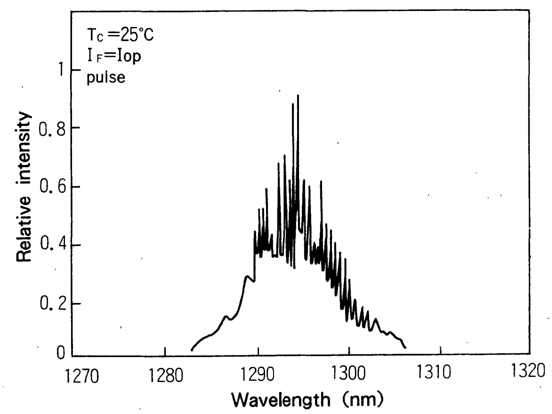
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current (Pulse) vs. Optical output power



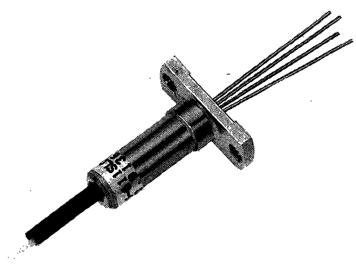
Light-emission spectrum

FU-611SLD

1.55 μm LD Module with Singlemode Fiber Pigtail

Module type FU-611SLD has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP LD (Laser diode).

FU-611SLD is suitable to light source for high-speed long haul digital optical communication systems and measuring instruments.



FU-611SLD

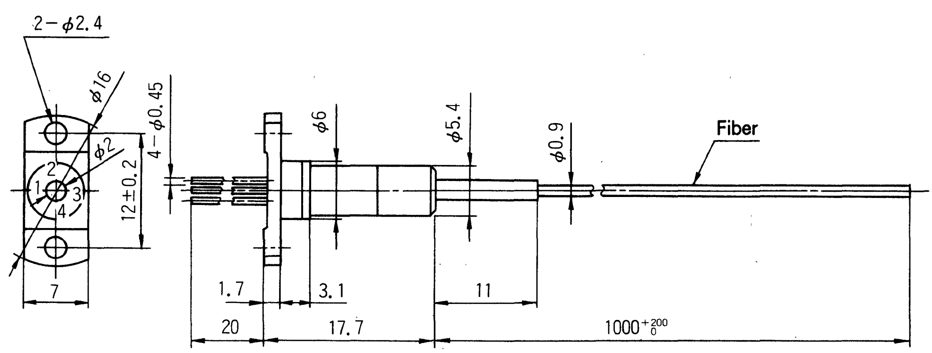
FEATURES

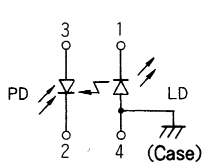
- High-speed response
- Emission wavelength is in 1.55μm band
- Low threshold current (14mA typ.)
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	2.4	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	0~65	℃
Storage temperature		T_{stg}	–	– 40~70	℃

OUTLINE DRAWINGS Unit (mm)





FU-611SLD

CHARACTERISTICS (T_c=25 °C, unless otherwise noted)

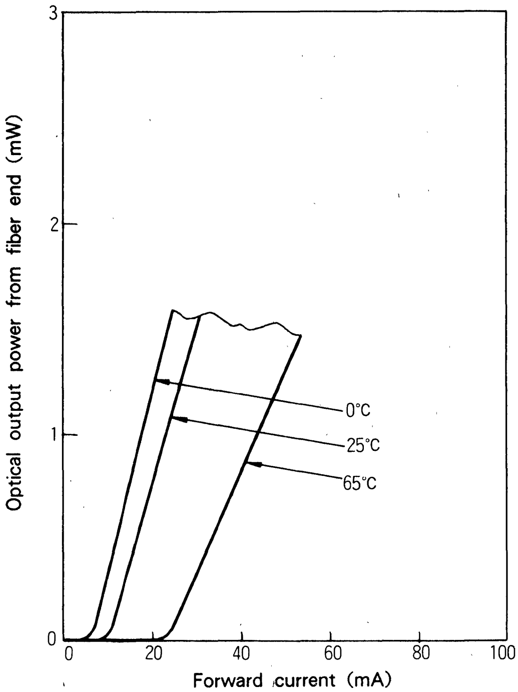
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	14	35	mA
Operating current	I_{op}	CW	–	40	60	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.7	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	1.5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1520	1550	1580	nm
Spectral width (FWHM)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	4	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 3)	E_r	T_c = 0~65℃, APC	–	0.4	–	dB
Differential efficiency	η	–	–	0.06	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = MAX\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

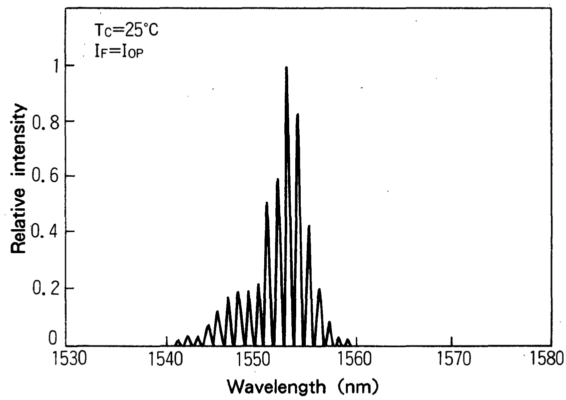
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

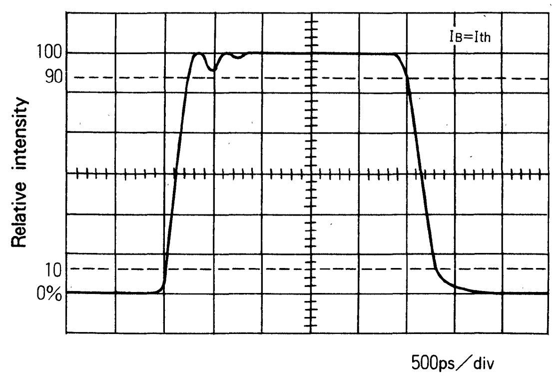
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



Pulse response

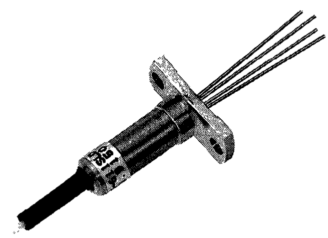
MITSUBISHI ELECTRIC

FU-611SLD-15

1.55 μ m LD Module with Singlemode Fiber Pigtail

Module type FU-611SLD-15 has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP high power LD (Laser diode).

FU-611SLD-15 is suitable to light source for measuring instruments.(especially, OTDR)



FU-611SLD-15

FEATURES

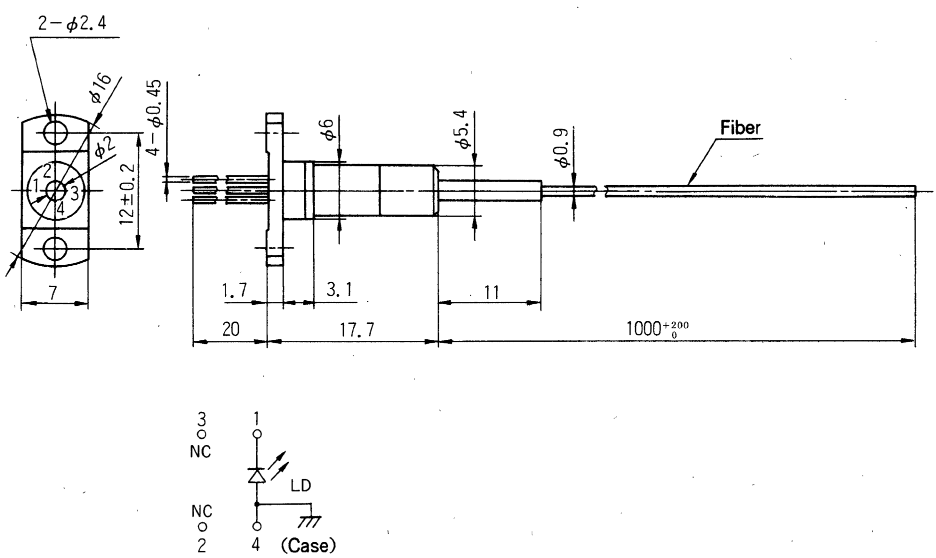
- High optical output power
- Emission wavelength is in 1.55μm band
- Laser diode are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Forward Current	I_{FL}	CW	150	mA
			Pulse (Note 1)	700	
	Reverse Voltage	V_{RL}	–	2	V
Operating case temperature		Tc	–	0~60	℃
Storage temperature		Tstg	–	−40~70	℃

Note 1) Pulse condition : Pulse width ≦ 10μs, Duty ratio ≦ 5%

OUTLINE DRAWINGS Unit (mm)



FU-611SLD-15

CHARACTERISTICS (T_c=25 °C, unless otherwise noted)

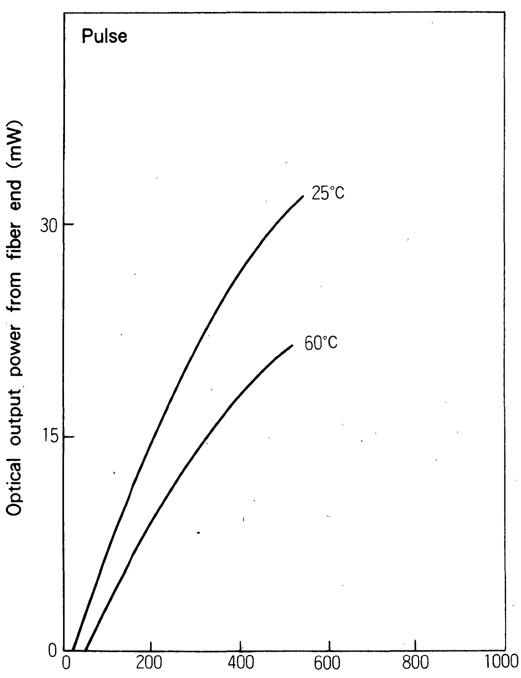
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	–	–	30	100	mA
Operating current	I_{op}	Pulse (Note 1)	–	500	650	mA
Operaitng voltage	V_{op}	$I_F = I_{op}$, Pulse (Note 1,2)	–	–	3.5	V
Optical output power from fiber end	P_F	$I_F = I_{op}$, Pulse (Note 1,2)	15	30	–	mW
Central wavelength	λc	$I_F = I_{op}$, Pulse (Note 1,2)	1520	1550	1580	nm
Spectral width (FWHM)	$\Delta\lambda$	$I_F = I_{op}$, Pulse (Note 1,2)	–	9	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	–	3	ns

Note 1) Pulse condition : Pulse width ≤ 10μs, Duty ratio ≤ 5%
Note 2) I_F : Forward current (LD)
Note 3) I_B : Bias current (LD)

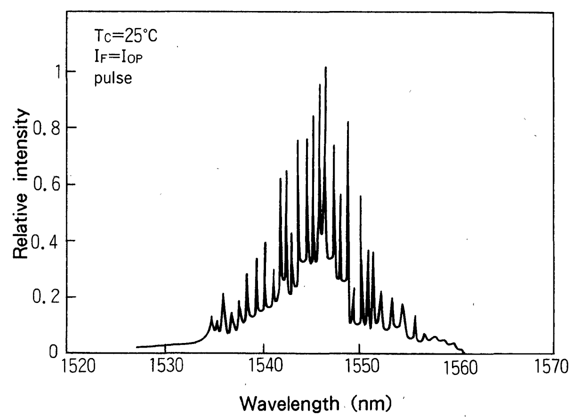
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum

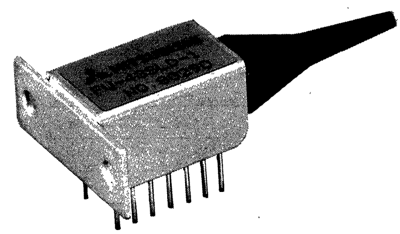
MITSUBISHI ELECTRIC

FU-43SLD-1

1.3μm LD Module with Singlemode Fiber Pigtail

Module type FU-43SLD-1 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for high-speed long haul digital optical communication systems and measuring instruments.



FU-43SLD-1

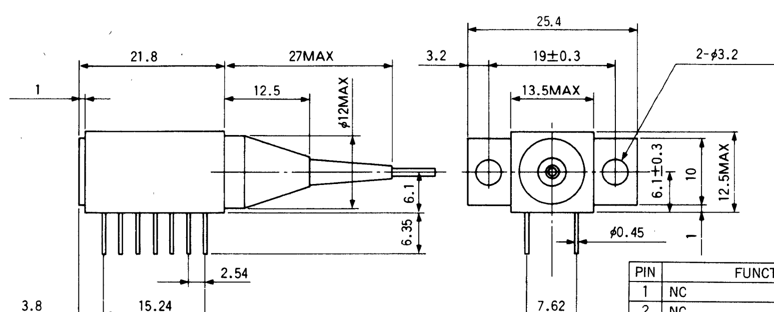
FEATURES

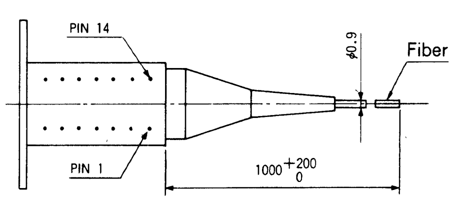
- High-speed response
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	3	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	0~65	℃
Storage temperature		Tstg	–	−40~70	℃

OUTLINE DRAWINGS Unit (mm)





PIN	FUNCTION
1	NC
2	NC
3	NC
4	NC
5	CASE GRAND, LASER ANODE
6	NC
7	DETECTOR CATHODE
8	DETECTOR ANODE
9	LASER CATHODE
10	CASE GRAND, LASER ANODE
11	NC
12	NC
13	NC
14	NC

FU-43SLD-1

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

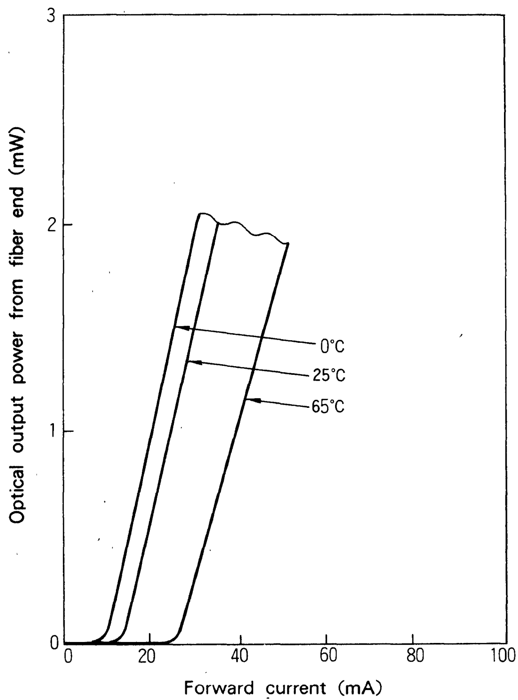
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral width (FWHM)	$\Delta \lambda$	CW, $I_F = I_{op}$	–	3	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 3)	E_r	Tc = 0~65℃, APC	–	0.4	–	dB
Differential efficiency	η	–	–	0.13	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = MAX\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

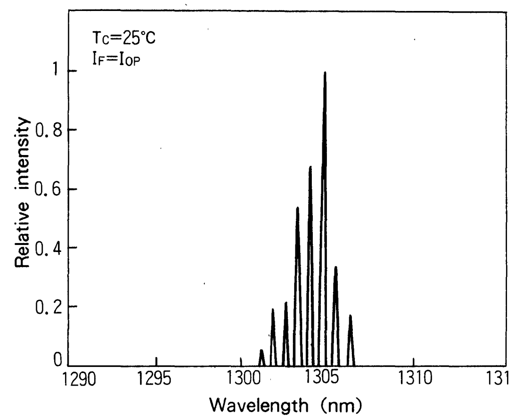
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

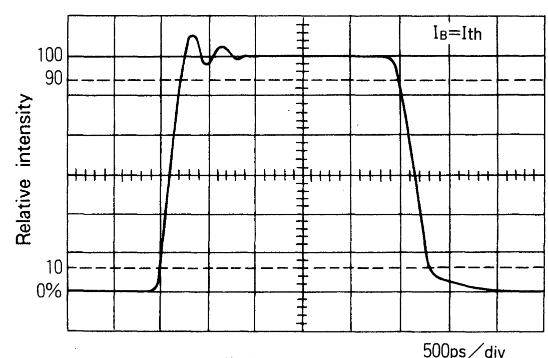
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



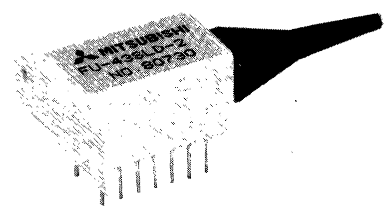
Pulse response

FU-43SLD-2

1.3 μm LD Module with Singlemode Fiber Pigtail

Module type FU-43SLD-2 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for short and medium haul digital local area network systems.



FU-43SLD-2

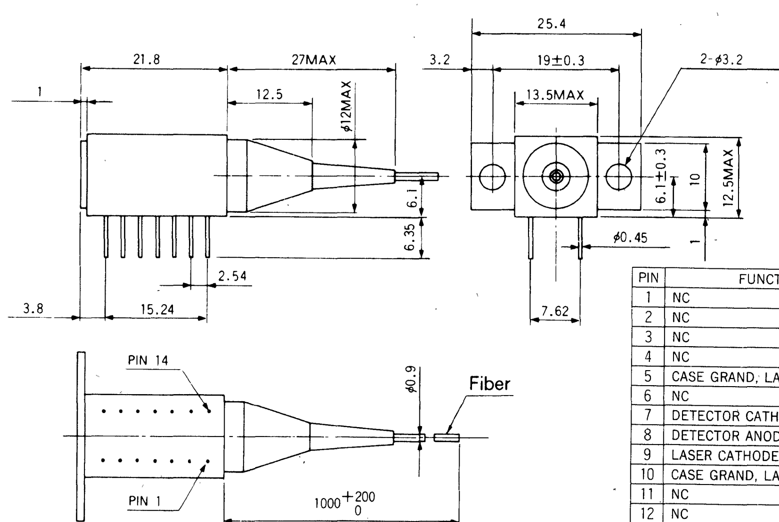
FEATURES

- High-speed response
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	0.3	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	0~65	℃
Storage temperature		Tstg	–	– 40~70	℃

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	NC
2	NC
3	NC
4	NC
5	CASE GRAND, LASER ANODE
6	NC
7	DETECTOR CATHODE
8	DETECTOR ANODE
9	LASER CATHODE
10	CASE GRAND, LASER ANODE
11	NC
12	NC
13	NC
14	NC

FU-43SLD-2

CHARACTERISTICS (T_c=25°C, unless otherwise noted)

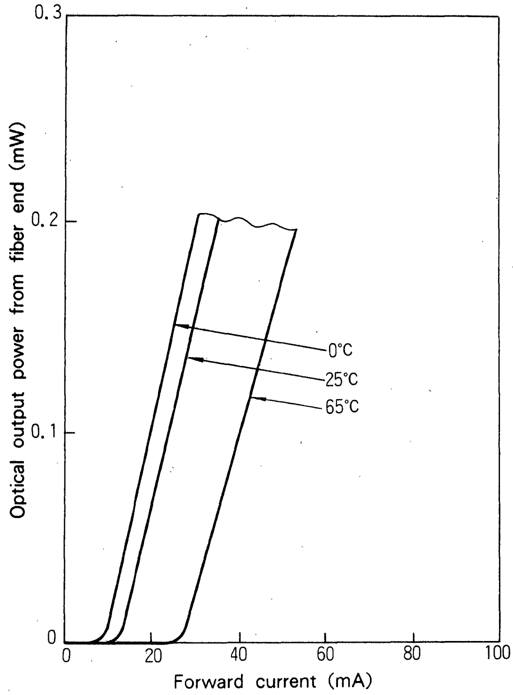
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	0.1	0.2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral width (FWHM)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	3	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 3)	E_r	T_c = 0~65°C, APC	–	0.4	–	dB
Differential efficiency	η	–	–	0.013	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = \text{MAX}\left|10 \cdot \log \frac{P_F}{P_F\ (25°C)}\right|$

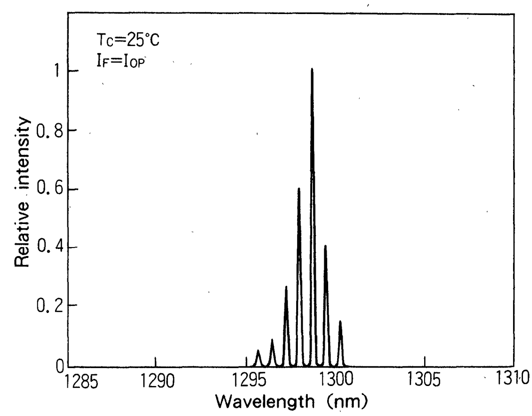
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

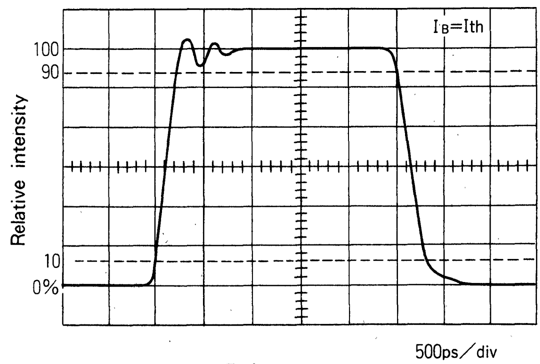
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



Pulse response

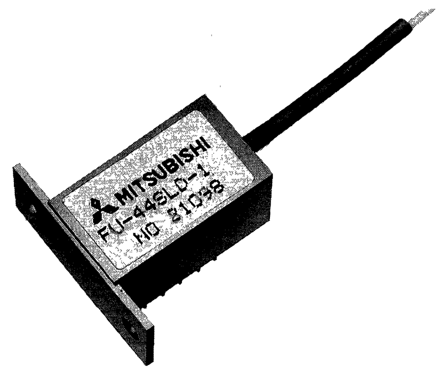
MITSUBISHI ELECTRIC

FU-44SLD-1

1.3 μm LD Module with Singlemode Fiber Pigtail

Module type FU-44SLD-1 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems and use in measuring instruments.



FU-44SLD-1

FEATURES

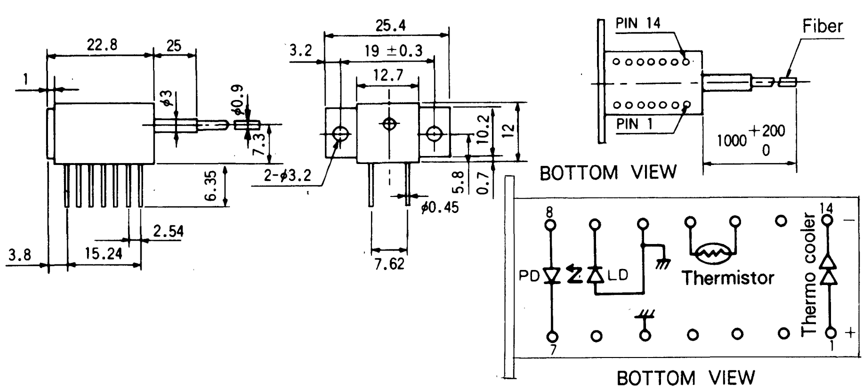
- High-speed response
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	3	mW
			Pulse (Note 1)	6	
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	–20~65	℃
Storage temperature		Tstg	–	–40~70	℃

Note 1) Pulse condition : Pulse width ≦ 1μs, Duty ratio ≦ 50%

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-44SLD-1

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral bandwidth (RMS) (Note 3)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	1.4	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90 % (Note 2)	–	0.3	–	ns
Tracking error (Note 4)	E_r	T_C = – 20~65 ℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.13	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)

Note 2) I_B : Bias current (LD)

Note 3) $\Delta\lambda = \sqrt{\frac{\Sigma ai\,(\lambda i - \lambda c)^2}{\Sigma ai}}$ $(ai \geqq ap \times 0.01)$

ai : Relative intensity of laser spectral emission modes
ap : Peak of laser spectral emission modes

Note 4) $E_r = \mathrm{MAX}\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

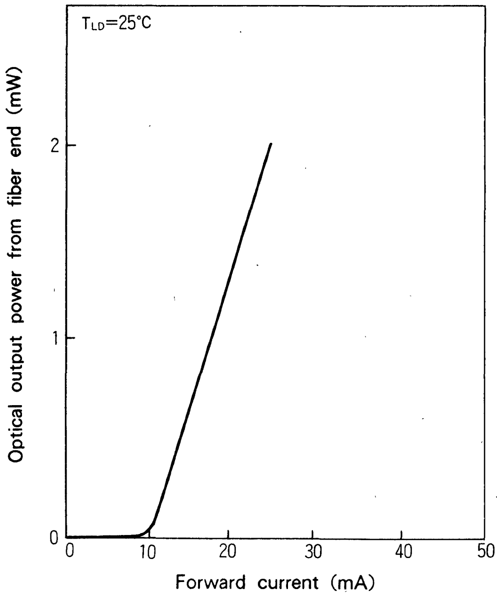
THERMAL CHARACTERISTICS (T_{LD}=25 °C T_C= – 20°C~65 °C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25 ℃	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65 ℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40 ℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40 ℃	–	1.6	2	V

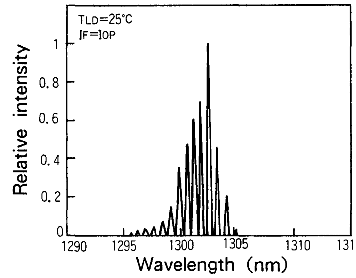
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

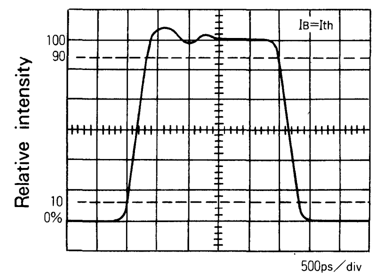
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



Pulse response

FU-44SLD-7

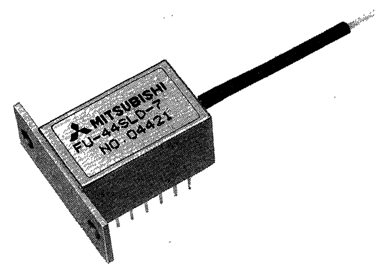
1.3μm LD Module with Singlemode Fiber Pigtail

Module type FU-44SLD-7 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems and use in measuring instruments.

FEATURES

- High-speed response
- High optical output
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed



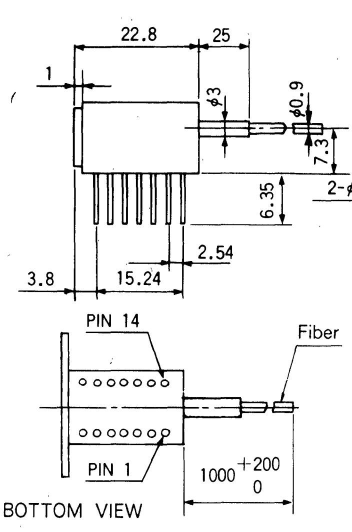
FU-44SLD-7

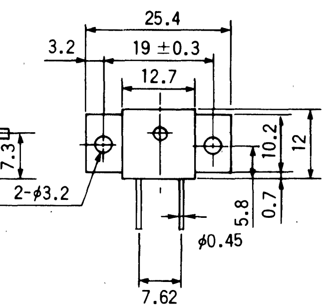
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	4.8	mW
			Pulse (Note 1)	11	
	Reverse Voltage	V_{RL}	–	2	V
	Forward Current	I_{FL}	Pulse (Note 1)	270	mA
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

Note 1) Pulse condition : Pulse width ≤ 4μs, Duty ratio ≤ 1%

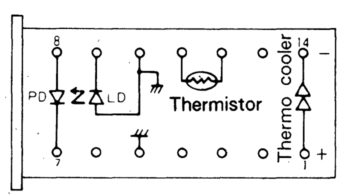
OUTLINE DRAWINGS Unit (mm)





PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-44SLD-7



MITSUBISHI ELECTRIC

CHARACTERISTICS (T_C=25 ℃, T_{LD}=25 ℃, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	45	90	mA
		Pulse (Note 1)	–	80	250	
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 2)	–	1.3	1.7	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2	3.6	–	mW
		Pulse (Note 1)	10	–	–	
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90 % (Note 3)	–	0.3	–	ns
Tracking error (Note 4)	E_r	T_C = – 20~65 ℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.11	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	1.2	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) Pulse condition : Pulse width ≦ 4μs, Duty ratio ≦ 1 %
Note 2) I_F : Forward current (LD)
Note 3) I_B : Bias current (LD)
Note 4) $E_r = \mathrm{MAX}\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

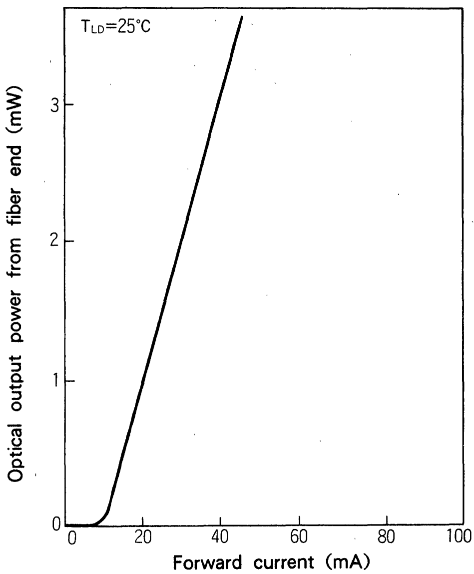
THERMAL CHARACTERISTICS (T_{LD}=25 °C, T_C= – 20°C~65°C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.6	2	V

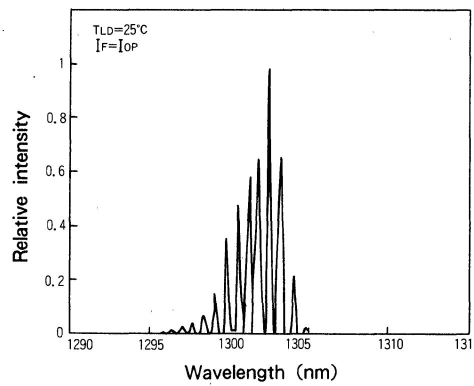
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



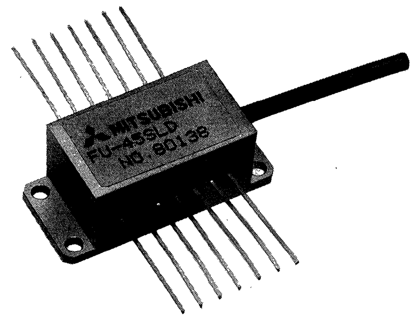
Light-emission spectrum

FU-45SLD

1.3μm LD Module with Singlemode Fiber Pigtail

Module type FU-45SLD has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode). The package is incorporated with butterfly pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems.



FU-45SLD

FEATURES

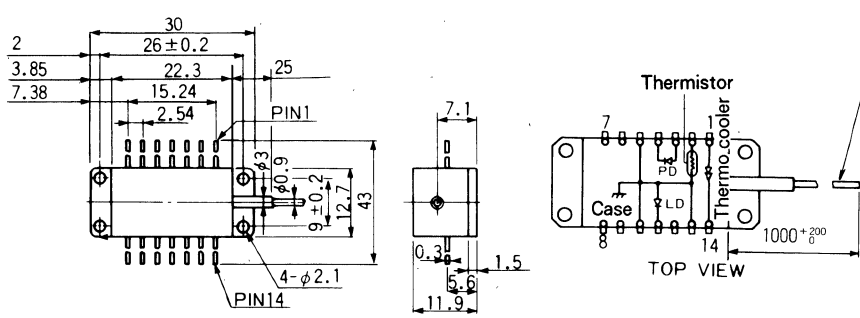
- High-speed response
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Built-in thermal electric cooler
- Butterfly package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25 ℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	3	mW
			Pulse (Note 1)	6	
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	– 20~65	℃
Storage temperature		Tstg	–	– 40~70	℃

Note 1) Pulse condition : Pulse width ≤ 1μs, Duty ratio ≤ 50 %

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	THERMISTOR, GND
6	NC
7	NC
8	NC
9	NC
10	LD ANODE, GND
11	LD CATHODE
12	NC
13	GND
14	COOLER CATHODE

FU-45SLD

CHARACTERISTICS (T_C=25 ℃, T_{LD}=25 ℃, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral bandwidth (RMS) (Note 3)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	1.4	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 4)	E_r	$T_C = -20$~65 ℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.13	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $\Delta\lambda = \sqrt{\dfrac{\Sigma ai\,(\lambda i - \lambda c)^2}{\Sigma ai}}$ ($ai \geqq a_P \times 0.01$)
ai : Relative intensity of laser spectral emission modes
a_P : Peak of laser spectral emission modes
Note 4) $E_r = \mathrm{MAX}\left|10 \cdot \log \dfrac{P_F}{P_F\ (25℃)}\right|$

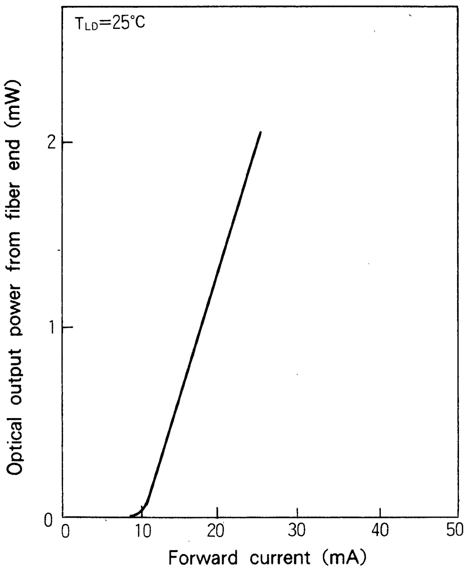
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, T_C= − 20°C~65°C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.6	2	V

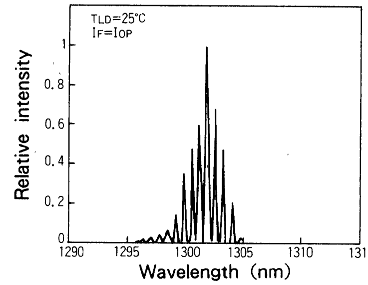
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

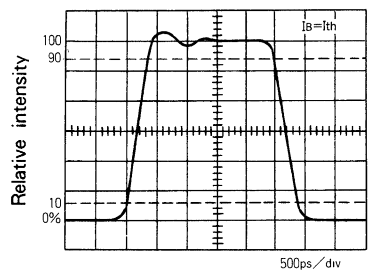
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



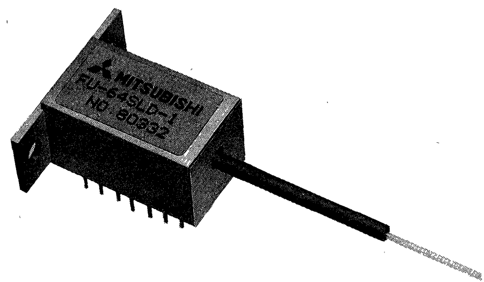
Pulse response

FU-64SLD-1

1.55μm LD Module with Singlemode Fiber Pigtail

Module type FU-64SLD-1 has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems and use in measuring instruments.



FU-64SLD-1

FEATURES

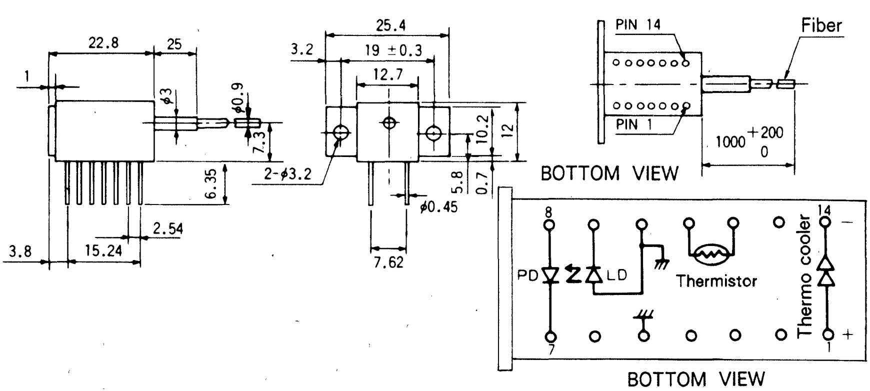
- High-speed response
- Emission wavelength is in 1.55μm band
- Low threshold current (14mA typ.)
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	2.4	mW
			Pulse (Note 1)	4.8	
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	– 20∼65	℃
Storage temperature		Tstg	–	– 40∼70	℃

Note 1) Pulse condition : Pulse width ≦ 1μs, Duty ratio ≦ 50 %

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-64SLD-1

MITSUBISHI ELECTRIC

1.55 μm LD Module with Singlemode Fiber Pigtail

CHARACTERISTICS (T_C=25°C, T_{LD}=25°C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	14	35	mA
Operating current	I_{op}	CW	–	40	60	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.7	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	1.5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1520	1550	1580	nm
Spectral bandwidth (RMS) (Note 3)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	2.2	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 4)	E_r	$T_C = -20$~65℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.06	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, $V_{RD} = 5V$	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	$V_{RD} = 5V$	–	0.1	1	μA
Capacitance (Photodiode)	C_t	$V_{RD} = 5V$, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $\Delta\lambda = \sqrt{\dfrac{\Sigma ai\ (\lambda i - \lambda c)^2}{\Sigma ai}}$ (ai ≧ a_P × 0.01)
ai : Relative intensity of laser spectral emission modes
a_P : Peak of laser spectral emission modes
Note 4) $E_r = MAX \left| 10 \cdot \log \dfrac{P_F}{P_F\ (25℃)} \right|$

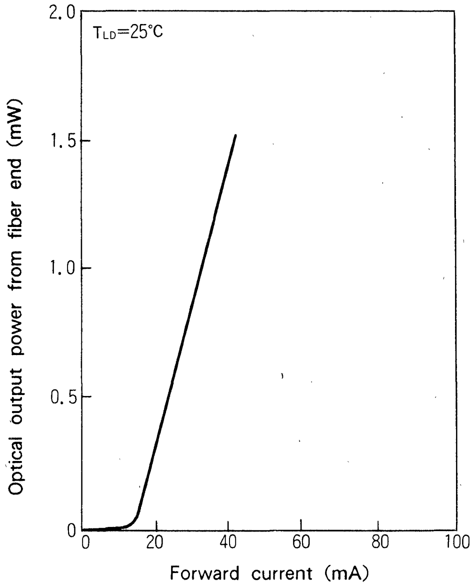
THERMAL CHARACTERISTICS (T_{LD}=25°C, T_C= – 20°C~65°C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	$T_{LD} = 25℃$	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	$T_C = 65℃$	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.6	2	V

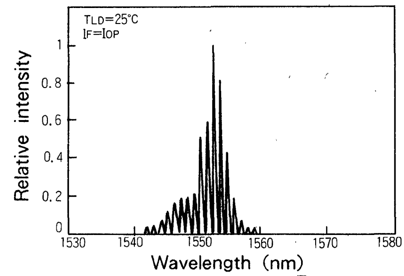
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

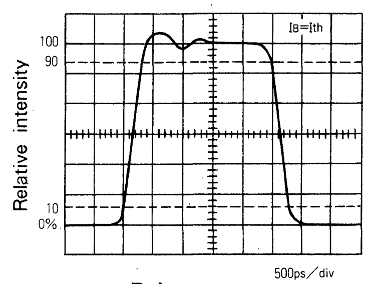
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



Pulse response

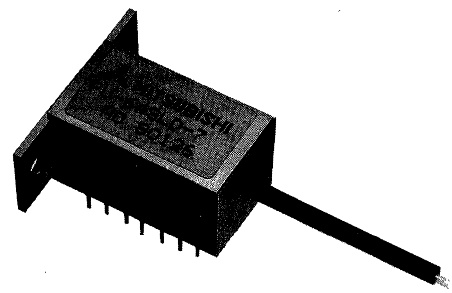
MITSUBISHI ELECTRIC

FU-64SLD-7

1.55 μm LD Module with Singlemode Fiber Pigtail

Module type FU-64SLD-7 has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems and use in measuring instruments.



FU-64SLD-7

FEATURES

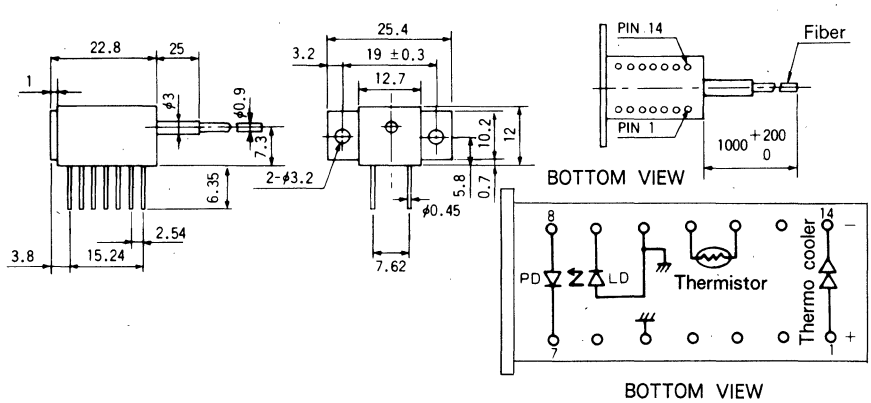
- High-speed response
- High optical output
- Emission wavelength is in 1.55μm band
- Low threshold current (15mA typ.)
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiodes for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25 ℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	6	mW
			Pulse (Note 1)	15	
	Reverse Voltage	V_{RL}	–	2	V
	Forward Current	I_{FL}	Pulse (Note 1)	400	mA
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

Note 1) Pulse condition : Pulse width ≦ 4μs, Duty ratio ≦ 1%

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-64SLD-7

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	15	35	mA
Operating current	I_{op}	CW	–	55	90	mA
		Pulse (Note 1)	–	–	380	
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 2)	–	1.2	1.7	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2	3.6	–	mW
		Pulse (Note 1)	10	–	–	
Central wavelength	λc	CW, $I_F = I_{op}$	1520	1550	1580	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90 % (Note 3)	–	0.3	–	ns
Tracking error (Note 4)	E_r	T_C = – 20~65 ℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.1	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.4	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) Pulse condition : Pulse width ≦ 4μs, Duty ratio ≦ 1 %
Note 2) I_F : Forward current (LD)
Note 3) I_B : Bias current (LD)
Note 4) $E_r = \mathrm{MAX} \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

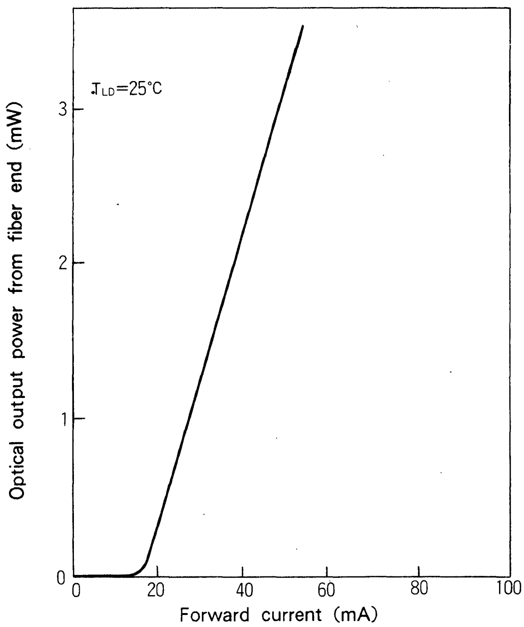
THERMAL CHARACTERISTICS (T_{LD}=25 °C, T_C= – 20°C~65°C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25 ℃	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65 ℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40 ℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40 ℃	–	1.6	2	V

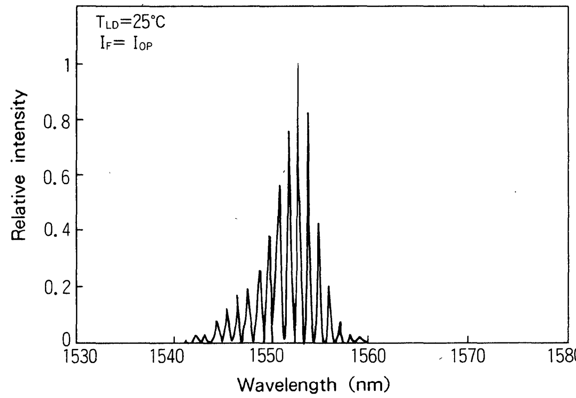
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



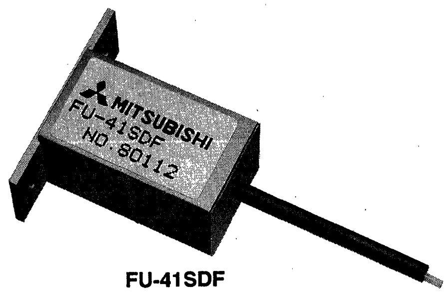
Light-emission spectrum

FU-41SDF, FU-44SDF

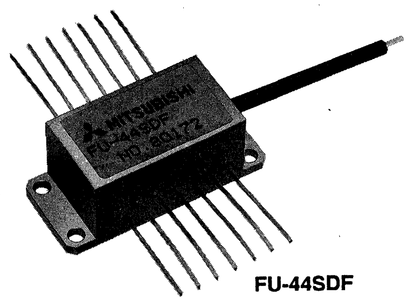
1.3 μ m DFB-LD Module with Singlemode Fiber Pigtail

Module type FU-41SDF and FU-44SDF have been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP DFB LD (Laser diode).

They are suitable to light source for use in long haul and high capacity optical fiber communication systems.



FU-41SDF



FU-44SDF

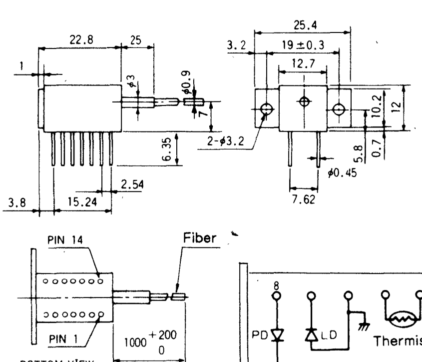
FEATURES

- Distributed Feedback (DFB) Laser diode
- High-speed response
- Emission wavelength is in 1.3 μm band
- Built-in thermal electric cooler
- Dual-in-line package (FU-41SDF)
- Butterfly package (FU-44SDF)
- With photodiodes for optical output monitor
- Diodes are hermetically sealed

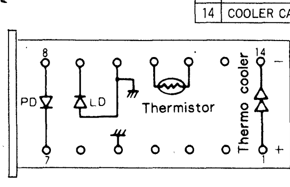
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings		Units
				FU-41SDF	FU-44SDF	
Laser diode	Optical output power from fiber end	P_F	CW	2.5	2.5	mW
	Reverse Voltage	V_{RL}	–	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	20	V
	Forward Current	I_{FD}	–	2	2	mA
Operating case temperature		T_C	–	−20~65	−20~65	℃
Storage temperature		T_{stg}	–	−40~70	−40~70	℃

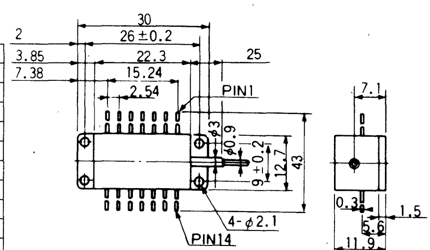
OUTLINE DRAWINGS Unit (mm)

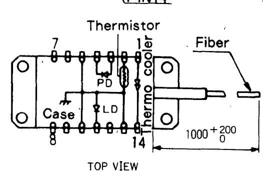


PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE



FU-41SDF





PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	THERMISTOR, GND
6	NC
7	NC
8	NC
9	NC
10	LD ANODE, GND
11	LD CATHODE
12	NC
13	GND
14	COOLER CATHODE

FU-44SDF

1.3 μ m DFB-LD Module with Singlemode Fiber Pigtail

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	FU-41SDF			FU-44SDF			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	15	40	–	15	40	mA
Operating current	I_{op}	CW	–	31	80	–	31	80	mA
Operaitng voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	1.5	–	1	1.5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1290	1310	1330	1290	1310	1330	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	30	35	–	dB
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90 % (Note 2)	–	0.3	–	–	0.3	–	ns
Tracking error (Note 3)	E_r	T_C = – 20~65 ℃, APC, ATC	–	0.2	–	–	0.2	–	dB
Differential efficiency	η	–	–	0.09	–	–	0.09	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = \mathrm{MAX} \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

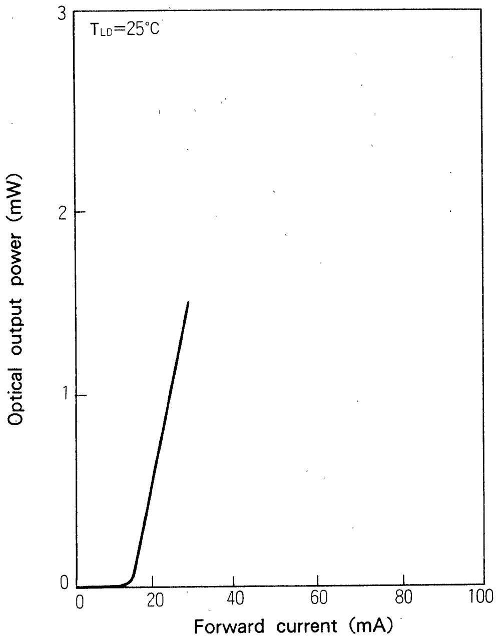
THERMAL CHARACTERISTICS (T_{LD}=25 °C, T_C= – 20 °C~+65 °C)

Items	Symbols	Conditions	FU-41SDF			FU-44SDF			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Thermistor resistance	R_{th}	T_{LD} = 25 ℃	9.5	10	10.5	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65 ℃	40	–	–	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40 ℃	–	0.6	1	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40 ℃	–	1.5	2	–	1.5	2	V

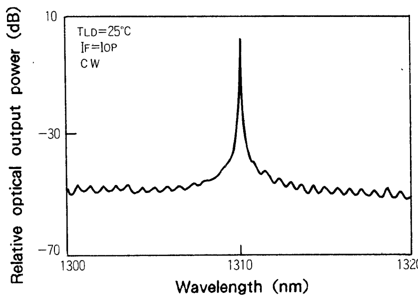
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Modefield dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

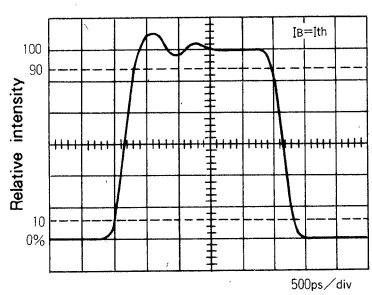
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



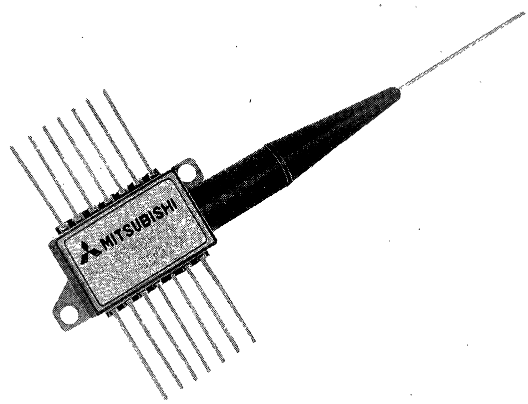
Pulse response (FU-41SDF)

MITSUBISHI ELECTRIC

FU-45SDF-38
(CATV Application)

1.3μm DFB-LD Module with Singlemode Fiber Pigtail

Module type FU-45SDF-38 has been developed for coupling a single-mode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser diode).
The module is suitable to light source for use in multi-channel long haul AM CATV systems.



FU-45SDF-38

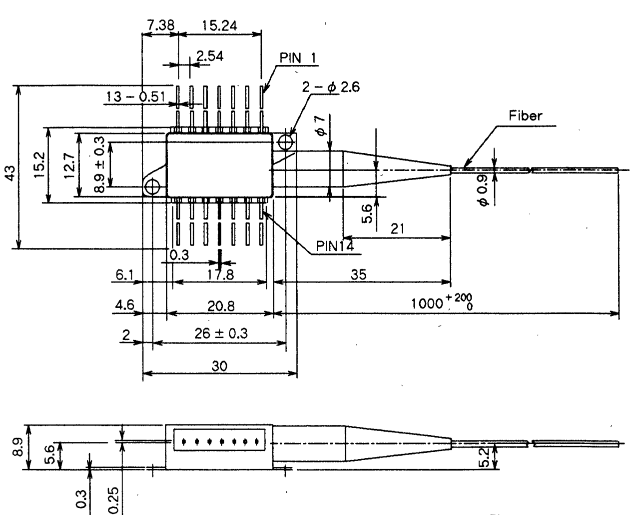
FEATURES

- Distributed Feedback (DFB) Laser diode
- Excellent linearity
- High-speed response
- Emission wavelength is in 1.3μm band
- Built-in optical isolator
- Built-in thermal electric cooler
- Butterfly package
- With photodiodes for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

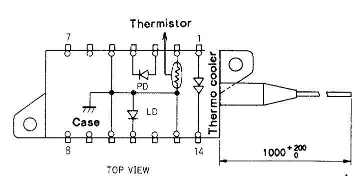
Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	15	mW
	Forward Current	I_F	CW	150	mA
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-45SDF-38

PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	GND
6	NC
7	NC
8	NC
9	NC
10	GND
11	LD CATHODE
12	NC
13	LD ANODE, GND
14	COOLER CATHODE



CHARACTERISTICS (T_C=25 ℃, T_{LD}=25 ℃, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	15	40	mA
Operating current	I_{op}	CW	–	50	100	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	4	6	–	mW
Light-Emission central wavelength	λc	CW, $I_F = I_{op}$	1290	1310	1330	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	dB
Cutoff frequency (– 1.5dB)	f_c	$I_F = I_{op}$	2	–	–	GHz
Composite second order	 CSO2 CSOL41 CSOH41 CSO78	79 channel test (Note 2) CSO2 ; f = 54MHz CSOL41 ; f = 324MHz CSOH41 ; f = 326.5MHz CSO78 ; f = 548.5MHz	 – – – –	(Note 3) – 57 – 57 – 64 – 55	 – 50 – 50 – 55 – 50	dBc
Composite triple beat	 CTB2 CTB41 CTB78	 CTB2 ; f = 55.25MHz CTB41 ; f = 325.25MHz CTB78 ; f = 547.25MHz	–	(Note 3) – 63 – 60 – 61	 – 53 – 50 – 51	dBc
Relative intensity noise (Note 4)	Nr2 Nr78	CW, I_F = Iop Nr2 ; f = 55.25MHz Nr78 ; f = 547.25MHz	–	– 160 – 157	– 155 – 152	dB/Hz dB/Hz
Tracking error (Note 5)	E_r	TC = – 20~65 ℃, APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.08	0.17	0.35	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	–	–	mA
Dark current (PD)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (PD)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : LD forward current

Note 2) 79 channel test : Distortion performances are tested under 79 channel loading.

Channel frequency ; 55.25~547.25MHz (6MHz spacing)

Optical modulation depth ; m = 0.035/ch

If (average) = Iop

Rmodule > 40dB

Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

where P_{FR} : Reflected optical power to LD module

Note 3) Typical values are no more than the reference values. Please contact Mitsubishi Electric for any specific requirements.

Note 4) Relative intensity noise does not include shot noise of receiver.

Note 5) $E_r = \text{MAX}\left|10 \cdot \log \frac{P_F}{P_F\ (25℃)}\right|$

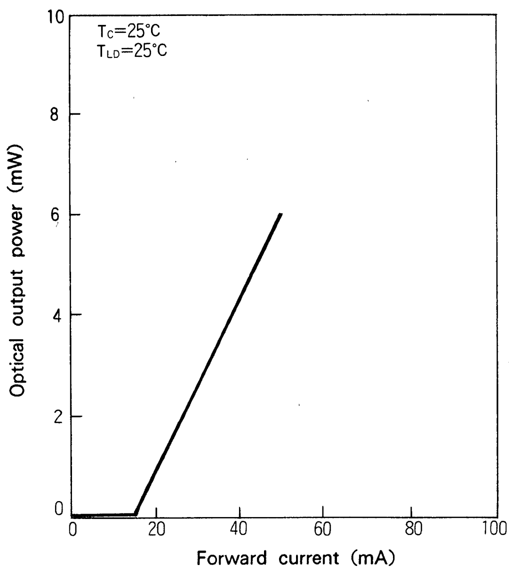
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, T_C= – 20~65 ℃)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25 ℃	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3950	–	K
Cooling capacity	ΔT	Tc = 65 ℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40 ℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40 ℃	–	1.2	2	V

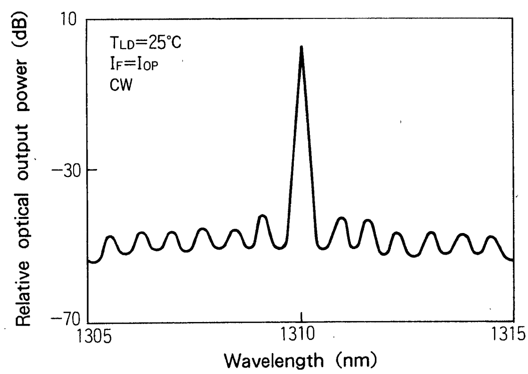
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

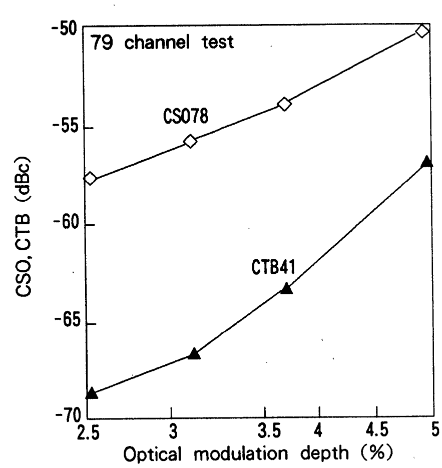
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



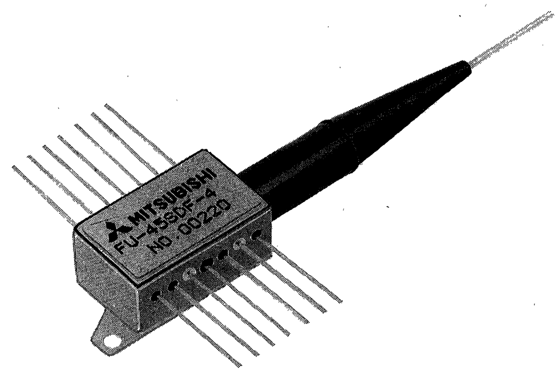
Distortion vs. optical modulation depth

FU-45SDF-4
(Digital Application)

1.3μm DFB-LD Module with Singlemode Fiber Pigtail

Module type FU-45SDF-4 has been developed for coupling a singlemode optical fiber and a 1.3μm wavelength InGaAsP DFB-LD.

The module is suitable to light source for use in high capacity long haul digital optical communication systems.



FU-45SDF-4

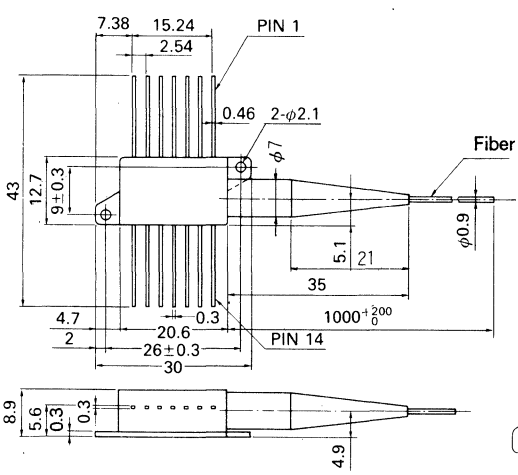
FEATURES

- Distributed Feedback (DFB) Laser diode
- High-speed response
- Emission wavelength is in 1.3μm band
- Built-in optical isolator
- Built-in thermal electric cooler
- Butterfly package
- With photodiodes for optical output monitor
- Diodes and T.E cooler are hermetically sealed

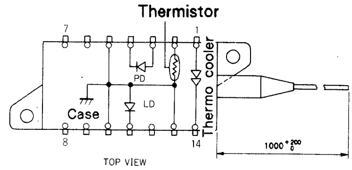
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	4	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	GND
6	NC
7	NC
8	NC
9	NC
10	GND
11	LD CATHODE
12	NC
13	LD ANODE, GND
14	COOLER CATHODE



FU-45SDF-4

MITSUBISHI ELECTRIC

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	15	40	mA
Operating current	I_{op}	CW	–	46	80	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Light-emission central wavelength	λc	CW, $I_F = I_{op}$	1290	1310	1330	nm
Spectral width (– 20dB full width)	$\Delta\lambda$	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	0.7	–	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	dB
Cutoff frequency (– 1.5dB)	f_c	$I_F = I_{op}$	3	–	–	GHz
Rise and Fall time (10~90%)	t_r, t_f	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	–	200	ps
Relative intensity noise	N_r	CW, $I_F = I_{op}$	–	– 155	– 145	dB/Hz
Tracking error (Note 3)	E_r	Tc = – 20~65℃, APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.02	0.06	0.2	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	–	–	mA
Dark current (PD)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (PD)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : LD forward current

Note 2) Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

Where P_{FR} : Reflected optical power to LD module.

Note 3) $E_r = \max \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

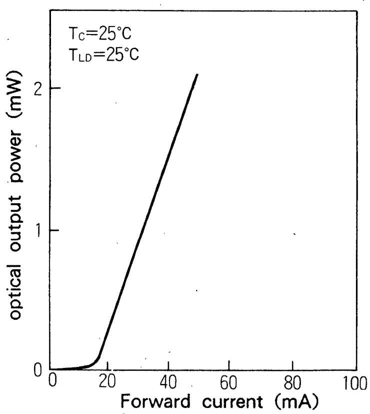
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, Tc= – 20~65 ℃)

Parameters	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3950	–	K
Cooling Capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler Current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler Voltage	V_{pe}	ΔT = 40℃	–	1.2	2	V

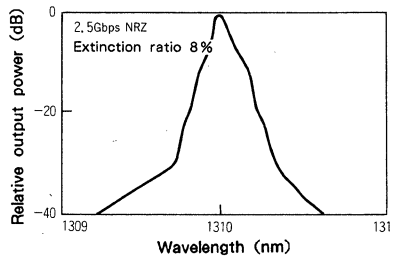
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

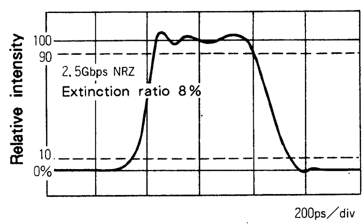
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



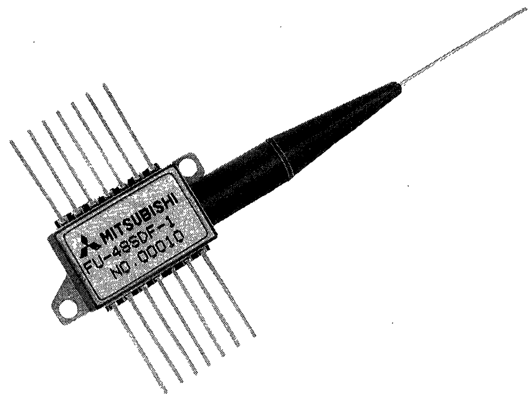
Light-emission spectrum



Pulse response characteristics

FU-48SDF-1
(for 2.5Gbps Digital Application)
DFB-LD Module with Single-mode Fiber Pigtail

Module type FU-48SDF-1 is a 1.31μm DFB-LD module with single-mode optical fiber. This product is based on FU-45SDF-4 and has improvement on high speed modulation characteristics by separating LD bias pin from RF input pin. It also has a RF termination circuit to match to characteristic impedance of LD drive signal.



FU-48SDF-1

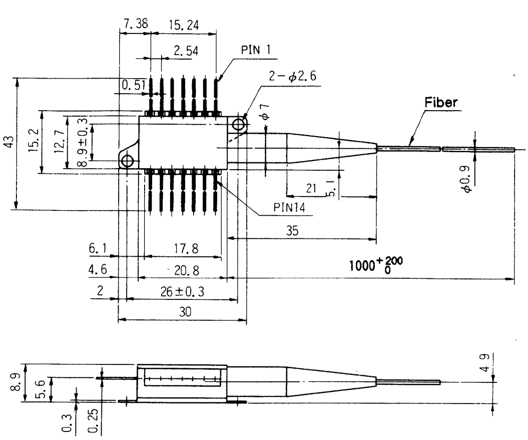
MAIN FEATURES

- Input impedance is 25 Ω
- Distributed Feedback (DFB) Laser diode module
- Single-mode optical fiber pig-tail
- Emission wavelength is in 1.31μm band
- Butterfly package
- Built-in thermal electric cooler
- Built-in optical isolator
- High-speed response

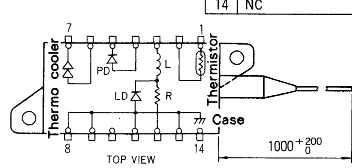
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	4	mW
	Forward current	I_F	CW	150	mA
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	−20~65	℃
Storage temperature		T_{stg}	–	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	THERMISTOR
2	THERMISTOR
3	LD BIAS(−)
4	PD ANODE
5	PD CATHODE
6	COOLER ANODE
7	COOLER CATHODE
8	GND
9	GND
10	NC
11	LD ANODE,GND
12	LD RF
13	LD ANODE,GND
14	NC



FU-48SDF-1

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	15	40	mA
Operating current	I_{op}	CW	–	46	80	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Input impedance	Z_{in}	$I_F = I_{OP}$	–	25	–	Ω
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2	3.5	–	mW
Light-emission central wavelength	λc	CW, $I_F = I_{op}$	1290	1310	1330	nm
Spectral width (– 20dB full width)	$\Delta\lambda$	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	0.4	–	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	33	40	–	dB
Cutoff frequency (– 1.5dB)	f_c	$I_F = I_{op}$	3.5	–	–	GHz
Rise and Fall time (10~90%)	t_r, t_f	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	–	150	ps
Relative intensity noise	N_r	CW, $I_F = I_{op}$	–	– 155	– 145	dB/Hz
Tracking error (Note 3)	E_r	Tc = – 20~65℃, APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.05	0.11	0.25	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	–	–	mA
Dark current (PD)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (PD)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : LD forward current
Note 2) Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

Where P_{FR} : Reflected optical power to LD module.

Note 3) $E_r = \max \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

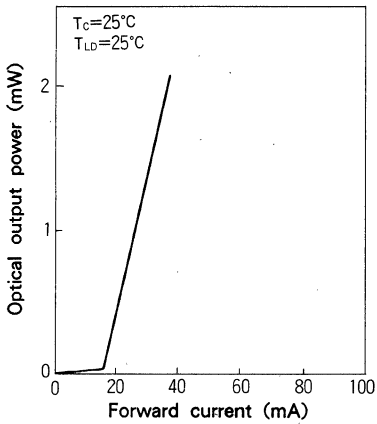
THERMAL CHARACTERISTICS (T_{LD}=25° C, T_C= – 20~65° C)

Parameters	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3950	–	K
Cooling Capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler Current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler Voltage	V_{pe}	ΔT = 40℃	–	1.2	2	V

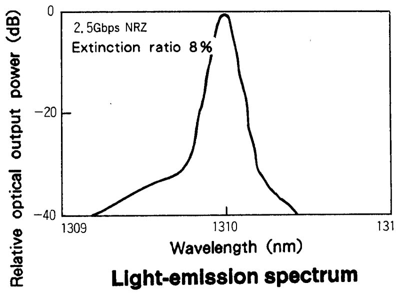
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

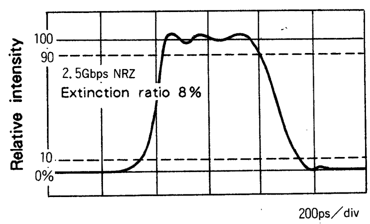
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



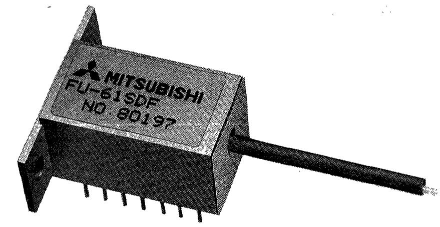
Pulse response characteristics

FU-61SDF,FU-64SDF

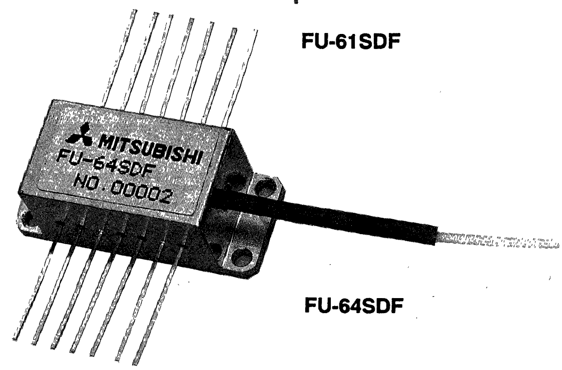
1.55μm DFB-LD Module with Singlemode Fiber Pigtail

Module type FU-61SDF and FU-64SDF have been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP DFB LD (Laser diode).

They are suitable to light source for use in long haul and high capacity optical fiber communication systems.



FU-61SDF



FU-64SDF

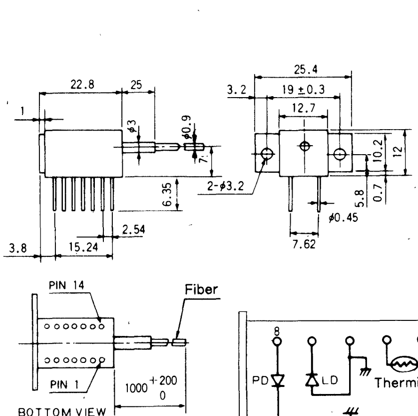
FEATURES

- Distributed Feedback (DFB) Laser diode
- High-speed response
- Emission wavelength is in 1.55μm band
- Built-in thermal electric cooler
- Dual-in-line package (FU-61SDF)
- Butterfly package (FU-64SDF)
- With photodiodes for optical output monitor
- Diodes are hermetically sealed

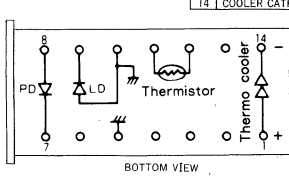
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings		Units
				FU-61SDF	FU-64SDF	
Laser diode	Optical output power from fiber end	P_F	CW	2.5	2.5	mW
	Reverse Voltage	V_{RL}	–	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	20	V
	Forward Current	I_{FD}	–	2	2	mA
Operating case temperature		T_C	–	–20~65	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	–40~70	℃

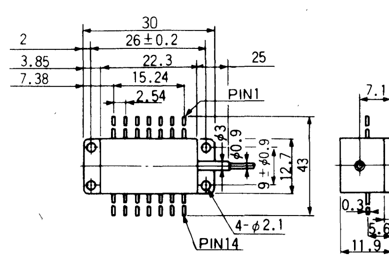
OUTLINE DRAWINGS Unit (mm)

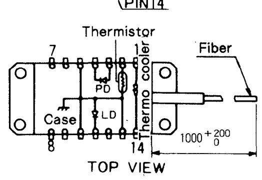


PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE



FU-61SDF





PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	THERMISTOR, GND
6	NC
7	NC
8	NC
9	NC
10	LD ANODE, GND
11	LD CATHODE
12	NC
13	GND
14	COOLER CATHODE

FU-64SDF

MITSUBISHI ELECTRIC

CHARACTERISTICS (T_C=25°C, T_{LD}=25°C, unless otherwise noted)

Items	Symbols	Conditions	FU-61SDF			FU-64SDF			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	23	40	–	23	40	mA
Operating current	I_{op}	CW	–	43	90	–	43	90	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	1.5	–	1	1.5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1530	1550	1570	1530	1550	1570	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	30	35	–	dB
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	–	0.3	–	ns
Tracking error (Note 3)	E_r	T_C = –20~65℃, APC, ATC	–	0.2	–	–	0.2	–	dB
Differential efficiency	η	–	–	0.08	–	–	0.08	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.5	–	0.1	0.5	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = MAX \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

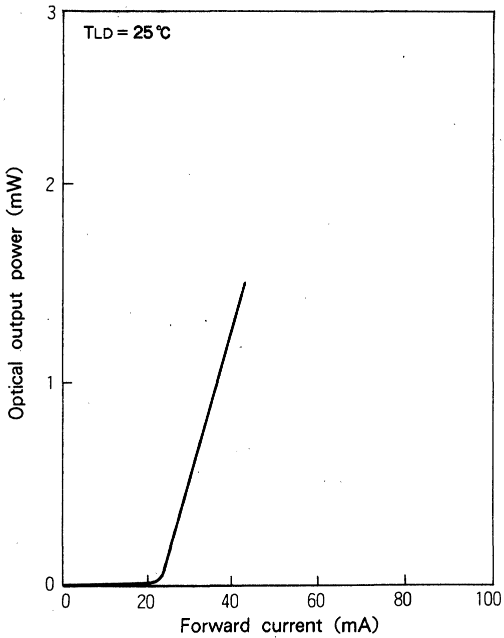
THERMAL CHARACTERISTICS (T_{LD}=25°C, T_C= – 20°C~+65°C)

Items	Symbols	Conditions	FU – 61SDF			FU – 64SDF			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	9.5	10	10.5	kΩ
B constant of thermistor resistance	B	–	–	3250	–	–	3250	–	K
Cooling capacity	ΔT	T_C = 65℃	40	–	–	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.5	2	–	1.5	2	V

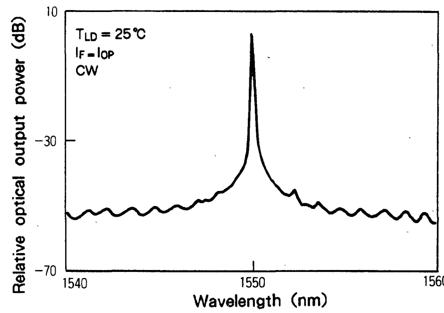
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

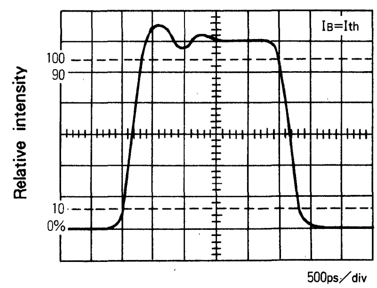
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



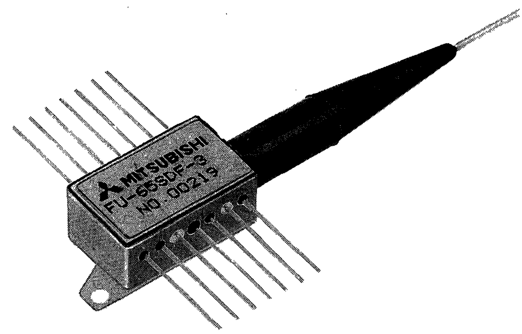
Pulse response
(FU-61SDF)

FU-65SDF-3
(Analog Application)

1.55 μm DFB-LD Module with Singlemode Fiber Pigtail

Module type FU-65SDF-3 has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP LD (Laser diode).

The module is suitable to light source for use in high capacity long haul analog optical communication systems.



FU-65SDF-3

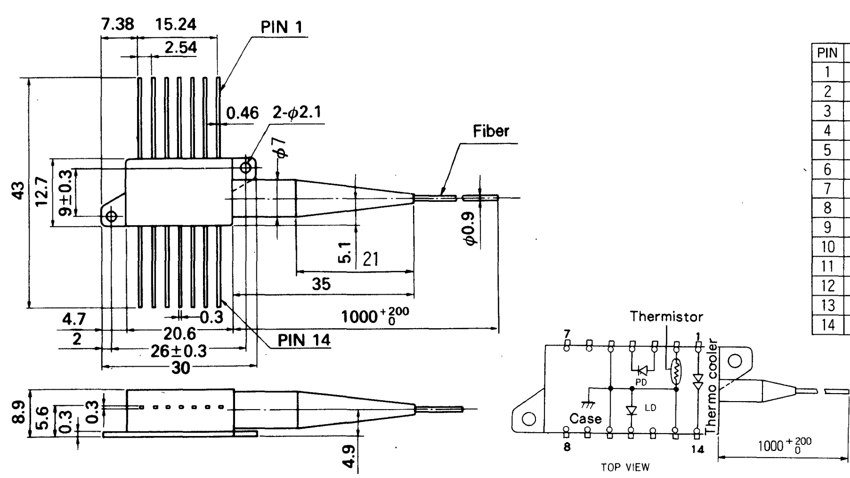
FEATURES

- Distributed Feedback (DFB) Laser diode
- High-speed response
- Emission wavelength is in 1.55μm band
- Built-in optical isolator
- Built-in thermal electric cooler
- Butterfly package
- With photodiodes for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	10	mW
	Forward Current	I_F	CW	150	mA
	Reverse Voltage	V_{RL}	−	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	−	20	V
	Forward Current	I_{FD}	−	2	mA
Operating case temperature		Tc	−	−20~65	℃
Storage temperature		T_{stg}	−	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	GND
6	NC
7	NC
8	NC
9	NC
10	GND
11	LD CATHODE
12	NC
13	LD ANODE, GND
14	COOLER CATHODE

FU-65SDF-3

MITSUBISHI ELECTRIC

CHARACTERISTICS (T_c=25°C, T_{LD}=25°C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	12	40	mA
Operating current	I_{op}	CW	–	55	90	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2	4	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1530	1550	1570	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	dB
Cutoff frequency (– 1.5dB)	f_c	$I_F = I_{op}$	2	–	–	GHz
2nd order distortion	D_2	2 tone test (Note 2) f_1 = 244MHz f_2 = 250MHz m = 0.35 (each) I_F (average) = I_{op} Rmodule > 40dB	–	– 40	– 30	dBc
3rd order distortion	D_3		–	– 60	– 45	dBc
Relative intensity noise	N_r		–	– 155	– 150	dB/Hz
Tracking error (Note 3)	E_r	Tc = – 20~65℃ APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.04	0.1	0.2	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	–	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) f_1, f_2 : Modulation frequency
m : Optical modulation depth/Carrier
Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

where P_{FR} : Reflected optical power to LD module

Note 3) $E_r = \text{MAX} \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

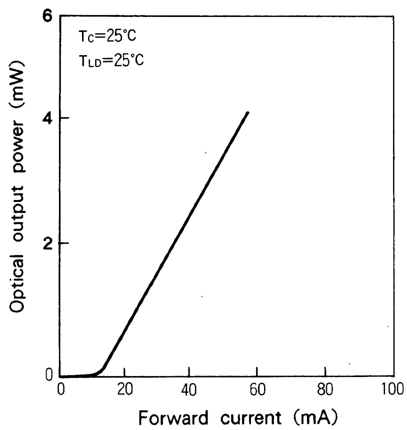
THERMAL CHARACTERISTICS (T_{LD}=25°C, T_c= – 20~65°C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3950	–	K
Cooling Capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler Current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler Voltage	V_{pe}	ΔT = 40℃	–	1.2	2	V

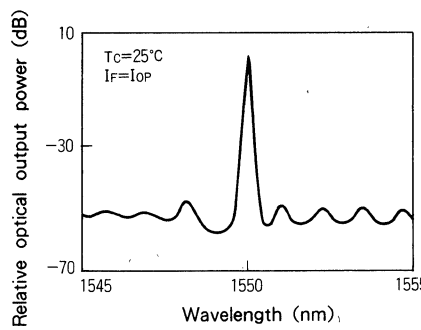
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



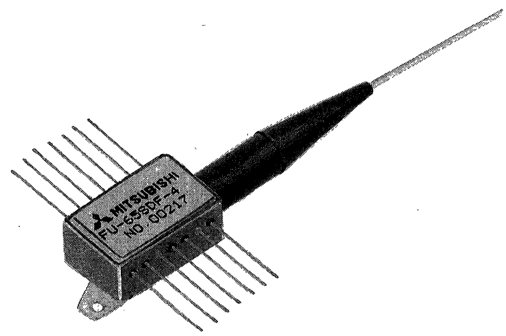
Light-emission spectrum

FU-65SDF-4

1.55 μm DFB-LD Module with Singlemode Fiber Pigtail(Digital Application)

Module type FU-65SDF-4 has been developed for coupling a singlemode optical fiber and a 1.55μm wavelength InGaAsP DFB-LD.

The module is suitable to light source for use in high capacity long haul digital optical communication systems.



FU-65SDF-4

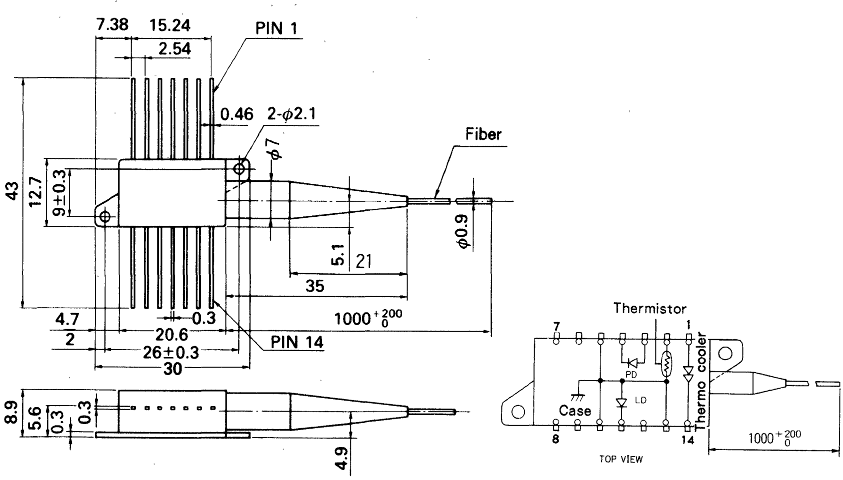
FEATURES

- Distributed Feedback (DFB) Laser diode
- High-speed response
- Emission wavelength is in 1.55μm band
- Built-in optical isolator
- Built-in thermal electric cooler
- Butterfly package
- With photodiodes for optical output monitor
- Diodes and T.E.cooler are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	4	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	20	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		Tc	–	–20~65	℃
Storage temperature		Tstg	–	–40~70	℃

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	THERMISTOR
3	PD ANODE
4	PD CATHODE
5	GND
6	NC
7	NC
8	NC
9	NC
10	GND
11	LD CATHODE
12	NC
13	LD ANODE, GND
14	COOLER CATHODE

FU-65SDF-4

1.55 μ m DFB-LD Module with Singlemode Fiber Pigtail(Digital Application)

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	12	40	mA
Operating current	I_{op}	CW	–	55	90	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1	2	–	mW
Light-emission central wavelength	λc	CW, $I_F = I_{op}$	1530	1550	1570	nm
Spectral width (–20dB full width)	$\Delta\lambda$	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	0.7	–	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	30	35	–	dB
Cutoff frequency (–1.5dB)	f_c	$I_F = I_{op}$	3	–	–	GHz
Rise and Fall time (10~90%)	t_r, t_f	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	–	200	ps
Relative intensity noise	N_r	CW, $I_F = I_{op}$	–	–155	–145	dB/Hz
Tracking error (Note 3)	E_r	Tc = –20~65 ℃, APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.02	0.05	0.2	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	–	–	mA
Dark current (PD)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (PD)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : LD forward current

Note 2) Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

Where P_{FR} : Reflected optical power to LD module.

Note 3) $E_r = \max \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

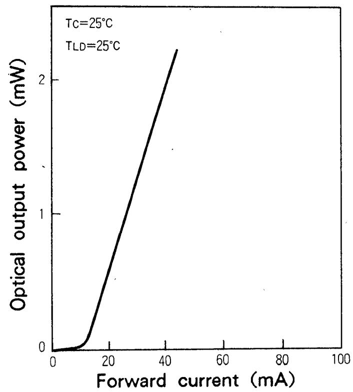
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, Tc= –20~65 ℃)

Parameters	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3950	–	K
Cooling Capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler Current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler Voltage	V_{pe}	ΔT = 40℃	–	1.2	2	V

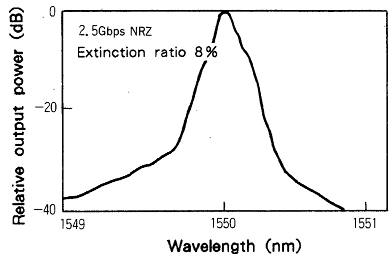
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

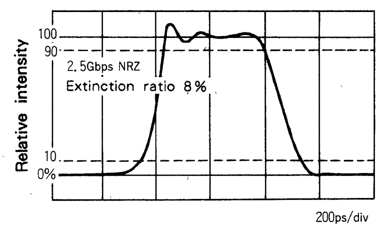
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



Pulse response characteristics

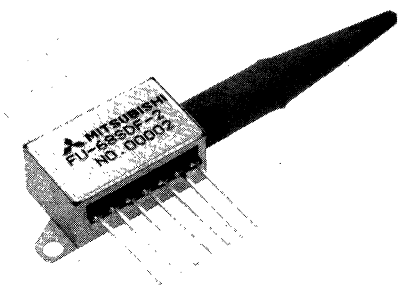
MITSUBISHI ELECTRIC

PRELIMINARY

FU-68SDF-2 (for 2.5Gbps Digital Application)

DFB-LD Module with Single-mode Fiber Pigtail

Module type FU-68SDF-2 is a 1.55μm DFB-LD module with single-mode optical fiber. This product is based on FU-65SDF-4 and has improvement on high speed modulation characteristics by separating LD bias pin from RF input pin. It also has a RF termination circuit to match to characteristic impedance of LD drive signal.



FU-68SDF-2

MAIN FEATURES

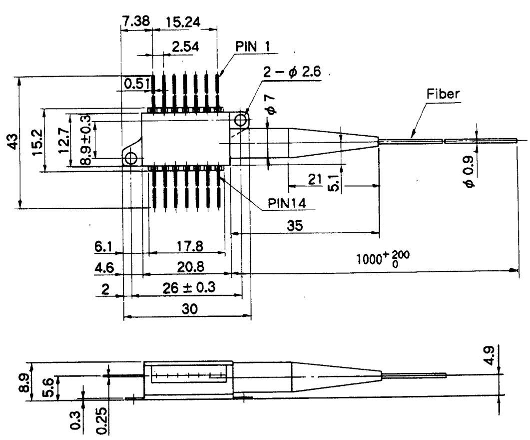
- Input impedance is 25 Ω
- Multi quantum wells(MQW) DFB Laser diode module
- Single-mode optical fiber pig-tail
- Emission wavelength is in 1.55μm band
- Butterfly package
- Built-in thermal electric cooler
- Built-in optical isolator
- High-speed response

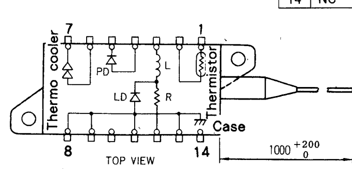
ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	4	mW
	Forward current	I_F	CW	150	mA
	Reverse Voltage	V_{RL}	−	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	−	20	V
	Forward Current	I_{FD}	−	2	mA
Operating case temperature		T_C	−	−20~65	℃
Storage temperature		T_{stg}	−	−40~70	℃

OUTLINE DRAWINGS Unit (mm)

PIN	FUNCTION
1	THERMISTOR
2	THERMISTOR
3	LD BIAS(−)
4	PD ANODE
5	PD CATHODE
6	COOLER ANODE
7	COOLER CATHODE
8	GND
9	GND
10	NC
11	LD ANODE,GND
12	LD RF
13	LD ANODE,GND
14	NC





FU-68SDF-2

CHARACTERISTICS (T_C=25 °C, T_{LD}=25 °C, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	12	40	mA
Operating current	I_{op}	CW	–	55	90	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.3	1.8	V
Input impedance	Z_{in}	$I_F = I_{op}$	–	25	–	Ω
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2	3.5	–	mW
Light-emission central wavelength	λc	CW, $I_F = I_{op}$	1530	1550	1570	nm
Spectral width (−20dB full width)	$\Delta\lambda$	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	0.2	–	nm
Side mode suppression ratio	S_r	CW, $I_F = I_{op}$	33	40	–	dB
Cutoff frequency (−1.5dB)	f_c	$I_F = I_{op}$	3.5	–	–	GHz
Rise and Fall time (10~90%)	t_r, t_f	2.5G bps NRZ Mark ratio 50% I_F peak = I_{op} Extinction ratio 8% Rmodule > 40dB (Note 2)	–	–	150	ps
Relative intensity noise	N_r	CW, $I_F = I_{op}$	–	−155	−145	dB/Hz
Tracking error (Note 3)	E_r	Tc = −20~65℃, APC, ATC	–	0.3	–	dB
Differential efficiency	η	–	0.02	0.05	0.2	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	–	–	mA
Dark current (PD)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (PD)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : LD forward current

Note 2) Rmodule : Optical return loss from fiber to LD module

$$\text{Rmodule} = -10 \cdot \log \frac{P_{FR}}{P_F}$$

Where P_{FR} : Reflected optical power to LD module.

Note 3) $E_r = \max \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

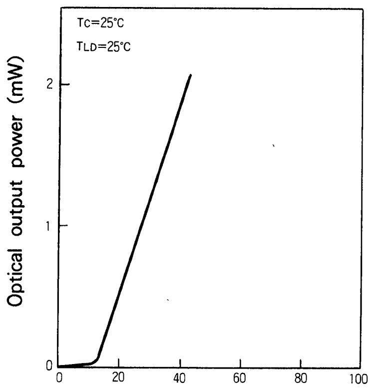
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, T_C= −20~65 ℃)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3950	–	K
Cooling Capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler Current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler Voltage	V_{pe}	ΔT = 40℃	–	1.2	2	V

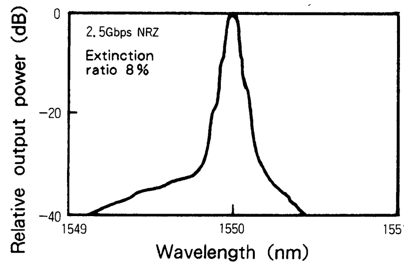
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	SM	–
Mode-field dia.	10 ± 1	μm
Cladding dia.	125 ± 2	μm
Jacket dia.	0.9	mm

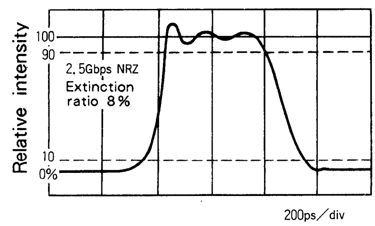
EXAMPLE OF CHARACTERISTICS



Forward current vs. optical output power



Light-emission spectrum



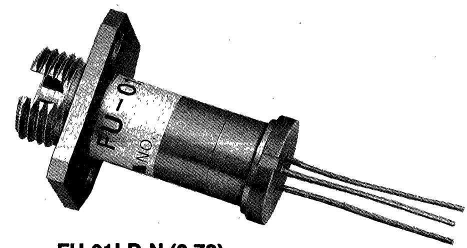
Pulse response characteristics

This product is under development, and indicated specifications in this sheet may be changeable without any notification. Could you please inquire of sales office about the latest specification, before it is purchased.

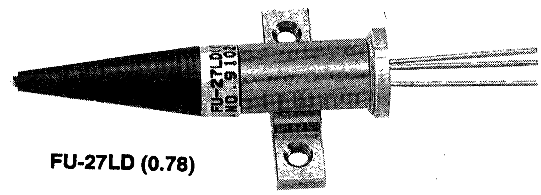
FU-01LD-N (0.78),FU-27LD(0.78)

0.78 μm LD Module for Multimode Fiber

LD Module types FU-01LD-N (0.78) and FU-27LD (0.78) contain AlGaAs LDs (Laser diodes) for 0.78μm band and are used as light source for intermediate and high speed local area network systems.



FU-01LD-N (0.78)



FU-27LD (0.78)

FEATURES

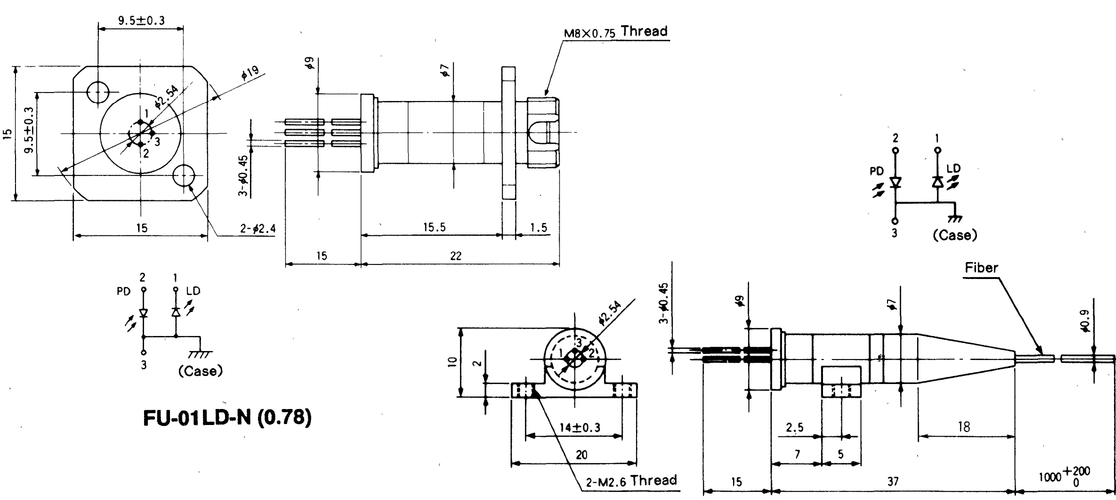
- High-speed response
- Emission wavelength is in 0.78μm wavelength band
- Connectorized package for FC connector (FU-01LD-N (0.78))
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings		Units
				FU-01LD-N(0.78)	FU-27LD(0.78)	
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	3	3	mW
	Reverse Voltage	V_{RL}	–	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	15	V
	Forward Current	I_{FD}	–	10	10	mA
Operating case temperature		T_C	–	– 20~60	– 20~60	℃
Storage temperature		T_{stg}	–	– 40~70	– 40~70	℃

Note 1) Fiber : GI type with core dia. 50μm and N.A.0.2

OUTLINE DRAWINGS Unit (mm)



FU-01LD-N (0.78)

FU-27LD (0.78)

CHARACTERISTICS (T_c=25°C, unless otherwise noted)

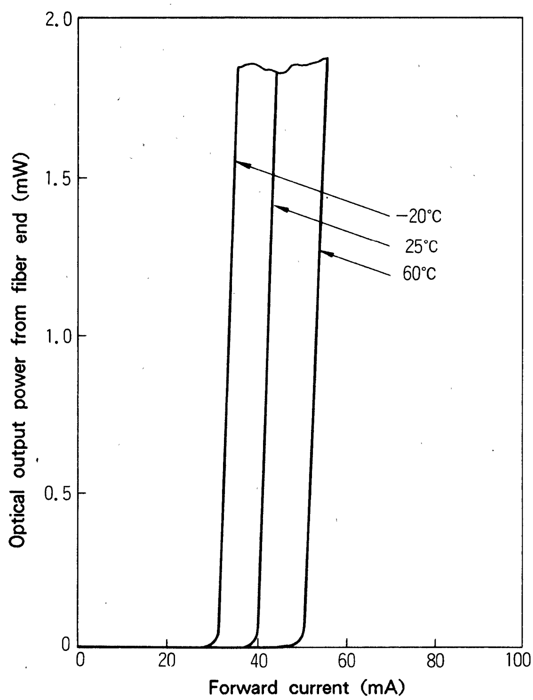
Items	Symbols	Conditions	FU-01LD-N (0.78)			FU-27LD (0.78)			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	40	60	–	40	60	mA
Operating current	I_{op}	CW	–	50	70	–	50	70	mA
Operaitng voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.5	2.5	–	1.8	2.5	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	1	1.8	–	1	1.8	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	765	785	795	765	780	795	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	0.4	–	–	0.4	–	ns
Tracking error (Note 4)	E_r	T_C = –20~60℃, APC	–	0.2	–	–	0.2	–	dB
Differential efficiency (Note 2)	η	–	–	0.18	–	–	0.18	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.15	0.4	–	0.15	0.4	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	–	0.5	–	–	0.5	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	7	–	–	7	–	pF
Optical connector type (Note 5)	–	–		FC			–		–

Note 1) I_F : Forward current (LD)
Note 2) Fiber : GI type with core dia. 50μm and N.A.0.2
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX\left|10 \cdot \log \frac{P_F}{P_F\ (25℃)}\right|$
Note 5) FU-01LD-N (0.78) only

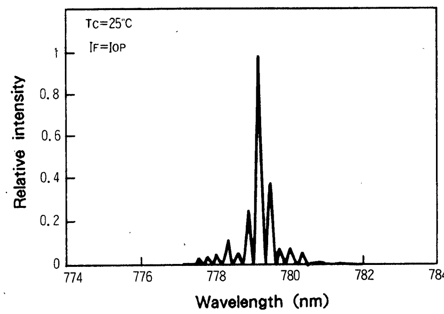
FIBER PIGTAIL SPECIFICATIONS (FU-27LD (0.78) only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

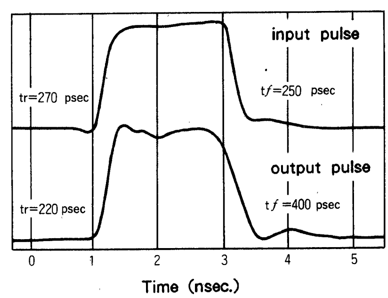
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



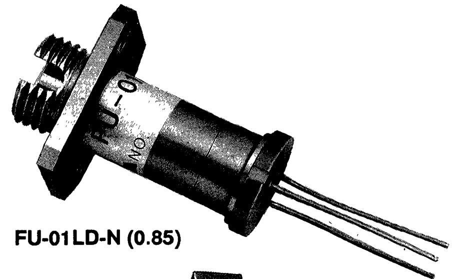
Pulse response

MITSUBISHI ELECTRIC

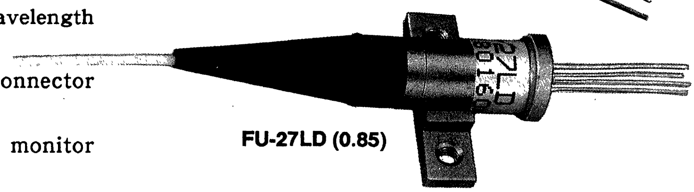
FU-01LD-N (0.85), FU-27LD (0.85)

0.85 μ m LD Module for Multimode Fiber

LD Module types FU-01LD-N (0.85) and FU-27LD (0.85) contain AlGaAs LDs (Laser diodes) for 0.85μm band and are used as light source for intermediate and high speed local area network systems.



FU-01LD-N (0.85)



FU-27LD (0.85)

FEATURES

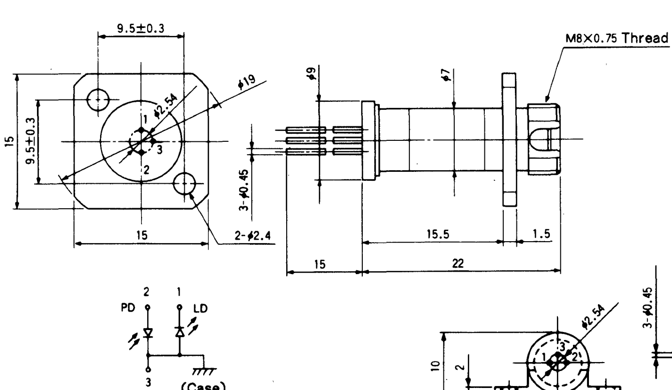
- High-speed response
- Emission wavelength is in 0.85μm wavelength band
- Connectorized package for FC connector (FU-01LD-N (0.85))
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25 ℃)

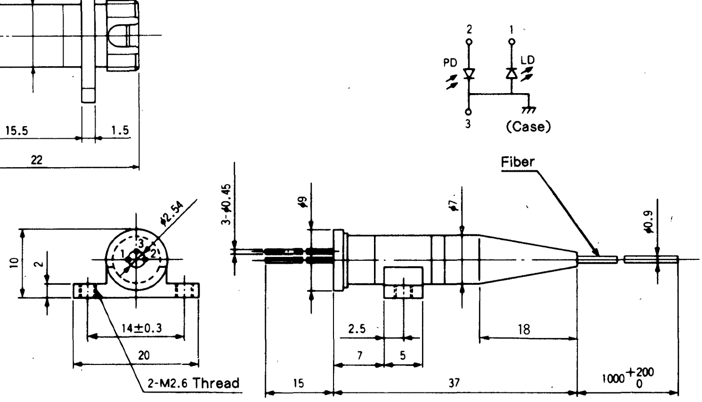
Items		Symbols	Conditions	Ratings		Units
				FU-01LD-N (0.85)	FU-27LD (0.85)	
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	3	3	mW
	Reverse Voltage	V_{RL}	–	2	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	15	V
	Forward Current	I_{FD}	–	10	10	mA
Operating case temperature		Tc	–	– 20~60	– 20~60	℃
Storage temperature		Tstg	–	– 40~70	– 40~70	℃

Note 1) Fiber : GI type with core dia. 50μm and N.A.0.2

OUTLINE DRAWINGS Unit (mm)



FU-01LD-N (0.85)



FU-27LD (0.85)

CHARACTERISTICS (Tc=25 °C, unless otherwise noted)

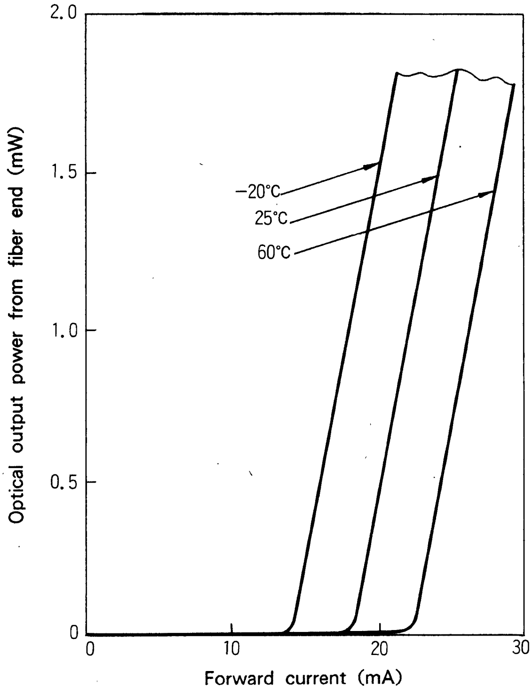
Items	Symbols	Conditions	FU-01LD-N (0.85)			FU-27LD (0.85)			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Threshold current	I_{th}	CW	–	18	30	–	18	30	mA
Operating current	I_{op}	CW	–	25	40	–	25	40	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.5	2	–	1.5	2	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	1	1.8	–	1	1.8	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	800	850	900	800	850	900	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	0.4	–	–	0.4	–	ns
Tracking error (Note 4)	E_r	TC = –20~60 ℃, APC	–	0.2	–	–	0.2	–	dB
Differential efficiency (Note 2)	η	–	–	0.25	–	–	0.25	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, $V_{RD} = 5V$	0.1	0.3	–	0.1	0.3	–	mA
Dark current (Photodiode)	I_D	$V_{RD} = 5V$	–	–	0.5	–	–	0.5	μA
Capacitance (Photodiode)	C_t	$V_{RD} = 5V$, f = 1MHz	–	7	–	–	7	–	pF
Optical connector type (Note 5)	–	–	FC			–			–

Note 1) I_F : Forward current (LD)
Note 2) Fiber : GI type with core dia. 50μm and N.A.0.2
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX \left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$
Note 5) FU-01LD-N (0.85) only

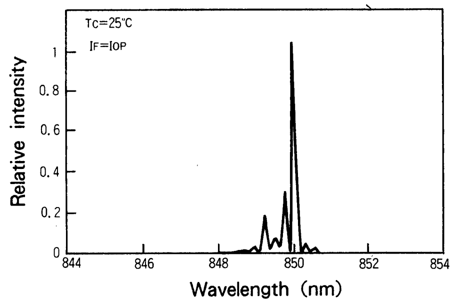
FIBER PIGTAIL SPECIFICATIONS (FU-27LD (0.85) only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

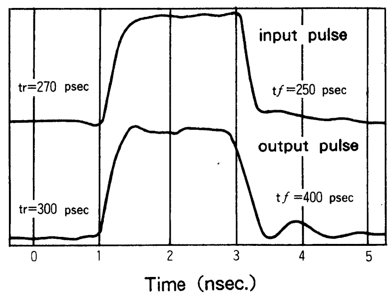
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



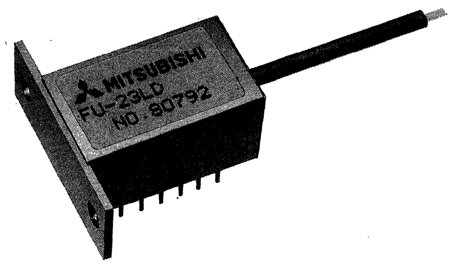
Pulse response

FU-23LD

0.85 μm LD Module with Multimode Fiber Pigtail

Module type FU-23LD has been developed for coupling a multimode optical fiber and a 0.85 μm wavelength AlGaAs LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in short and medium haul digital or analog optical communication systems.



FU-23LD

FEATURES

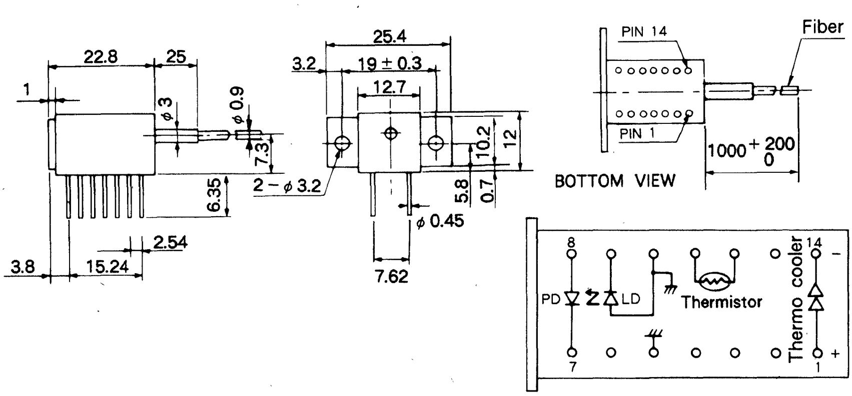
- High-speed response
- High optical output
- Emission wavelength is in 0.85μm band
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	6	mW
			Pulse (Note 1)	9	
	Reverse Voltage	V_{RL}	–	3	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	10	mA
Operating case temperature		Tc	–	– 20~65	℃
Storage temperature		Tstg	–	– 40~70	℃

Note 1) Pulse condition : Pulse width ≦ 1μs, Duty ratio ≦ 50 %

OUTLINE DRAWINGS Unit (mm)



BOTTOM VIEW

PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-23LD

CHARACTERISTICS (T_C=25 ℃, T_{LD}=25 ℃, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	16	50	mA
Operating current	I_{op}	CW	–	35	65	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.8	–	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	2.5	4	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	795	850	905	nm
Rise and Fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.4	–	ns
Tracking error (Note 3)	E_r	Tc = – 20~65℃, APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.2	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.3	1	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	–	0.5	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	7	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 3) $E_r = MAX\left| 10 \cdot \log \frac{P_F}{P_F\ (25℃)} \right|$

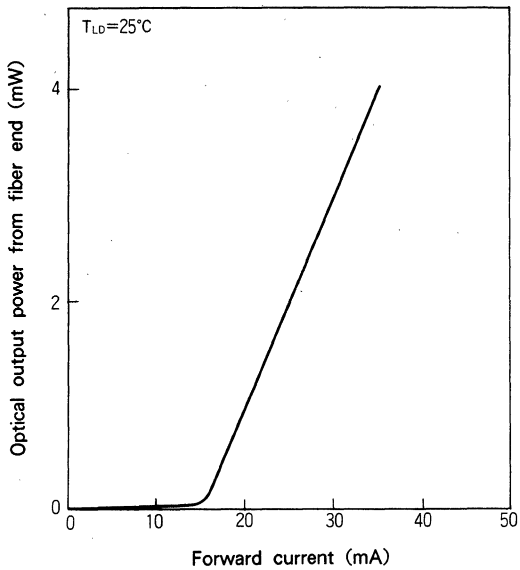
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, T_C= – 20 ℃~65 ℃)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.6	2	V

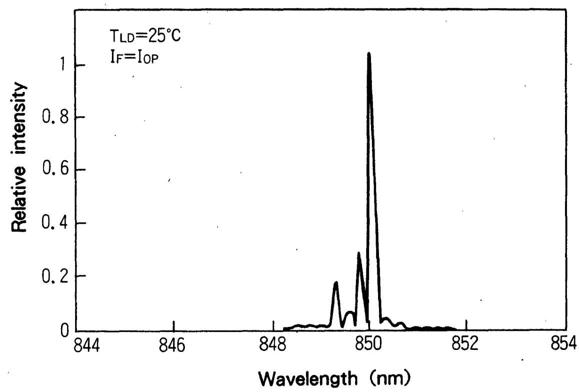
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



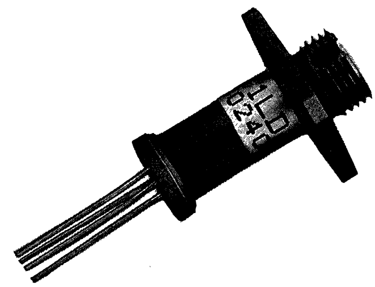
Light-emission spectrum

FU-11LD-N

1.3μm Connectorized LD Module for Multimode Fiber

Module type FU-11LD-N has been developed for coupling a multimode optical fiber and a 1.3μm wavelength InGaAsP LD (Laser Diode).

This module is the optimum light source for use in medium haul digital optical communication systems.



FU-11LD-N

FEATURES

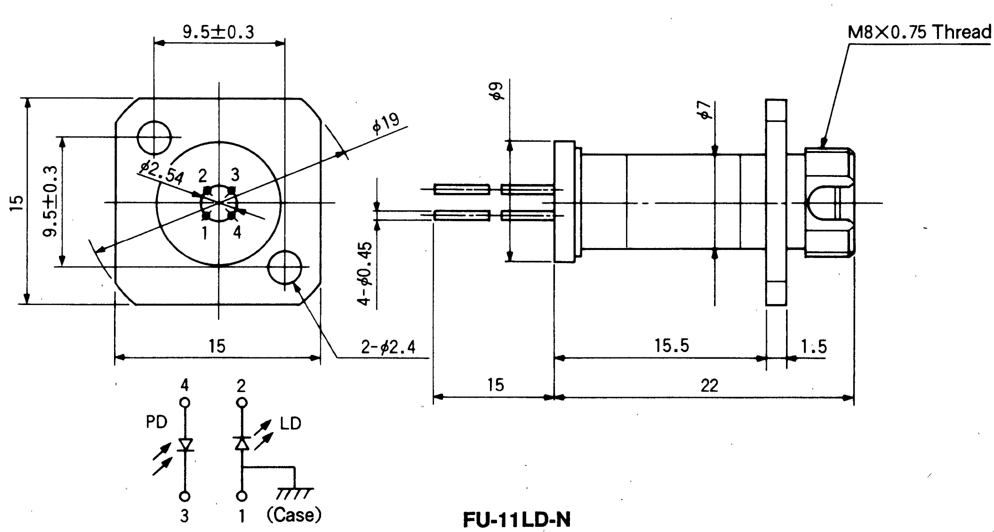
- High optical output
- Emission wavelength is in 1.3μm band
- Low threshold current (10mA typ.)
- Connectorized package for FC connector
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end (Note 1)	P_F	CW	7.5	mW
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	−20～65	℃
Storage temperature		T_{stg}	–	−40～70	℃

Note 1) Fiber : GI type with core dia. 50μm and N.A.0.2

OUTLINE DRAWINGS Unit (mm)



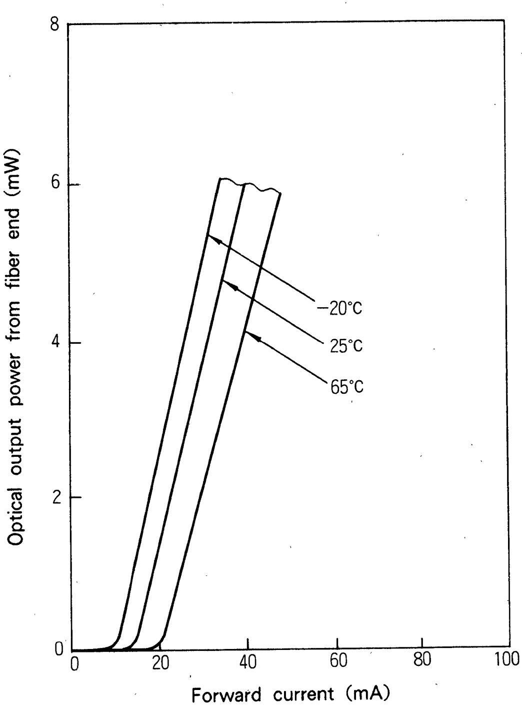
FU-11LD-N

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

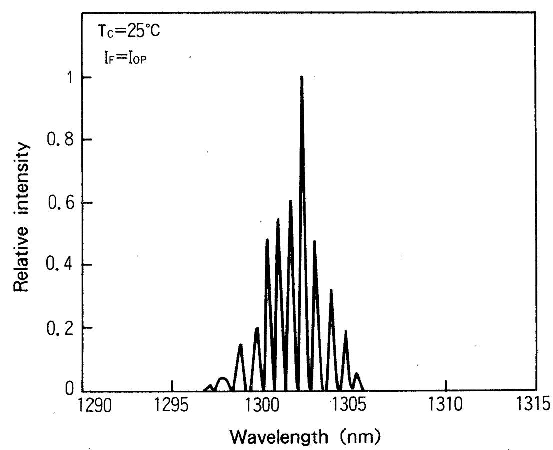
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	35	65	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end (Note 2)	P_F	CW, $I_F = I_{op}$	2	5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 3)	–	0.3	–	ns
Tracking error (Note 4)	E_r	Tc = −20~65℃, APC	–	0.3	–	dB
Differential efficiency (Note 2)	η	–	–	0.2	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.2	1	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF
Optical connector type	–	–		FC		–

Note 1) I_F : Forward current (LD)
Note 2) Fiber : GI type with core dia. 50μm and N.A.0.2
Note 3) I_B : Bias current (LD)
Note 4) $E_r = MAX\left|10 \cdot \log \frac{P_F}{P_F(25℃)}\right|$

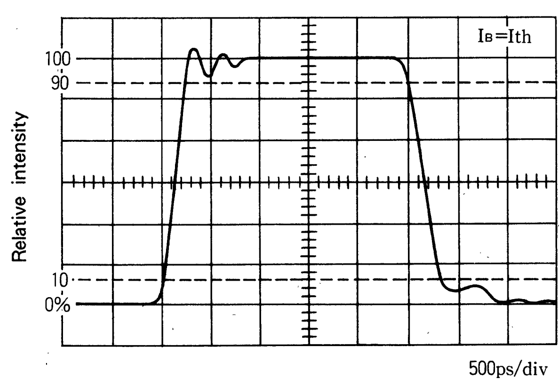
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum



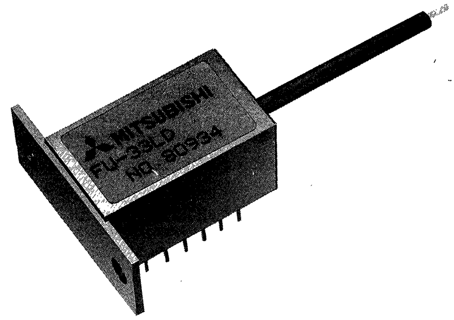
Pulse response

FU-33LD

1.3 µm LD Module with Multimode Fiber Pigtail

Module type FU-33LD has been developed for coupling a multimode optical fiber and a 1.3µm wavelength InGaAsP LD (Laser diode). The package is incorporated with dual-in-line pins for electrical connection.

This module is suitable to light source for use in high-speed long haul digital optical communication systems and use in measuring instruments.



FU-33LD

FEATURES

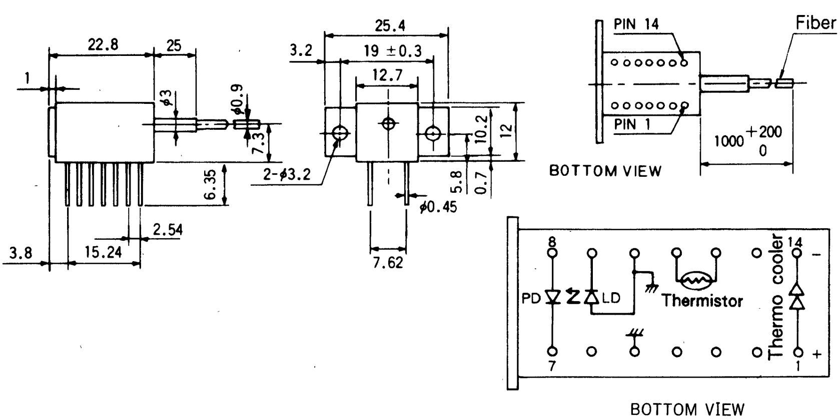
- High-speed response
- High optical output
- Emission wavelength is in 1.3µm band
- Low threshold current (10mA typ.)
- Built-in thermal electric cooler
- Dual-in-line package
- With photodiode for optical output monitor
- Diodes are hermetically sealed

ABSOLUTE MAXIMUM RATINGS (T_{LD}=25°C)

Items		Symbols	Conditions	Ratings	Units
Laser diode	Optical output power from fiber end	P_F	CW	3.6	mW
			Pulse (Note 1)	7.2	
	Reverse Voltage	V_{RL}	–	2	V
Photodiode for monitoring	Reverse Voltage	V_{RD}	–	15	V
	Forward Current	I_{FD}	–	2	mA
Operating case temperature		T_C	–	–20~65	℃
Storage temperature		T_{stg}	–	–40~70	℃

Note) Pulse condition : Pulse width ≦ 1 µs, Duty ratio ≦ 50 %

OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	COOLER ANODE
2	NC
3	NC
4	NC
5	LD ANODE, GND
6	NC
7	PD CATHODE
8	PD ANODE
9	LD CATHODE
10	LD ANODE, GND
11	THERMISTOR
12	THERMISTOR
13	NC
14	COOLER CATHODE

FU-33LD

CHARACTERISTICS (T_c=25 ℃, T_{LD}=25 ℃, unless otherwise noted)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Threshold current	I_{th}	CW	–	10	30	mA
Operating current	I_{op}	CW	–	25	45	mA
Operating voltage	V_{op}	CW, $I_F = I_{op}$ (Note 1)	–	1.2	1.6	V
Optical output power from fiber end	P_F	CW, $I_F = I_{op}$	1.5	2.5	–	mW
Central wavelength	λc	CW, $I_F = I_{op}$	1270	1300	1330	nm
Spectral bandwidth (RMS) (Note 3)	$\Delta\lambda$	CW, $I_F = I_{op}$	–	1.4	–	nm
Rise and fall times	t_r, t_f	$I_B = I_{th}$, 10~90% (Note 2)	–	0.3	–	ns
Tracking error (Note 4)	E_r	Tc = –20~65℃ APC, ATC	–	0.2	–	dB
Differential efficiency	η	–	–	0.17	–	mW/mA
Monitor current	I_{mon}	CW, $I_F = I_{op}$, V_{RD} = 5V	0.1	0.6	–	mA
Dark current (Photodiode)	I_D	V_{RD} = 5V	–	0.1	1	μA
Capacitance (Photodiode)	C_t	V_{RD} = 5V, f = 1MHz	–	10	–	pF

Note 1) I_F : Forward current (LD)
Note 2) I_B : Bias current (LD)
Note 4) $E_r = \mathrm{MAX}\left|10 \cdot \log \frac{P_F}{P_F\ (25℃)}\right|$

Note 3) $\Delta\lambda = \sqrt{\frac{\Sigma ai\ (\lambda i - \lambda c)^2}{\Sigma ai}}$ (ai ≧ ap × 0.01)
ai : Relative intensity of laser spectral emission modes
ap : Peak of laser spectral emission modes

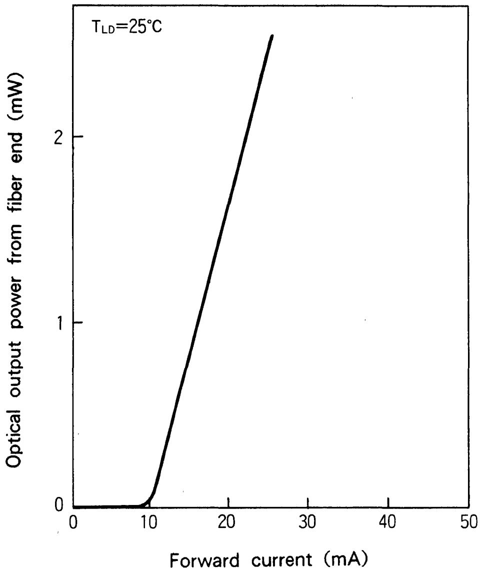
THERMAL CHARACTERISTICS (T_{LD}=25 ℃, T_c= – 20 ℃~65 ℃)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Thermistor resistance	R_{th}	T_{LD} = 25℃	9.5	10	10.5	kΩ
B Constant of thermistor resistance	B	–	–	3250	–	K
Cooling capacity	ΔT	Tc = 65℃	40	–	–	℃
Cooler current	I_{pe}	ΔT = 40℃	–	0.6	1	A
Cooler voltage	V_{pe}	ΔT = 40℃	–	1.6	2	V

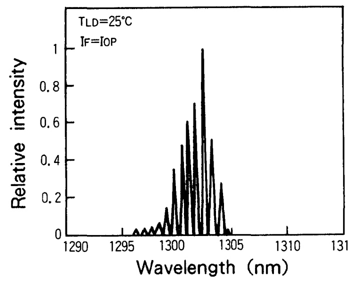
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

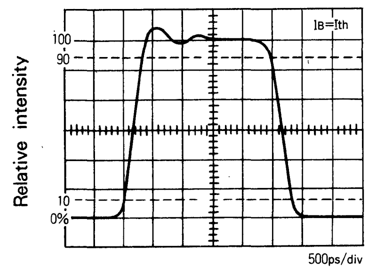
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum

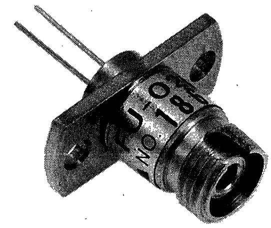


Pulse response

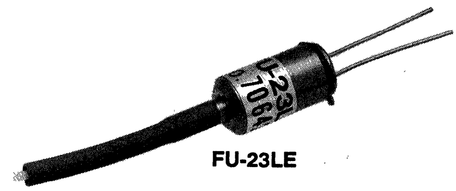
FU-02LE-N, FU-23LE

0.85 μm LED Module for Multimode Fiber

LED Module, FU-02LE-N and FU-23LE contain a highly-reliable 0.85μm band AlGaAs/Ga Light-emitting diode and are used as light source for both digital and analog optical communication systems.



FU-02LE-N



FU-23LE

FEATURES

- High optical output power
- High-speed modulation
- Superior linearity between current and optical output
- High reliability

ABSOLUTE MAXIMUM RATINGS (Tc=25 °C)

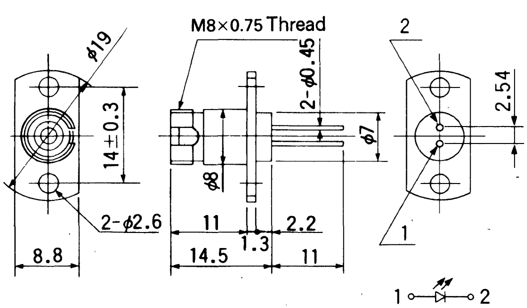
Items	Symbols	Conditions		Ratings		Units
				FU-02LE-N	FU-23LE	
Forward current (Note 1)	I_F	Tc ≦ 50℃	CW	75	75	mA
			Pulse (Note 2)	120	120	
Reverse voltage	V_R	–		3	3	V
Operating case temperature	Tc	–		–20~65	–20~65	℃
Storage temperature	T_{stg}	–		–40~70	–40~70	℃

Note 1) Forward current at Tc > 50℃

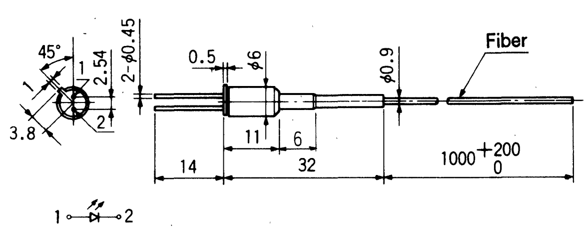
$$I_F(Tc) = I_F(Tc \leq 50℃) \cdot \frac{100-Tc}{50}$$

Note 2) Frequency > 100kHz, Duty ratio < 50 %

OUTLINE DRAWINGS Unit (mm)



FU-02LE-N



FU-23LE

CHARACTERISTICS (T_c=25°C, unless otherwise noted)

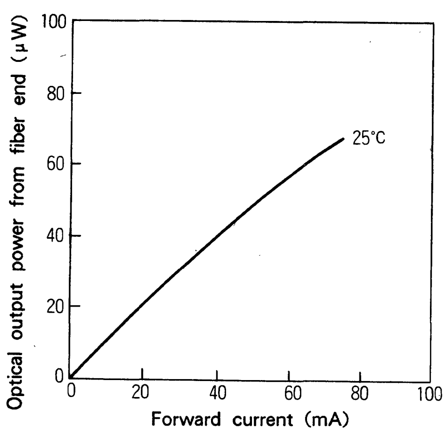
Items	Symbols	Conditions	FU-02LE-N			FU-23LE			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Central wavelength	λc	I_F = 50mA	780	840	880	780	840	880	nm
Spectral bandwidth (FWHM)	$\Delta\lambda$	I_F = 50mA	–	45	–	–	45	–	nm
Optical output power from fiber end (Note 1)	P_F	I_F = 75mA	40	65	–	40	65	–	μW
Cutoff frequency (– 1.5dB)	fc	I_F = 25mA + 4mA$_{P-P}$	10	30	–	10	30	–	MHz
Forward voltage	V_F	I_F = 50mA	–	1.6	2.2	–	1.6	2.2	V
Reverse current	I_R	V_R = 3.0V	–	–	10	–	–	10	μA
Optical connector type (Note 2)	–	–	FC			–			–

Note 1) Fiber : GI type with core dia. 50μm and N.A.0.2
Note 2) FU-02LE-N only

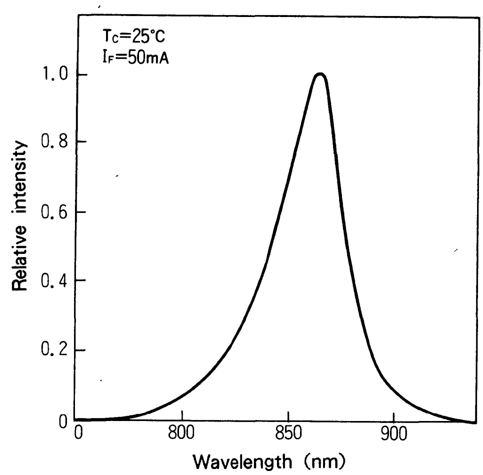
FIBER PIGTAIL SPECIFICATIONS (FU-23LE only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

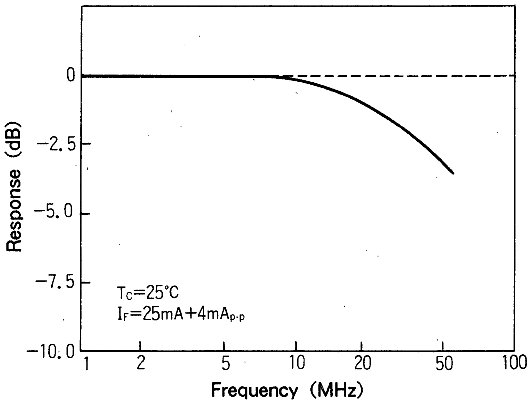
EXAMPLE OF CHARACTERISTICS



Forward current vs. Optical output power



Light-emission spectrum

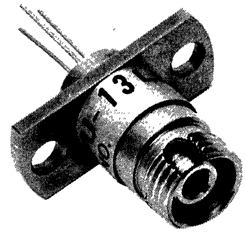


Frequency response

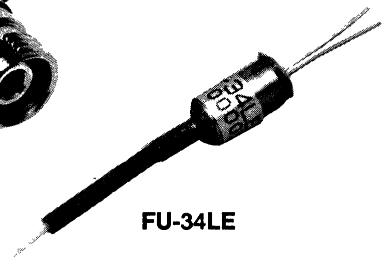
FU-13LE-N, FU-34LE

1.3 μm LED Module for Multimode Fiber

LED Module, FU-13LE-N and FU-34LE contain a highly-reliable 1.3μm band InGaAsP/InP Light-emitting diode and are used as light source for digital optical communication systems.



FU-13LE-N



FU-34LE

FEATURES

- High optical output power
- High-speed modulation (fc = 150MHz)
- High reliability

ABSOLUTE MAXIMUM RATINGS (Tc=25 °C)

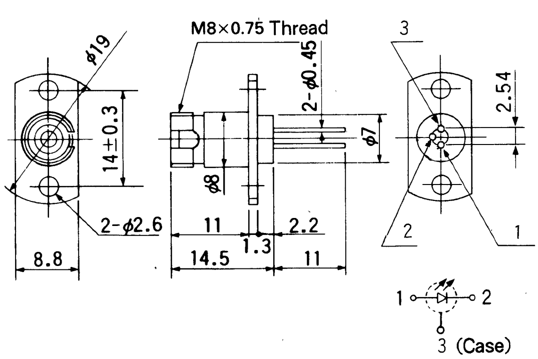
Items	Symbols	Conditions		Ratings		Units
				FU-13LE-N	FU-34LE	
Forward current (Note 1)	I_F	Tc ≦ 50℃	CW	120	120	mA
			Pulse (Note 2)	150	150	
Reverse voltage	V_R	–		2	2	V
Operating case temperature	Tc	–		−20~65	−20~65	℃
Storage temperature	T_{stg}	–		−40~70	−40~70	℃

Note 1) Forward current at Tc > 50℃

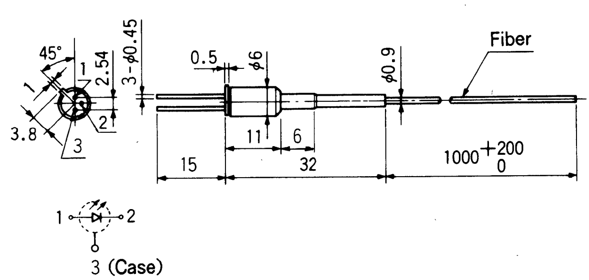
$$I_F(Tc) = I_F\ (Tc \leqq 50℃) \cdot \frac{100 - Tc}{50}$$

Note 2) Frequency > 100kHz, Duty ratio < 50%

OUTLINE DRAWINGS Unit (mm)



FU-13LE-N



FU-34LE

CHARACTERISTICS (Tc=25 °C, unless otherwise noted)

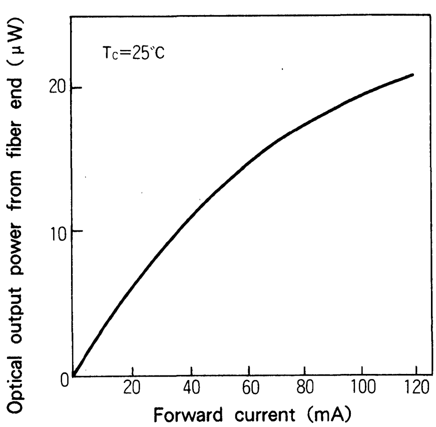
Items	Symbols	Conditions	FU-13LE-N			FU-34LE			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Central wavelength	λc	I_F = 100mA	1260	1300	1340	1260	1300	1340	nm
Spectral bandwidth (FWHM)	$\Delta\lambda$	I_F = 100mA	–	130	150	–	130	150	nm
Optical output power from fiber end (Note 1)	P_F	I_F = 100mA	10	15	–	10	15	–	μW
Cutoff frequency (– 1.5dB)	fc	I_F = 100mA + 4mA$_{P-P}$	–	150	–	–	150	–	MHz
Forward voltage	V_F	I_F = 100mA	–	1.5	2	–	1.5	2	V
Reverse current	I_R	V_R = 2V	–	300	–	–	300	–	μA
Optical connector type (Note 2)	–	–	FC			–			–

Note 1) Fiber : GI type with core dia. 50μm and N.A.0.2
Note 2) FU-13LE-N only

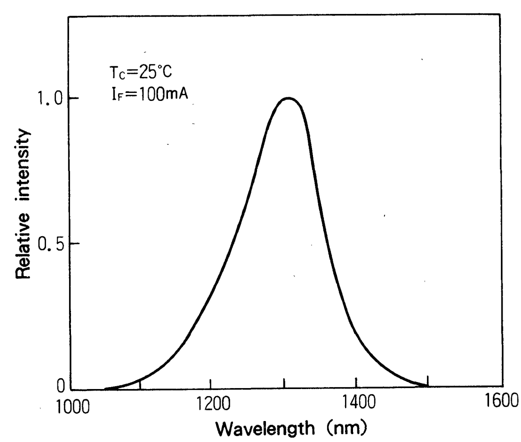
FIBER PIGTAIL SPECIFICATIONS (FU-34LE only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS

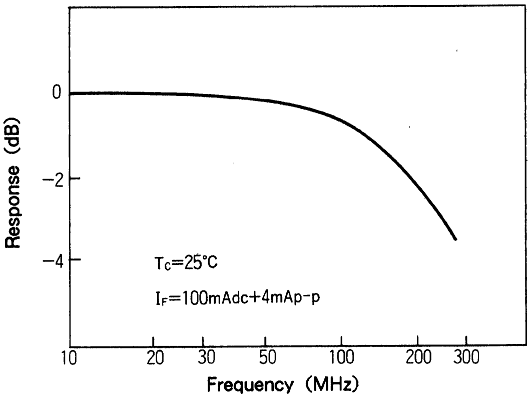


Forward current vs. Optical output power



Light-emission spectrum

MITSUBISHI ELECTRIC



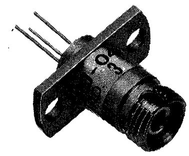
Frequency response

FU-04PD-N, FU-21PD

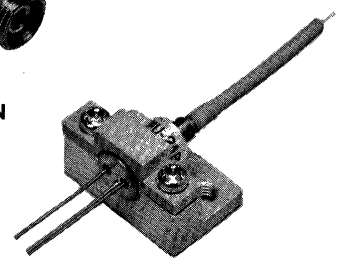
PD Module for Short Wavelength Band

FU-04PD-N and FU-21PD are detector modules containing highly reliable Si photodiode for short wavelength band (0.5∼1μm).

These modules are used as light-receiving devices for short and medium haul optical communication systems.



FU-04PD-N



FU-21PD

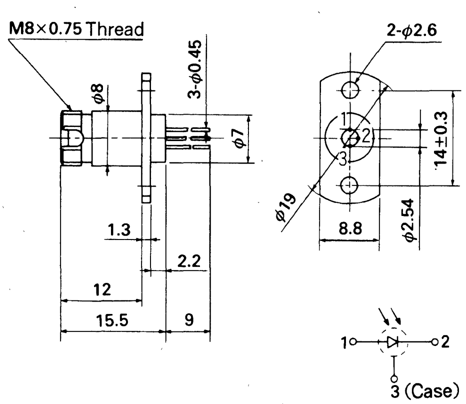
FEATURES

- High-responsivity
- High-speed response
- Easy handling
- Receptacle type (FU-04PD-N)

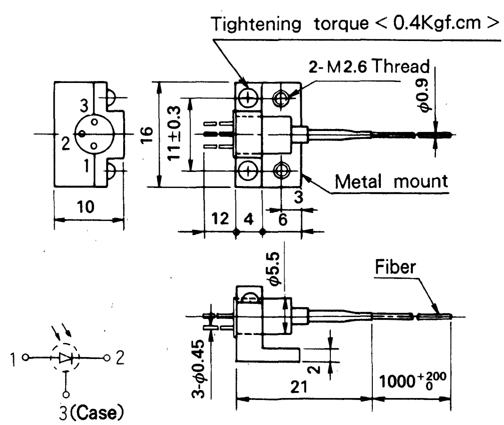
ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items	Symbols	Ratings		Units
		FU-04PD-N	FU-21PD	
Reverse voltage	V_R	50	50	V
Power consumption	P_m	50	50	mW
Operating case temperature	Tc	−20∼60	−20∼60	℃
Storage temperature	T_{stg}	−40∼70	−40∼70	℃

OUTLINE DRAWINGS Unit (mm)



FU-04PD-N



FU-21PD

MITSUBISHI ELECTRIC

CHARACTERISTICS (T_c=25°C, unless otherwise noted)

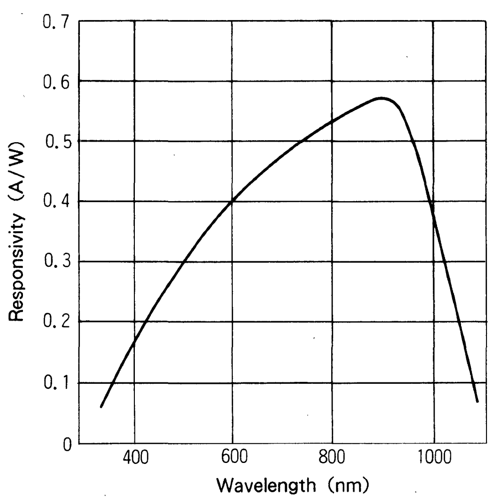
Items	Symbols	Conditions	FU-04PD-N			FU-21PD			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Detection range	–	–	430～1060			430～1060			nm
Responsivity (Note 1)	R	λ = 850nm	0.45	0.55	–	0.45	0.55	–	A/W
Noise equivalent power	NEP	V_R = 5V, λ = 850nm	–	5×10^{-15}	–	–	5×10^{-15}	–	$W/\sqrt{Hz}$
Dark current	I_D	V_R = 5V	–	0.1	2	–	0.1	2	nA
Cutoff frequency (–3dB)	fc	R_L = 50 Ω, V_R = 40V	–	150	–	–	150	–	MHz
Capacitance	Ct	f = 1MHz, V_R = 5V	–	3	–	–	3	–	pF
Optical connector type (Note 2)	–	–	FC			–			–

Note 1) Fiber : GI type with core dia. 50μm and N.A. 0.2
Note 2) FU-04PD-N only

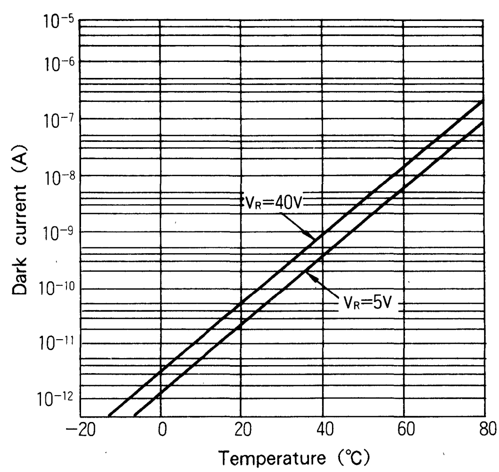
FIBER PIGTAIL SPECIFICATIONS (FU-21PD only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

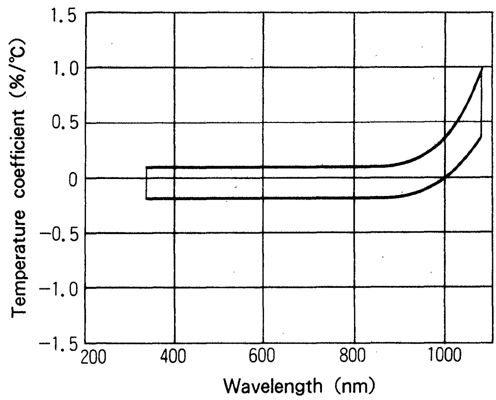
EXAMPLE OF CHARACTERISTICS



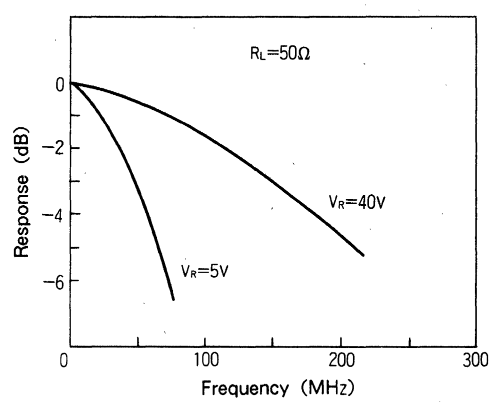
Wavelength responsivity



Temperature vs. Dark current



Temperature responsivity coefficient



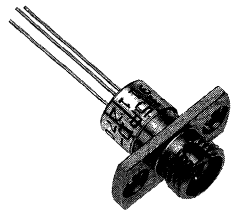
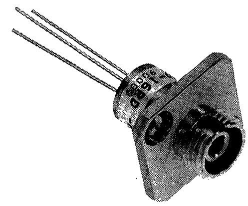
Frequency response

MITSUBISHI ELECTRIC

FU-15PD-N, FU-16PD-N

PD Module for Long Wavelength Band

FU-15PD-N and FU-16PD-N are detector modules containing highly reliable InGaAs photodiode for long wavelength band (1~1.6μm).
InGaAs photodiode has very low dark current.
These modules are used as detector for high-speed and long haul optical communication systems.

FU-15PD-N FU-16PD-N

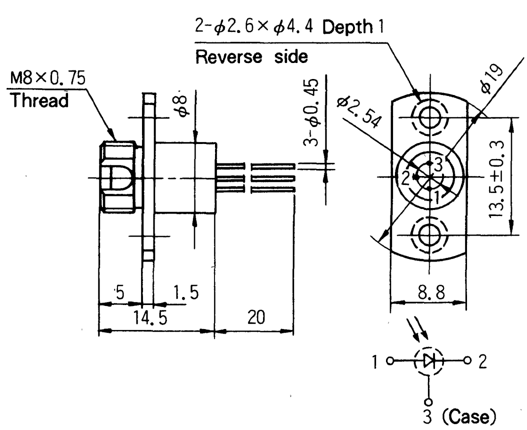
FEATURES

- High-responsivity
- Low dark current (1nA max)
- High-speed response
- Easy handling
- Receptacle type

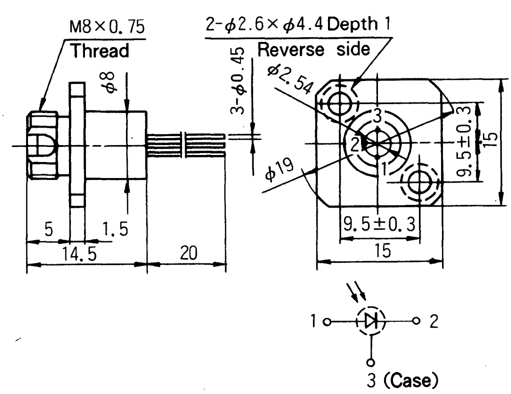
ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items	Symbols	Ratings		Units
		FU-15PD-N	FU-16PD-N	
Reverse voltage	V_R	20	20	V
Reverse current	I_R	500	500	μA
Forward current	I_F	2	2	mA
Operating case temperature	T_C	−30~70	−30~70	℃
Storage temperature	T_{stg}	−40~70	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-15PD-N



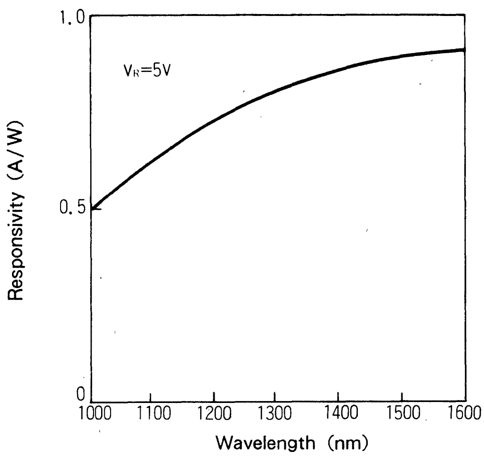
FU-16PD-N

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

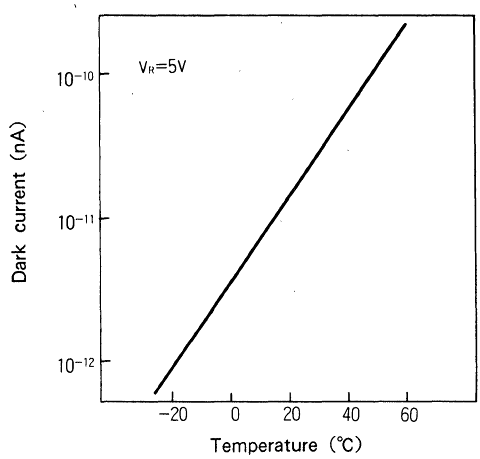
Items	Symbols	Conditions	FU-15PD-N			FU-16PD-N			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Detection range	–	–	1000～1600			1000～1600			nm
Responsivity (Note 1)	R	λ = 1300nm	0.65	0.8	–	0.65	0.8	–	A/W
Dark current	I_D	V_R = 5V	–	–	1	–	–	1	nA
Cutoff frequency (−3dB)	f_c	R_L = 50 Ω, V_R = 5V	1	1.5	–	1	1.5	–	GHz
Capacitance	C_t	V_R = 5V, f = 1MHz	–	1	2	–	1	2	pF
Optical connector type	–	–	FC			FC			–

Note 1) Fiber : GI type with core dia. 50μm and N.A. 0.2

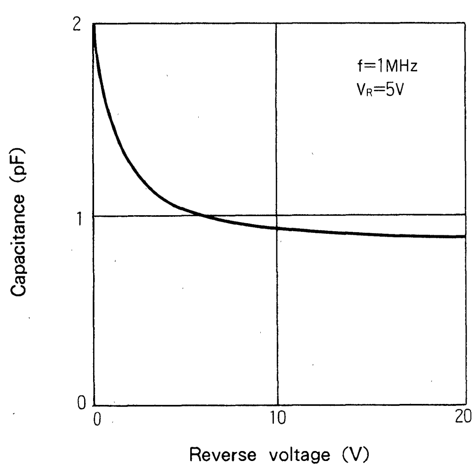
EXAMPLE OF CHARACTERISTICS



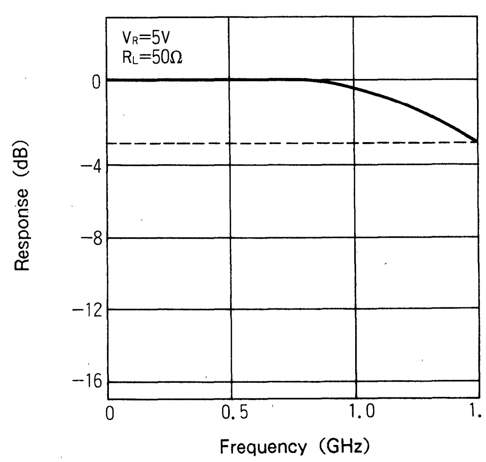
Wavelength responsivity



Temperature vs. Dark current



Reverse voltage vs. Capacitance



Frequency response

MITSUBISHI ELECTRIC

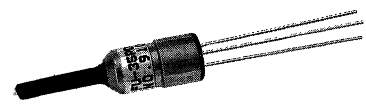
FU-35PD

PD Module for Long Wavelength Band

FU-35PD is detector module containing highly-reliable InGaAs photodiode for long wavelength band (1~1.6μm).

InGaAs photodiode has very low dark current.

This module is used as detector for high-speed and long haul optical communication systems.



FU-35PD

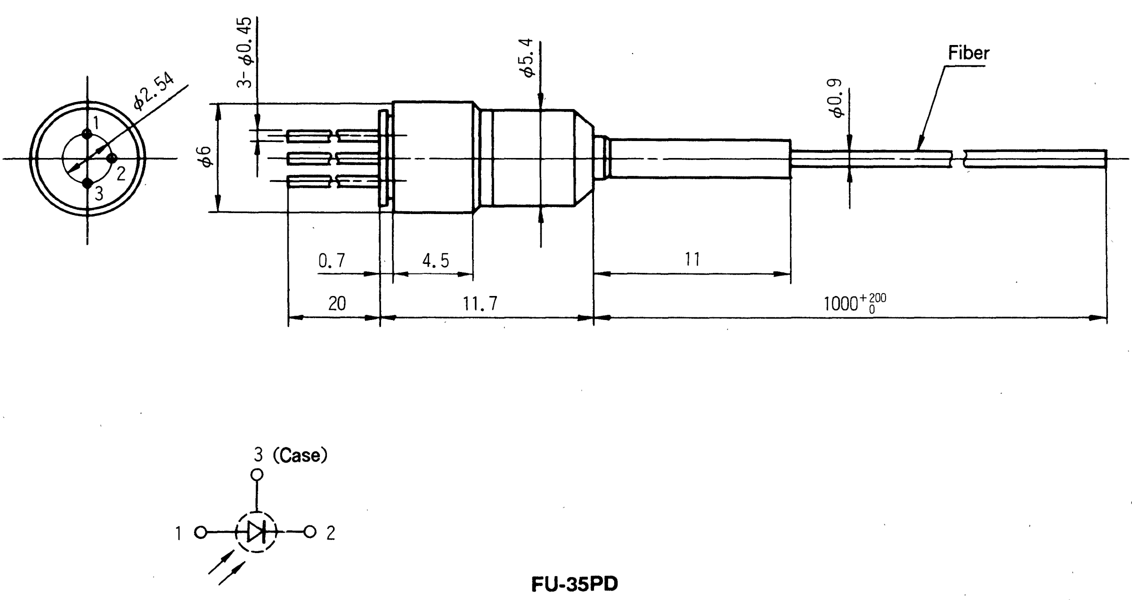
FEATURES

- High-responsivity
- Low dark current (1nA max)
- High-speed response
- Easy handling
- Compact package

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items	Symbols	Ratings	Units
Reverse voltage	V_R	20	V
Reverse current	I_R	500	μA
Forward current	I_F	2	mA
Operating case temperature	Tc	−30~70	℃
Storage temperature	T_{stg}	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-35PD

CHARACTERISTICS (T_c=25 ℃, unless otherwise noted)

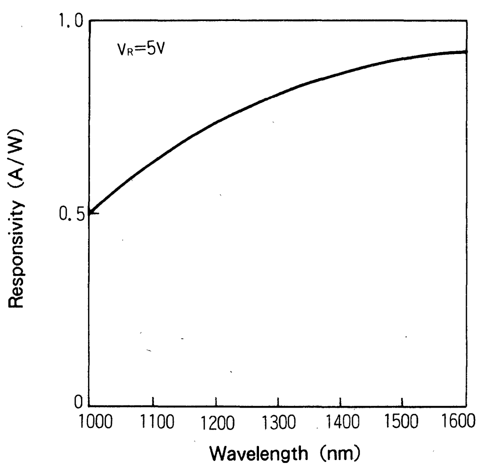
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Detection range	–	–	1000~1600			nm
Responsivity (Note 1)	R	λ = 1300nm, V_R = 5V	0.65	0.8	–	A/W
Dark current	I_D	V_R = 5V	–	–	1	nA
Cutoff frequency (−3dB)	f_c	R_L = 50 Ω, V_R = 5V	1	1.5	–	GHz
Capacitance	C_t	V_R = 5V, f = 1MHz	–	1	2	pF

Note 1) Fiber : GI type with core dia. 50 μm and N.A. 0.2

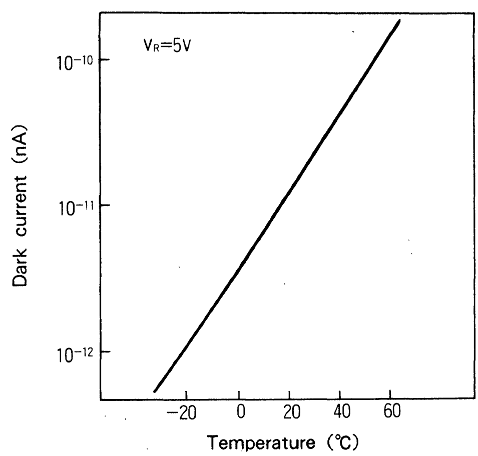
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

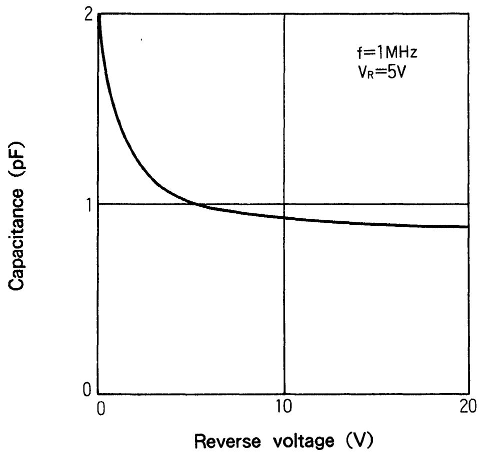
EXAMPLE OF CHARACTERISTICS



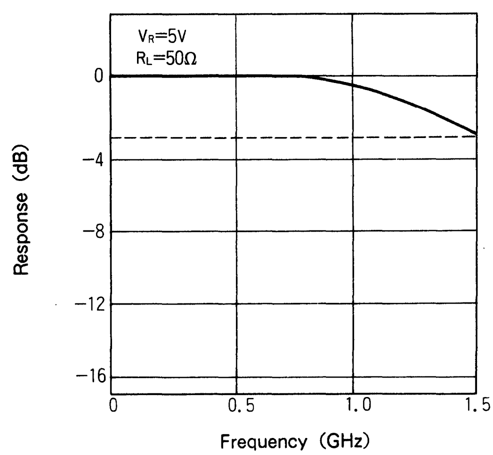
Wavelength responsivity



Temperature vs. Dark current



Reverse voltage vs. Capacitance



Frequency response

FU-05AP-N, FU-25AP

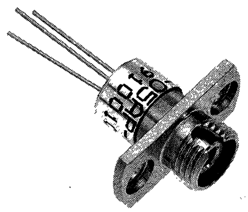
APD Module for Short Wavelength Band

FU-05AP-N and FU-25AP are detector modules containing highly reliable Si APD (Avalanche photodiode) with high-speed response.

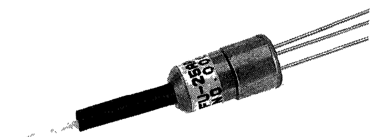
These modules are used as detector for high-speed optical communication systems.

FEATURES

- High-speed response (f_c = 2GHz)
- Low noise level
- Can be connected to optical fiber with high efficiency
- Compact package



FU-05AP-N

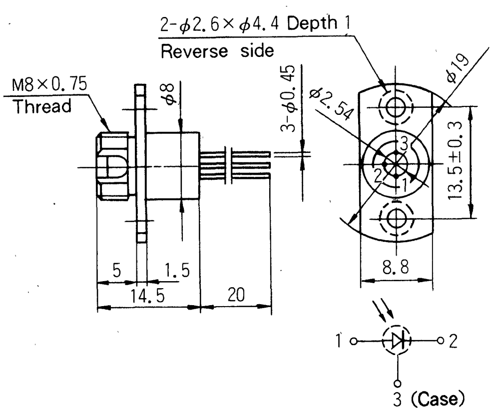


FU-25AP

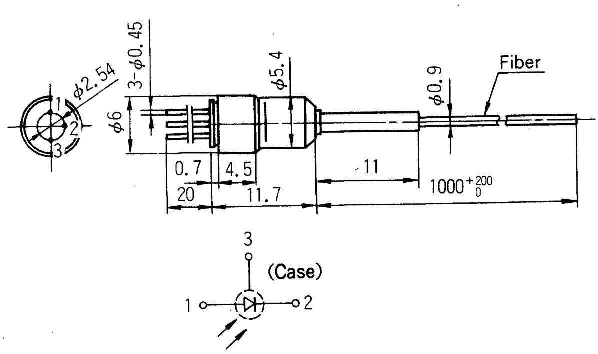
ABSOLUTE MAXIMUM RATINGS (Tc=25 °C)

Items	Symbols	Conditions	Ratings		Units
			FU-05AP-N	FU-25AP	
Reverse current	I_R	Tc ≦ 70 ℃	200	200	μA
Forward current	I_F	Tc ≦ 70 ℃	10	10	mA
Operating case temperature	Tc	–	– 20~70	– 20~70	℃
Storage temperature	T_{stg}	–	– 40~70	– 40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-05AP-N



FU-25AP

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CHARACTERISTICS (T_c=25 ℃, unless otherwise noted)

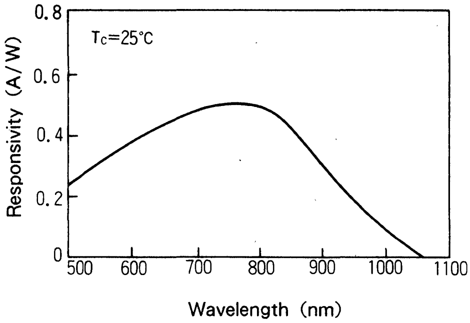
Items	Symbols	Conditions	FU-05AP-N			FU-25AP			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Detection range	–	–	500～1000			500～1000			nm
Responsivity (Note 1)	R	λ = 850nm, V_R = 50V	0.33	0.4	–	0.33	0.4	–	A/W
Breakdown voltage	V_{BR}	I_D = 100 μA	100	150	200	100	150	200	V
Temperature coefficient of breakdown voltage	β	–	–	0.12	–	–	0.12	–	%/℃
Dark current	I_D	V_R = 50V	–	0.3	1	–	0.3	1	nA
Noise equivalent power	NEP	λ = 800nm	–	1×10^{-14}	–	–	1×10^{-14}	–	$W/\sqrt{Hz}$
Excess noise factor	F	M = 100 (Note 2)	–	$M^{0.25}$	–	–	$M^{0.25}$	–	–
Maximum multiplication rate	M_{max}	I_{po} = 10nA, R_L = 1k Ω	–	1000	–	–	1000	–	–
Cutoff frequency (–3dB)	fc	M = 100, R_L = 50 Ω	–	2	–	–	2	–	GHz
Capacitance	Ct	V_R = 0.9V_{BR}, f = 1MHz	–	1.5	2	–	1.5	2	pF
Optical connector type (Note 3)	–	–	FC			–			–

Note 1) Fiber : GI type with core dia. 50 μm and N.A. 0.2
Note 2) M. Multiplication rate
Note 3) FU-05AP-N only

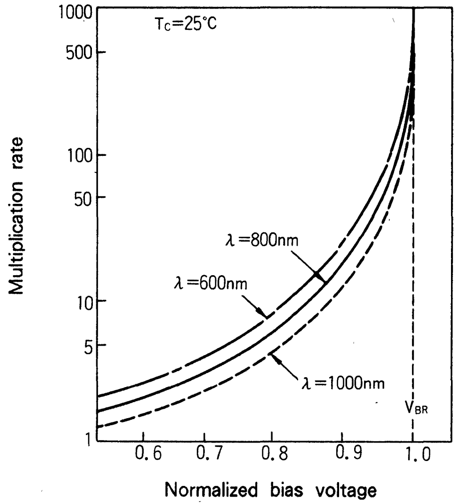
FIBER PIGTAIL SPECIFICATIONS (FU-25AP only)

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

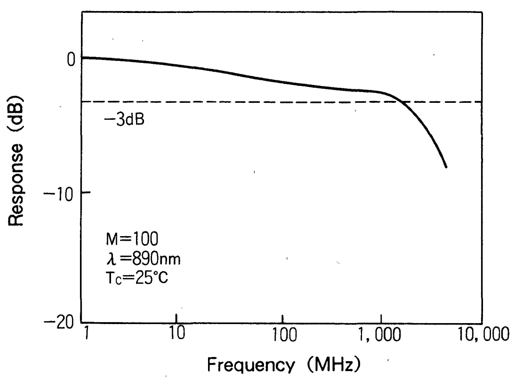
EXAMPLE OF CHARACTERISTICS



Wavelength responsivity



Multiplication rate



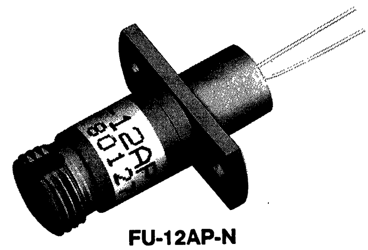
Frequency response

FU-12AP-N, FU-32AP

APD Module for Long Wavelength Band

FU-12AP-N and FU-32AP are detector module containing highly reliable Ge APD (Avalanche photodiode) for long wavelength band (0.8~1.5 μm) and has high-speed response.

These modules are used as detector for high-speed, long and medium haul optical communication systems.



FU-12AP-N

FEATURES

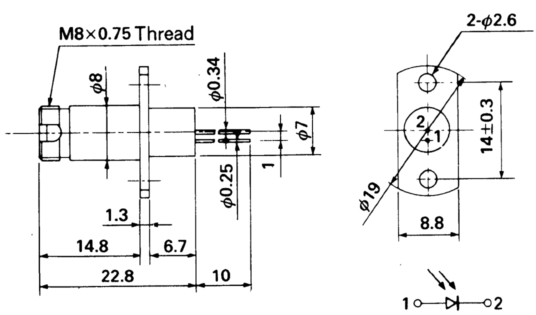
- High-responsivity
- High-speed response (1GHz typ.)
- Low capacitance
- Easy handling

FU-32AP

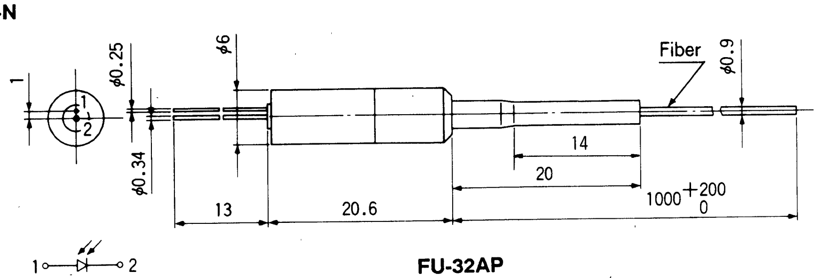
ABSOLUTE MAXIMUM RATINGS (Tc=25 ℃)

Items	Symbols	Ratings		Units
		FU-12AP-N	FU-32AP	
Reverse current	I_R	1	1	mA
Forward current	I_F	100	100	mA
Operating case temperature	Tc	−30~70	−30~70	℃
Storage temperature	Tstg	−40~70	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-12AP-N



FU-32AP

CHARACTERISTICS (T_c=25 °C, unless otherwise noted)

Items	Symbols	Conditions	FU-12AP-N			FU-32AP			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Detection range	–	–	800~1500			800~1500			nm
Responsivity (Note 1)	R	λ=1300nm, V_R=10V	0.68	0.72	–	0.68	0.72	–	A/W
Breakdown voltage	V_{BR}	I_D = 100 μA	25	30	40	25	30	40	V
Temperature coefficient of breakdown voltage (Note 2)	β	–	–	0.1	–	–	0.1	–	%/℃
Dark current	I_D	V_R = 0.9V_{BR}	–	0.3	0.5	–	0.3	0.5	μA
Excess noise factor	F	λ = 1300nm, M = 10 I_{po}=2 μA, B=1MHz (Note 3)	–	$M^{0.95}$	–	–	$M^{0.95}$	–	–
Cutoff frequency (−3dB)	fc	λ=1300nm, M=10, R_L=50Ω	800	1000	–	800	1000	–	MHz
Capacitance	Ct	V_R = 20V, f = 1MHz	–	2	2.5	–	2	2.5	pF
Optical connector type (Note 4)	–	–	FC			–			–

Note 1) Fiber : GI type with core dia. 50μm and N.A. 0.2

Note 2) $$\beta = \frac{V_{BR}(25℃+\Delta T) - V_{BR}(25℃)}{V_{BR}(25℃)\cdot \Delta T} \times 100\ (\%/℃)$$

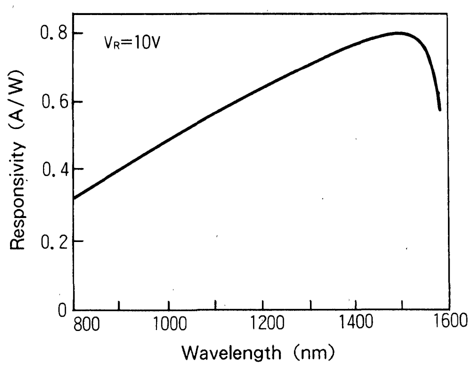
Note 3) M : Multiplication rate

Note 4) FU-12AP-N only

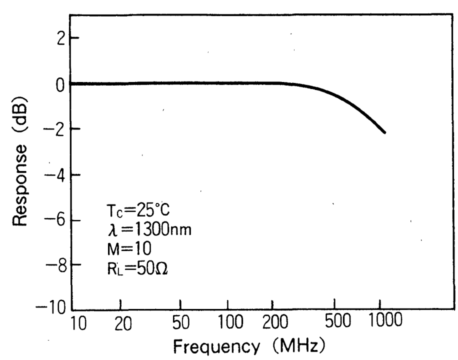
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

EXAMPLE OF CHARACTERISTICS

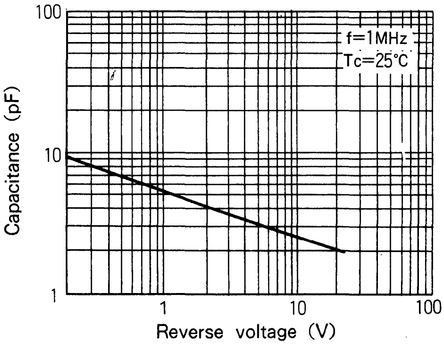


Wavelength responsivity

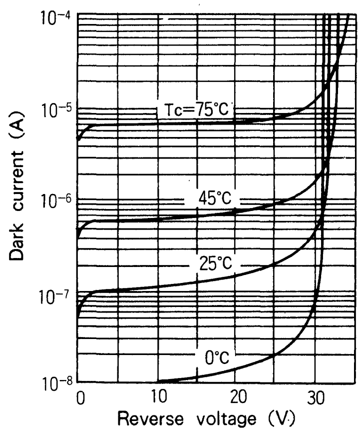


Frequency response

MITSUBISHI ELECTRIC



Reverse voltage vs. Capacitance



Reverse voltage vs. Dark current

FU-13AP-N

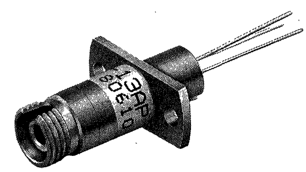
APD Module for Long Wavelength Band

FU-13AP-N is detector module containing highly-reliable InGaAs APD (Avalanche photodiode) module for the long wavelength band (1~1.6μm) and has high-speed response.

This module is used as detector for high-speed, long haul optical communication systems.

FEATURES

- High-responsivity
- High-speed response (> 1GHz)
- Low capacitance
- Easy handling

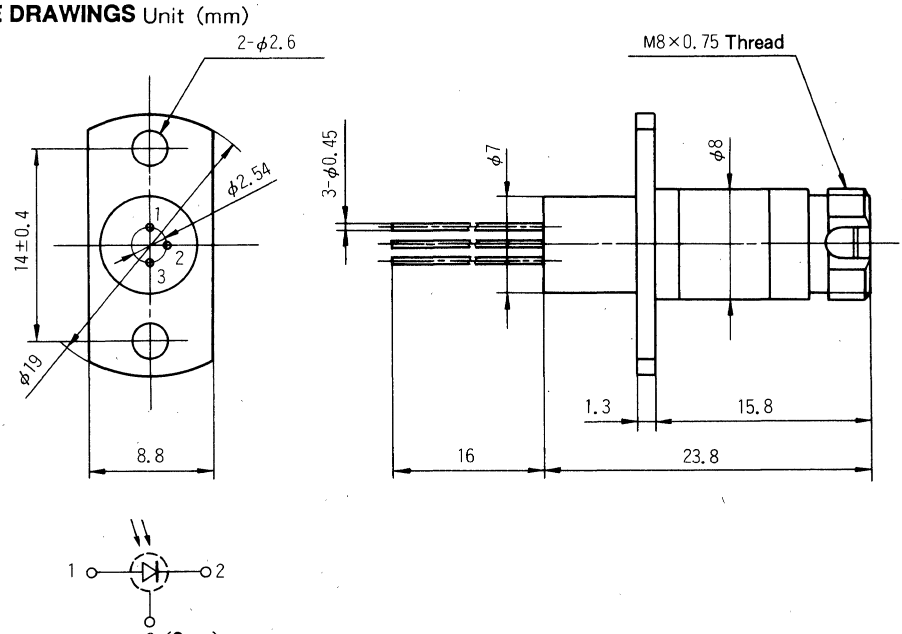


FU-13AP-N

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items	Symbols	Ratings	Units
Reverse current	I_R	500	μA
Forward current	I_F	2	mA
Operating case temperature	Tc	−30~70	℃
Storage temperature	T_{stg}	−40~70	℃

OUTLINE DRAWINGS Unit (mm)



FU-13AP-N

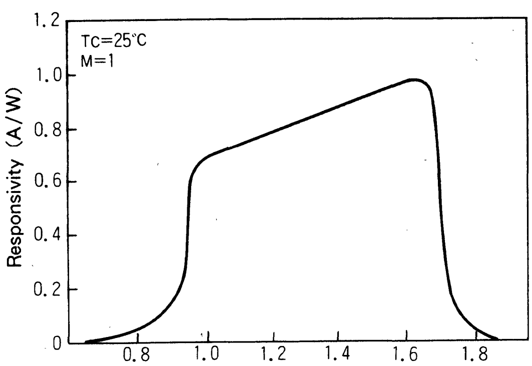
MITSUBISHI ELECTRIC

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

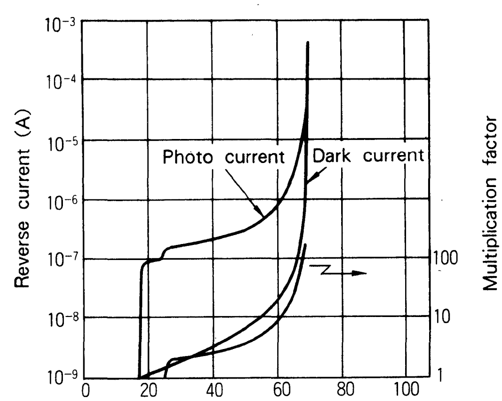
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Detection range	–	–	1000~1600			nm
Responsivity (Note 1)	R	λ = 1300nm, M = 1 (Note 2)	–	0.8	–	A/W
		λ = 1550nm, M = 1 (Note 2)	–	0.93	–	
Breakdown voltage	V_{BR}	$I_D = 100\mu A$	–	70	–	V
Breakdown voltage at case temperature	V_{BRt}	$I_D = 100\mu A$, Tc = –30~70℃	–	0.17	–	%/℃
Dark current	I_D	$V_R = 0.9V_{BR}$	–	–	100	nA
Excess noise factor	F	λ = 1300nm M = 10 f = 10MHz	–	$M^{0.7}$	–	–
Cutoff frequency (–3dB)	fc	λ = 1300nm M = 10 $R_L = 50\,\Omega$	1	3	–	GHz
Capacitance	Ct	$V_R = 0.9V_{BR}$, f = 1MHz	–	1	–	pF
Optical connector type	–	–	FC			–

Note 1) Fiber : GI type with core dia. 50 μm and N.A. 0.2
Note 2) M : Multiplication ratio

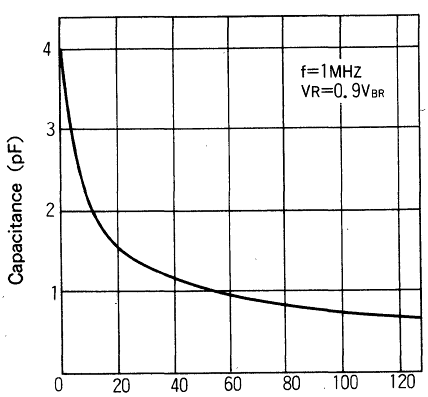
EXAMPLE OF CHARACTERISTICS



Wavelength responsivity



Dark current, Photo current and Multiplication factor vs. Reverse bias



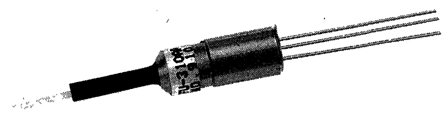
Reverse voltage capacitance

FU-310AP

APD Module for Long Wavelength Band

FU-310AP is detector module containing highly-reliable InGaAs APD (Avalanche photodiode) module for the long wavelength band (1~1.6μm) and has high-speed response.

This module is used as detector for high-speed, long haul optical communication systems.



FU-310AP

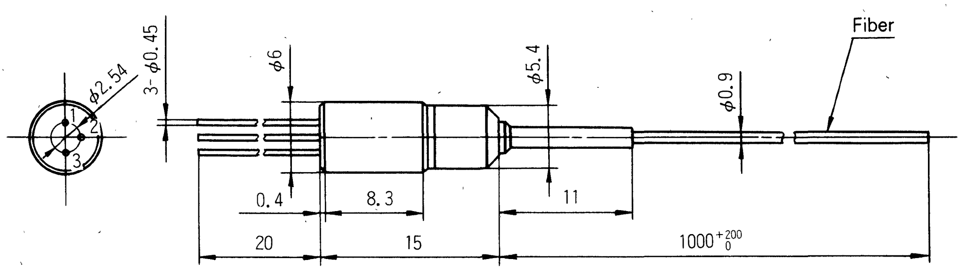
FEATURES

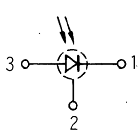
- High-responsivity
- High-speed response (> 1GHz)
- Low capacitance
- Easy handling

ABSOLUTE MAXIMUM RATINGS (Tc=25℃)

Items	Symbols	Ratings	Units
Reverse current	I_R	500	μA
Forward current	I_F	2	mA
Operating case temperature	Tc	−30~70	℃
Storage temperature	T_{stg}	−40~70	℃

OUTLINE DRAWINGS Unit (mm)





FU-310AP

MITSUBISHI ELECTRIC

CHARACTERISTICS (Tc=25°C, unless otherwise noted)

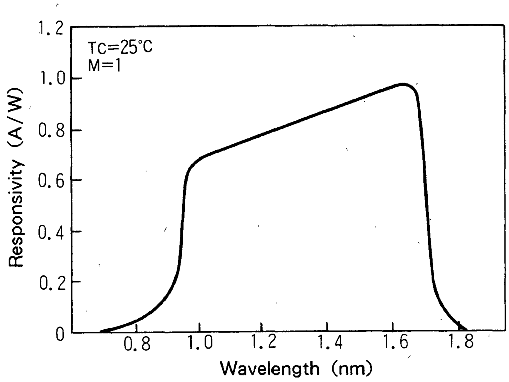
Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Detection range	–	–	1000~1600			nm
Responsivity (Note 1)	R	λ = 1300nm, M = 1 (Note 2)	–	0.8	–	A/W
		λ = 1550nm, M = 1 (Note 2)	–	0.93	–	
Breakdown voltage	V_{BR}	I_D = 100μA	–	70	–	V
Breakdown voltage at case temperature	V_{BRt}	I_D = 100μA, Tc = –30~70℃	–	0.17	–	%/℃
Dark current	I_D	$V_R = 0.9V_{BR}$	–	–	100	nA
Excess noise factor	F	λ = 1300nm M = 10 f = 10MHz	–	$M^{0.7}$	–	–
Cutoff frequency (–3dB)	fc	λ = 1300nm M = 10 R_L = 50 Ω	1	3	–	GHz
Capacitance	Ct	$V_R = 0.9V_{BR}$, f = 1MHz	–	1	–	pF

Note 1) Fiber : GI type with core dia. 50 μm and N.A. 0.2
Note 2) M : Multiplication ratio

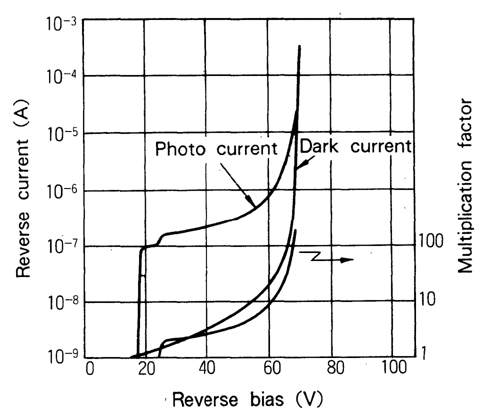
FIBER PIGTAIL SPECIFICATIONS

Items	Specifications	Units
Type	GI	–
Core dia.	50 ± 3	μm
N.A.	0.2	–
Cladding dia.	125 ± 3	μm
Jacket dia.	0.9	mm

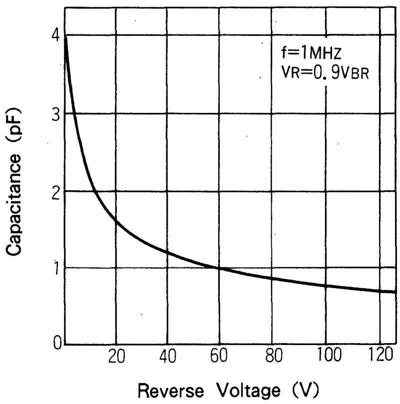
EXAMPLE OF CHARACTERISTICS



Wavelength responsivity



Dark current, Photo current and Multiplication factor vs. Reverse bias



Reverse voltage vs. Capacitance

MF-125DS-TR113-006

Digital Optical Transceiver Module with Clock Recovery

MF-125DS-TR113-006 contains 1300nm lensed surface-emitting LED and InGaAs PIN photodetector. This transceiver combines both transmitting and receiving functions in a single module with 50 micron core FC-type fiber optic connectors. The 125 Mb/s (NRZ) data link offers clock recovery and alarm output for link monitoring.

MF-125DS-TR113-006

FEATURES

- High power 1300nm LED transmitter
- Wide dynamic range (16dB) receiver
- Loss budget of 11dB (10^{-10} BER)
- 125 Mb/s operation (NRZ)

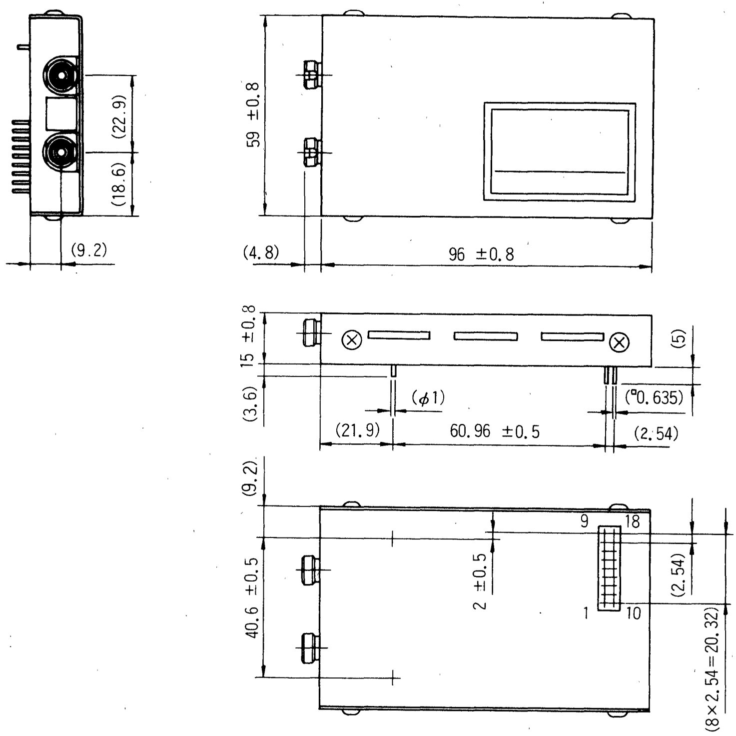
ABSOLUTE MAXIMUM RATINGS (T_A=+25 °C)

Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		V_{EE}	0	− 6.0	V
Input signal voltage		V_i	0	V_{EE}	V
Operating temperature		T_A	0	+ 50	℃
Storage temperature		T_{stg}	− 30	+ 70	℃
Humidity		H	10	90	%
Soldering	temperature	T_s	−	260	℃
	time	t_s	−	10	Sec

CHARACTERISTICS (T_c=25 °C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Signal bit rate	B_R	4B5B NRZI	125Mb/s ± 50ppm			−
Optical output power	P_F	Peak value Fiber : core 50um NA 0.21	− 20	−	− 15	dBm
Wavelength	λ_P	−	1270	1300	1380	nm
Spectral width	$\Delta\lambda$	−	−	140	−	nm
Optical receiving level (peak value)	P_R	BER < 2.5×10^{-10} DATA : PRBS2^{10}-1	− 31	−	− 15	dBm
Input/output interface	−	−	DIFF, ECL (10KH)			−
Power supply voltage	V_{EE}	−	− 5.46	− 5.2	− 4.94	V
Power supply current	I_{EE}	V_{EE} = − 5.2V	−	650	750	mA
Optical device	−	InGaAsP/InP LED/InGaAs PD				−

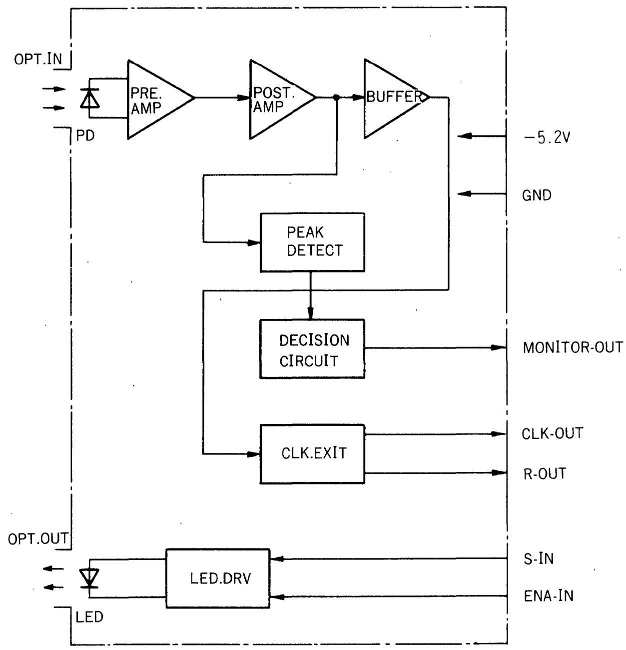
OUTLINE DRAWINGS Unit (mm)



PIN	FUNCTION
1	DATA OUT
2	CLK OUT
3	$\overline{\text{CLK OUT}}$
4	ALM OUT
5	−5.2V
6	DATA IN
7	$\overline{\text{DATA IN}}$
8	ENA IN
9	$\overline{\text{ENA IN}}$
10	$\overline{\text{DATA OUT}}$
11	GND1
12	GND2
13	$\overline{\text{ALM OUT}}$
14	GND3
15	GND4
16	GND5
17	GND6
18	GND7

MF-125DS-TR113-006

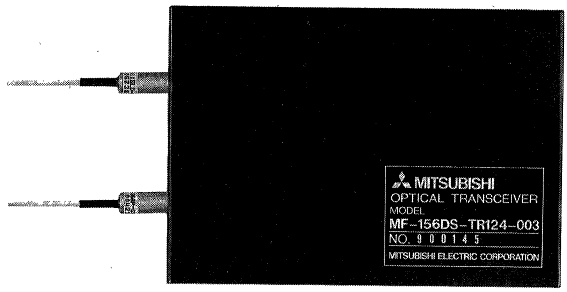
BLOCK DIAGRAM



MF-156DS-TR124-002/003

Digital Optical Transceiver Module with Clock Recovery

MF-156DS-TR124-002/003 is a high performance transceiver for CCITT SDH and ANSI SONET application. It combines both transmitting and receiving function, and its optical devices are InGaAsP LD and Ge APD.
This transceiver can operate with single −5.2V power supply and offer "ENABLE" input to shutdown the laser, "REC ALM" for optical input signal detection and clock recovery.



MF-156DS-TR124-003

FEATURES

- Operation 155.52Mb/s (NRZ)
- CCITT SDH (STM-1) compliant
- Transmitter and Receiver combines in one package
- Compact package by monolithic specific IC technology
- Transmitter-disable option
- Receiver failed alarm option
- Single −5.2V power supply
- ECL logic interface

ABSOLUTE MAXIMUM RATINGS (T_A=+25°C)

Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		V_{EE}	0	−6	V
Input signal voltage		V_I	0	V_{EE}	V
Soldering	temperature	T_s	−	260	℃
	time	t_s	−	10	Sec
Operating ambient temperature		T_A	+10	+55	℃
Storage temperature		T_{stg}	−20	+70	℃
Relative Humidity*		RH	10	90	%

* without making drops

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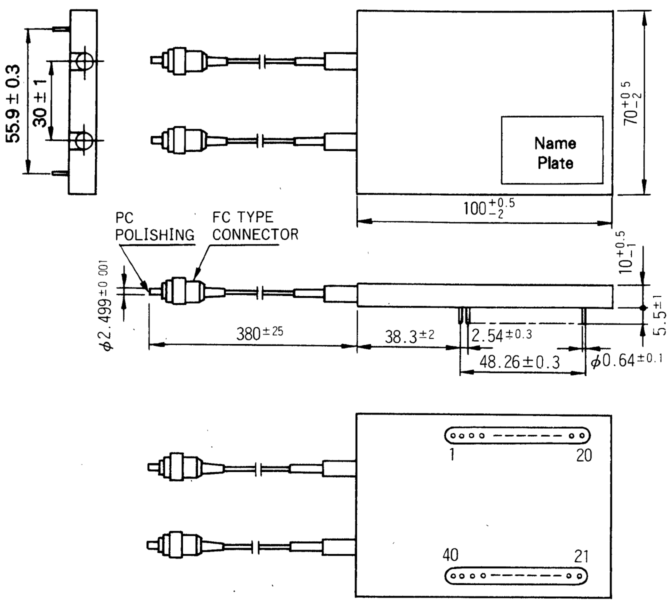
OUTLINE DRAWINGS Unit (mm)

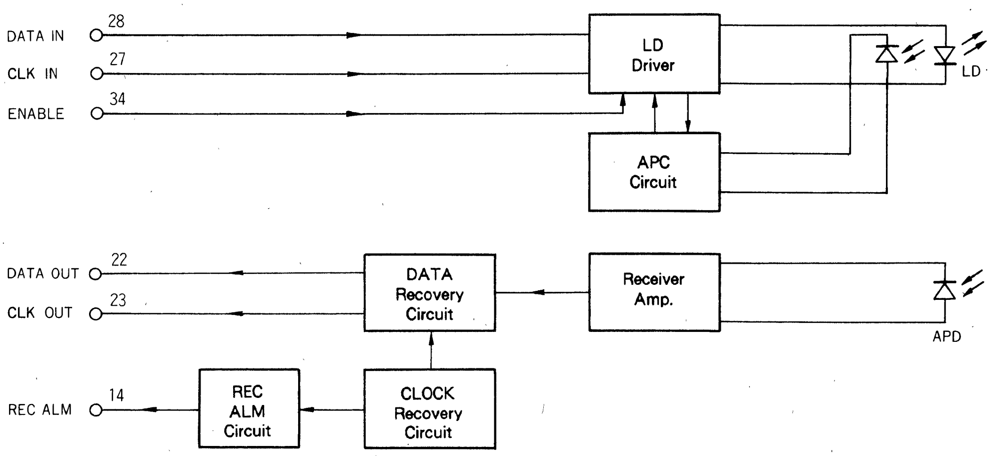
PIN ASSIGNMENT

PIN No.	FUNCTION
1, 29, 31, 36, 38, 39, 40	NC
2~13, 15, 16, 19, 20, 21, 24, 26, 30, 32, 33, 35, 37	GND
14	REC ALM
17	V_{EE} 1
18	V_{EE} 2
22	DATA OUT
23	CLK OUT
25	V_{EE} 3
27	CLK IN
28	DATA IN
34	ENABLE



MF-156DS-TR124-002/003

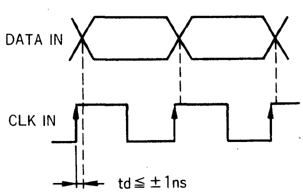
BLOCK DIAGRAM

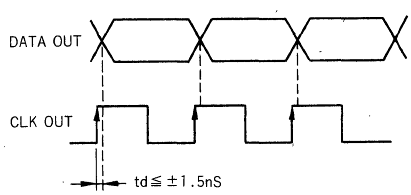


CHARACTERISTICS

Items \ Model Name	MF-156DS-TR124-002	MF-156DS-TR124-003
Signal bit rate	155.52Mb/s ± 20ppm	
Optical modulation	Intensity Modulation	
Line pattern/code	$PN2^{23}-1$ unipolar NRZ	
Optical device (transmitter)	LD	
Center wavelength	1285~1335mm	
Spectral width	4nm (rms)	7.7nm (rms)
Optical output power	−1~−4dBm	−9~−12dBm
Optical device (receiver)	APD	
Receiver Sensitivity (average value) PRBS $2^{23}-1$	−16dBm~−37dBm	−9dBm~−35dBm
Bit error rate	$\leqq 1 \times 10^{-9}$	$\leqq 1 \times 10^{-9}$
Electrical interface *1	unipolar NRZ / ECL (10KH compatible)	
Optical interface	FC connector SM10/125	
Power supply *2	−5.2V ± 5%	
Power consumption	550mA max (TYP 460mA)	

* 1● Electrical input and output interface condition.





● 680Ω/−5.2V pull down resistance is built in for DATA IN and CLK IN.
● 680Ω/−5.2V pull down resistance is built in for ENABLE input.
(ECL "H" disables the optical output power.)
● Pull down resistance is not built in for DATA OUT, CLK OUT or REC ALM OUT. Please prepare 680Ω/−5.2V for each signal by customer's side.
(When optical input signal shuts down, REC ALM OUT changes from "L" to "H".)

* 2● Please reduce noise or ripple less than 10mVP-P at power supply input.

MF-622DF-T12-007~011

Optical Transmitter and Receiver Module

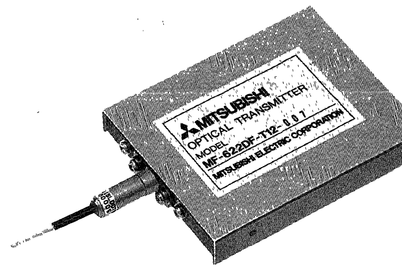
FEATURES

MF-622DF-T12-007
- 1.3μm multi-mode laser
- Application for interconnect distances less than 2km
- I-4 Standard
- Without cooler

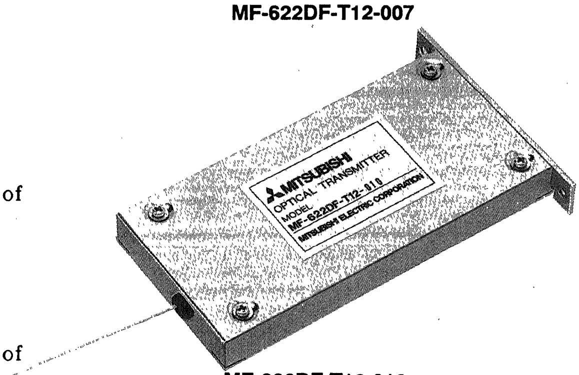
MF-622DF-T12-008
- 1.3μm multi-mode laser
- Application for interconnect distances of approximately 15km
- S-4.1 Standard
- Without cooler

MF-622DF-T12-009(without cooler)
MF-622DF-T12-010(with cooler)
- 1.3μm single-mode laser(DFB laser)
- Application for interconnect distances of approximately 40km
- L-4.1a Standard

MF-622DF-T12-011
- 1.55μm single-mode laser(DFB laser)
- Application for interconnect distances of approximately 60km
- L-4.2 Standard
- With cooler



MF-622DF-T12-007



MF-622DF-T12-010

ABSOLUTE MAXIMUM RATINGS (T_A=+25 °C)

Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		V_{EE}	0	−6	V
Input signal voltage		V_I	0	V_{EE}	V
Soldering	temperature	T_s	−	260	℃
	time	t_s	−	10	Sec
Storage temperature		T_{stg}	−20	+70	℃
Relative Humidity*		RH	10	90	%

* without making drops

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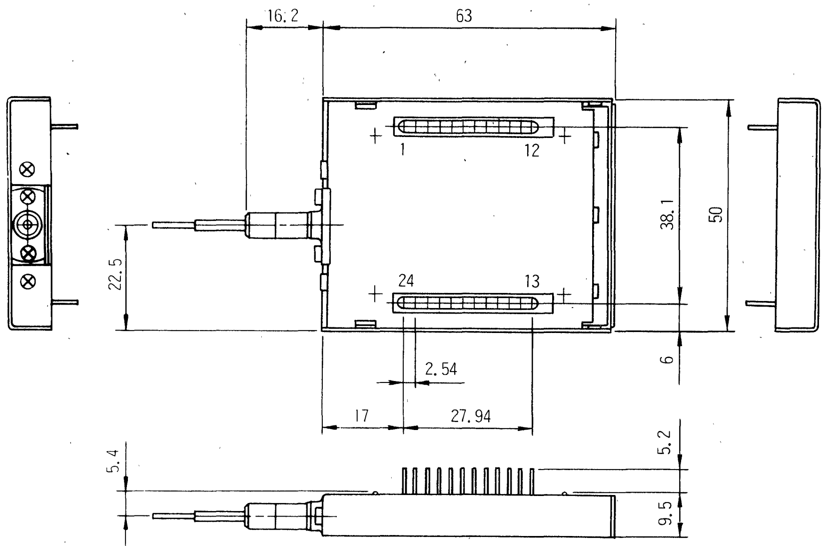
CHARACTERISTICS

Items	MF-622DF-T12-007	MF-622DF-T12-008	MF-622DF-T12-009	MF-622DF-T12-010 (with Isolator)	MF-622DF-T12-011 (with Isolator)	Units
Bit Rate	622.08					Mb/s
Code	NRZ					–
Source	MLM-LD	MLM-LD	DFB	DFB	DFB	–
Optical Output Power ave.	−15~−8	−15~−8	−4~0	−4~0	−4~+1	dBm
Center Wavelength	1270~1355	1270~1355	1270~1335	1270~1335	1530~1570	nm
Spectral Width	≦35	≦2.5	–	–	–	nm
Optical Fiber	SMF					–
Extinction Ratio	≧10					dB
Mask Pattern	CCITT Recommended Mask					–
Max Dispersion Penalty	1					dB
Dispersion	11	80	110	110	250	ps/nm
Operating Temperature	0~55	0~55	0~55	0~55	0~55	℃
Power Supply	−5.2±5% 200 max.	−5.2±5% 200 max.	−5.2±5% 200 max.	−5.2±5% 200max. ±2(for cooler) 1000 max.	−5.2±5% 200 max. ±2(for cooler) 1000 max.	V mA V mA
Functions	Laser Bias Current Monitor. Laser Backface Monitor. Signal Disable. Optical Loss of Output					–

OUTLINE DRAWINGS Unit (mm)

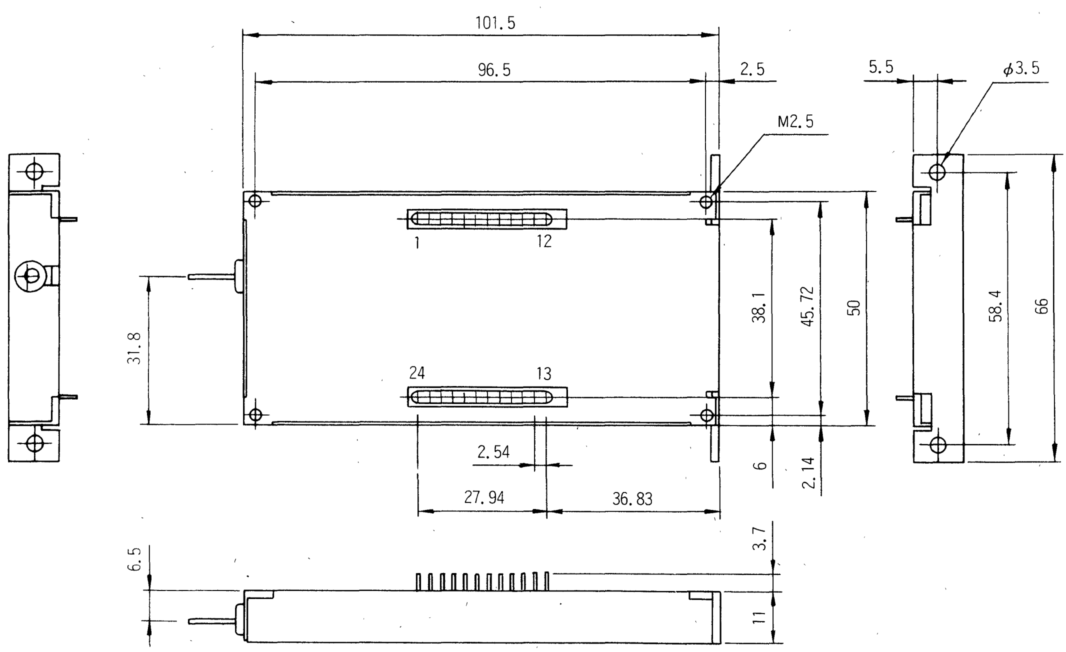


MF-622DF-T12-007/008/009

PIN ASSIGNMENT

Pin No.	Parameter
1	GND
2	GND
3	−5.2V
4	−5.2V
5	OPEN
6	GND
7	DATA
8	GND
9	GND
10	GND
11	GND
12	GND
13	GND
14	LASER BIAS CURRENT MONITOR(+)
15	LASER BIAS CURRENT MONITOR(−)
16	LASER BACKFACE MONITOR(+)
17	LASER BACKFACE MONITOR(−)
18	SIGNAL DISABLE
19	GND
20	ALARM OUTPUT
21	TEMPERATURE MONITOR(+)[1]/OPEN[2]
22	TEMPERATURE MONITOR(−)[1]/OPEN[2]
23	COOLER (+)[1]/GND[2]
24	COOLER (−)[1]/GND[2]

1 With cooler
2 Without cooler



MF-622DF-T12-010/011

MITSUBISHI ELECTRIC

MF-622DS-R13-002/R14-002,003

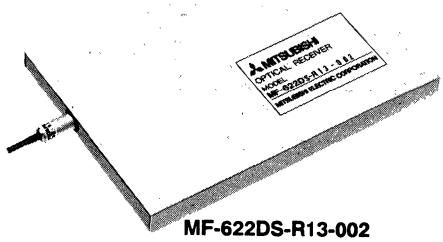
Optical Transmitter and Receiver Module

FEATURES

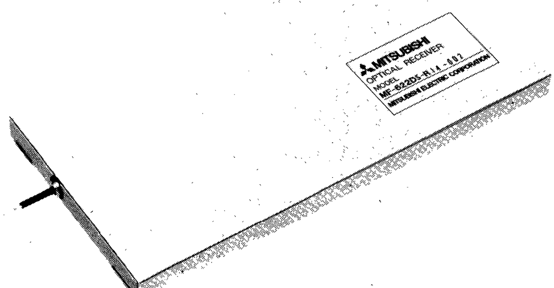
MF-622DS-R13-002
- Operation is the 1.3 μm wavelength window
- Low cost InGaAs PIN PD
- I-4.1 Standard

MF-622DS-R14-002
- Operation is the 1.3 μm wavelength window
- Low cost Ge APD and wide dynamic range
- Both S-4.1 and L-4.1a Standard

MF-622DS-R14-003
- Operation is the 1.55 μm wavelength window
- High sensitivity InGaAs APD
- L-4.2 Standard



MF-622DS-R13-002



MF-622DS-R14-002,003

ABSOLUTE MAXIMUM RATINGS (T_A=+25 ℃)

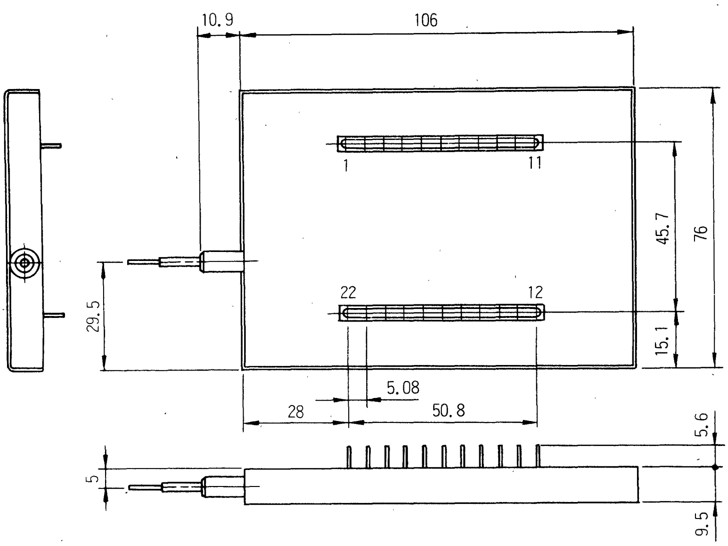
Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		V_{EE}	0	−6	V
		V_{CC}		+6	
Input signal voltage		V_I	0	V_{EE}	V
Soldering	temperature	Ts	−	260	℃
	time	ts	−	10	Sec
Storage temperature		T_{stg}	−20	+70	℃
Relative Humidity*		RH	10	90	%

* without making drops

CHARACTERISTICS

Items	MF-622DS-R13-002	MF-622DS-R14-002	MF-622DS-R14-003	Units
Bit Rate	622.08 ± 20ppm			Mb/s
Line Pattern	$PN2^{23}-1$			−
Code	NRZ			−
Wavelength Window	1310	1310	1550	nm
Optical Fiber	MMF (GI50/125)			
Sensitivity	−23∼−8	−29∼−8	−33∼−17	dBm
Jitter Tolerance	CCITT Recommended Mask			−
Operating Temperature	0∼55			℃
Power Supply	−5.2±5% 500 max / +5.0±5% 100 max	−5.2±5% 750max / +5.0±5% 100 max		V mA
Function	Loss of Signal Status			−

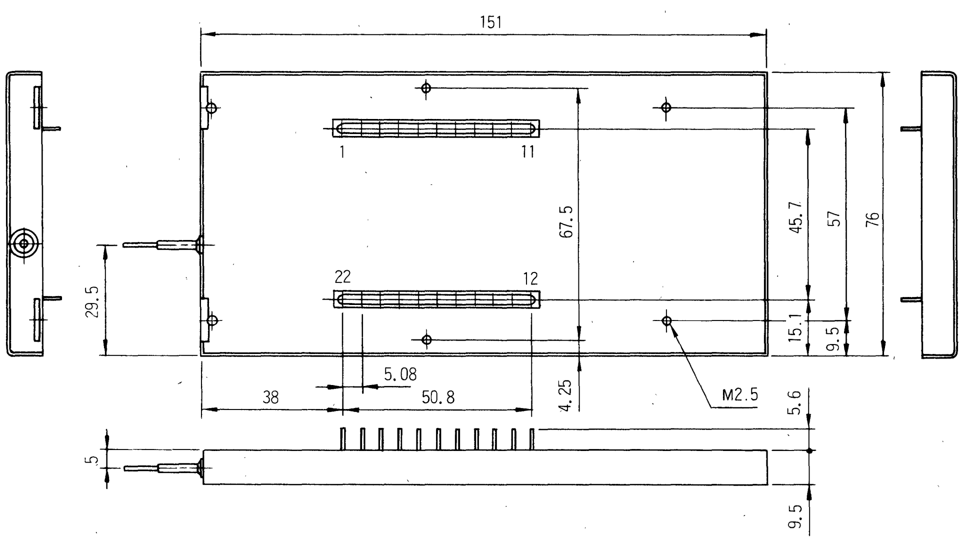
OUTLINE DRAWINGS Unit (mm)



MF-622DS-R13-002

PIN ASSIGNMENT

Pin No.	Parameter
1	GND
2	LOSS OF SIGNAL
3	GND
4	OPEN
5	GND
6	DATA OUTPUT
7	GND
8	OPEN
9	GND
10	CLOCK OUTPUT
11	GND
12	GND
13	OPEN
14	GND
15	− 5.2V
16	GND
17	OPEN
18	GND
19	+ 5.0V
20	GND
21	OPEN
22	OPEN

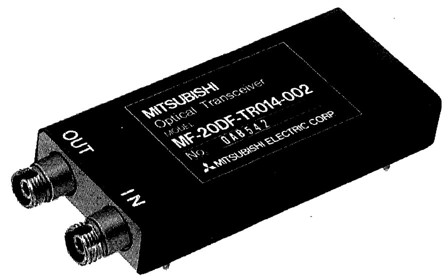


MF-622DS-R14-002,003

MF-20DF-TR014-002

Digital Optical Transciver

MF-20DF-TR014-002 is a fiber optic transciver designed for operation at data rate 5~10Mb/s (Manchester code). It combines both transmitting and resciving function.



MF-20DF-TR014-002

FEATURES

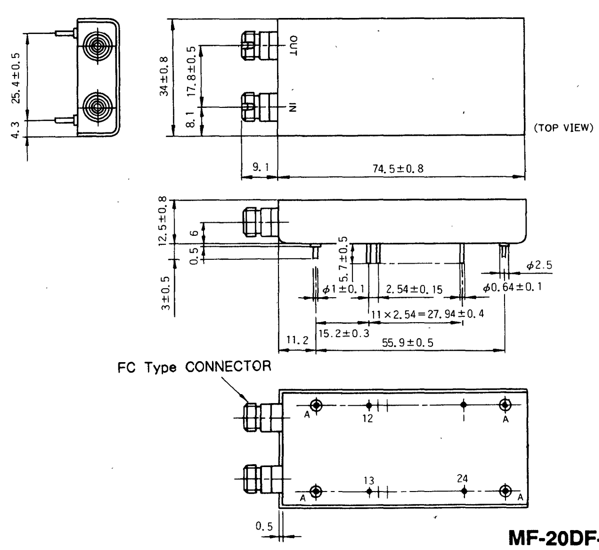
- Transmitter and Receiver combines in one package
- 5~10Mb/s operation (Manchester code, packet data)
- High power 850nm LED optical output
- Wide dynamic renge (16dB)
- High Sensitivity (MIN-46dBm average value)
- Single +5V power supply
- TTL input/output interface

ABSOLUTE MAXIMUM RATINGS (T_A=+25°C)

Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		Vcc	0	+6.0	V
Input signal voltage		Vi	0	Vcc	V
Operating ambient temperature		Ta	0	+60	℃
Storage temperature		Tst	−30	+70	℃
Relative Humidity *1		RH	10	85	%
Soldering	temperature	Ts	−	260	℃
	time	ts	−	10	Sec
Optical input power *2		PA	−	−24	dBm

NOTES :
*1. without making drops
*2. average value

OUTLINE DRAWINGS Unit (mm)



PIN ASSIGNMENT

PIN No.	FUNCTION
13, 17~24	RX GND
16	TX DATA
15	Vcc (TX)
14	TX GND
4, 6	N/C
7~12	RX GND
5	RX DATA
2, 3	Vcc (RX)
1	CASE GND

MF-20DF-TR014-002

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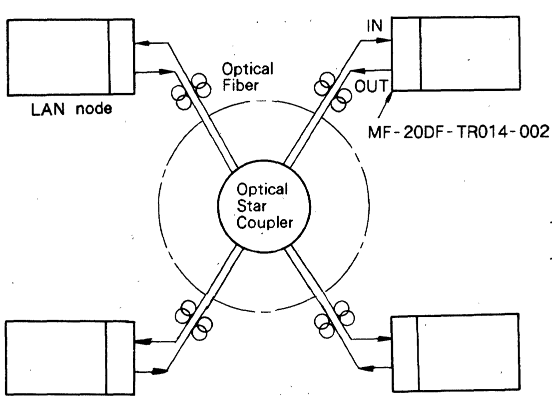
CHARACTERISTICS (Tc=25 °C)

Items		Symbols	Min.	Typ.	Max.	Units
Signal bit rate (Manchester code)		B_r	5	–	10	Mb/s
Optical modulation		–	Intensity modulation			–
Center wavelength		λc	800	850	910	nm
Spectral width		$\Delta\lambda$	–	45	60	nm
Optical output power (average value)	* 1	P_f	– 17	– 15.5	– 14	dBm
Receiver Sensitivity (average value)		P_r	– 46	–	– 30	dBm
Bit error rate		BER	10^{-9}			–
Pulse distortion		ΔW	–	–	± 15 %	%
Optical connector type		–	FC – 01PN (PC connector)			–
Electrical interface		V_i	TTL			–
Power supply	* 2	Vcc	+ 4.75	+ 5.0	+ 5.25	V
Power consumption		Icc	–	250	340	mA

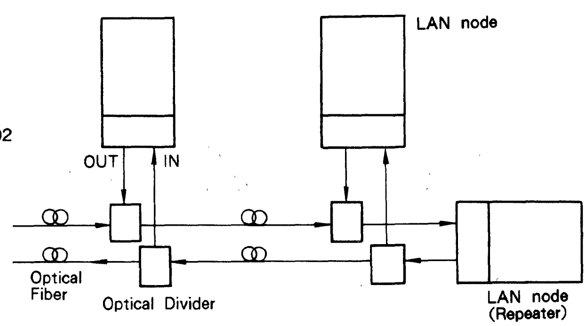
NOTES :
* 1. Test Optical Fiber : core dia. 50 μm, Clad dia. 125 μm, N.A.0.2, length 1m.
* 2. Please reduce noise or ripple less than 50mVP-P at power supply input.

APPLICATIONS CASE FOR LOCAL AREA NETWORK

application case to use optical star coupler



application case to use optical Divider

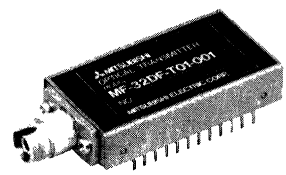


MITSUBISHI ELECTRIC

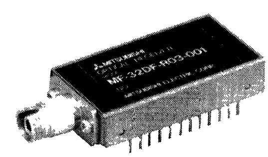
MF-32DF-T01/R03

Digital Optical Transmitter/Receiver Module

The MF-32DF-T01/R03 is a fiber optic transmitter/receiver pair designed for operation at data rates from 3 to 32Mb/s. The transmitter includes a 850nm lensed LED. The receiver uses an Si PIN photodetector. Both LED and photodetector are coupled to a standard 50 micron core FC-type connector.



MF-32DF-T01



MF-32DF-R03

FEATURES

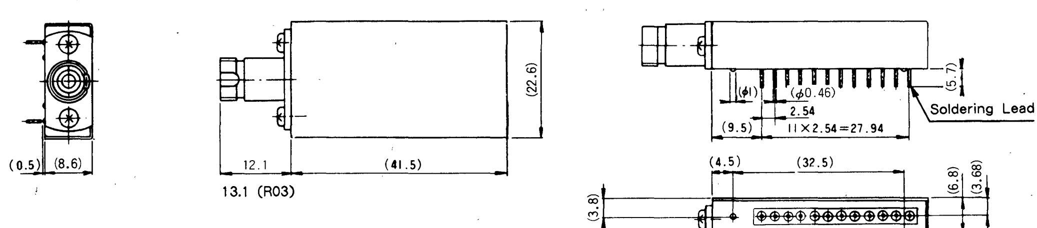
- Dual-in-line-package
- High power 850nm LED transmitter
- Wide dynamic range receiver
- ECL input/output interface
- 3Mb/s to 32Mb/s operation (NRZ)

ABSOLUTE MAXIMUM RATINGS (T_A=25 °C)

Items		Symbols	Ratings		Units
			Min.	Max.	
Power supply voltage		V_{EE1} *	0	−6	V
		V_{CC1} **	0	+6	V
		V_{EE2} **	0	−6	V
Input signal voltage		V_i	V_{EE}	0	V
Operating temperature		T_C	0	+50	℃
Storage temperature		T_{stg}	−30	+70	℃
Soldering	temperature	T_s	−	260	℃
	time	t_s	−	10	Sec

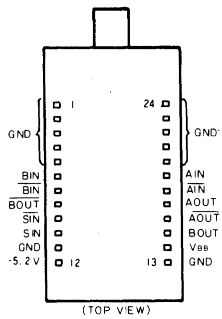
* Transmitter
* * Receiver

OUTLINE DRAWINGS Unit (mm)

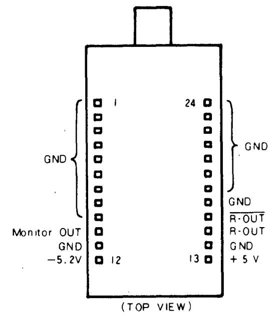


MF-32DF-T01/R03

PIN ARRANGEMENT



MF-32DF-T01



MF-32DF-R03

CHARACTERISTICS (Tc=25 °C)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units
Signal bit rate	B_R	NRZ(Duty ratio 40~60%)	3	–	32	Mb/s
Optical output power	P_F	Peak value Fiber : core 50 μm NA0.2	– 16	– 14	– 12	dBm
Wavelength	λ_P	–	780	840	880	nm
Spectral width	$\Delta\lambda$	–	–	45	–	nm
Optical receiving level	P_R	BER < 10^{-9} DATA : PRBS2^{10-1} PEAK VALUE	– 31	–	– 13	dBm
Input/output interface	–		Differential ECL OR ECL10K			
Power supply current	I_{EE1}*	V_{EE1} = – 5.2V	–	200	240	mA
	I_{CC1}**	V_{CC1} = 5V	–	60	70	
	I_{EE2}**	V_{EE2} = – 5.2V	–	60	70	

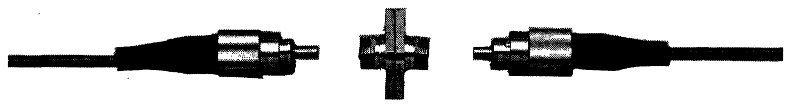
* Transmitter
* * Receiver

MITSUBISHI ELECTRIC

FC-01PN-SMF, FC-01PN•PC-SMF, FC-01PN•SPC-SMF,FC-01RN(S)

Optical Connector with Singlemode Fiber

The optical fiber connector is used for optical fiber connections and also connections of optical fiber and various components.



FC-01PN-(L)-SMF, FC-01PNW-(L)-SMF, FC-01PN-(L)•PC-SMF, FC-01PNW-(L)•PC-SMF
FC-01PN-(L)•SPC-SMF, FC-01PNW-(L)•SPC-SMF, FC-01RN(S)

FEATURES

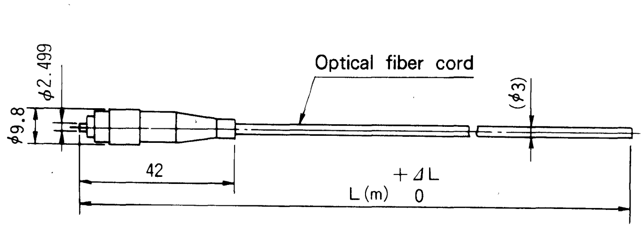
- Low coupling loss
- High reliability

CHARACTERISTICS

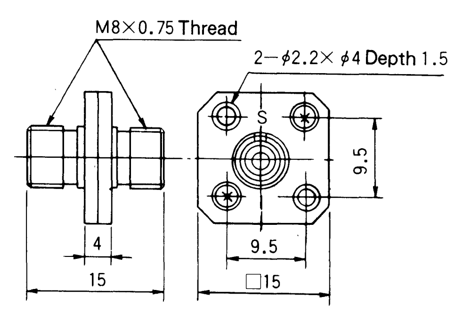
Items \ Name/type	Optical fiber connector plug with singlemode fiber						Adapter
	FC-01PN-(L)-SMF (Note 2)	FC-01PNW-(L)-SMF	FC-01PN-(L)•PC-SMF	FC-01PNW-(L)•PC-SMF	FC-01PN-(L)•SPC-SMF	FC-01PNW-(L)•SPC-SMF	FC-01RN(S) (Note 3)
Coupling loss	1dB Max. (Note 1)		1dB Max. (Note 1)		1dB Max. (Note 1)		–
Return loss	–		27dB Max.		40dB Max.		–
Number of times for connection	> 1,000 times						
Temperature	– 20~60℃						
Humidity	< 95%						
End surface of ferrule	Flat		Sphere (PC connector)		Sphere (Super-PC connector)		–

Note 1 : This value is for two optical connectors connected with adapter.
The values corresponding to singlemode fiber with mode field dia. 10 μm.
Note 2 : L = optical-fiber cord length.
Note 3 : for connector plug with single mode fiber.

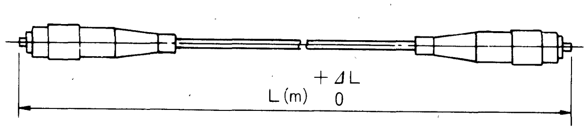
OUTLINE DRAWINGS Unit (mm)



FC-01PN-(L)-SMF
FC-01PN-(L)•PC-SMF
FC-01PN-(L)•SPC-SMF



FC-01RN(S)



FC-01PNW-(L)-SMF
FC-01PNW-(L)•PC-SMF
FC-01PNW-(L)•SPC-SMF

L < 1m : ΔL = 100mm
1m ≦ L < 2m : ΔL = 200mm
2m ≦ L : ΔL = 0.1 × L

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ORDERING METHOD

Details for ordering are shown below. Please, advise the length of optical fiber cord and the number of units.

Model No.	Optical fiber cord length	Kinds of optical fiber	End surface of ferrule
FC-01PN-(1)SMF	1m	If not assigned, single-mode fiber with mode field dia. 10 μ m standard will be supplied.	Flat
FC-01PN-(3)SMF	3m		
FC-01PN-(5)SMF	5m		
FC-01PN-(L)SMF	Assigned length Lm		
FC-01PNW-(1)SMF	1m		
FC-01PNW-(3)SMF	3m		
FC-01PNW-(5)SMF	5m		
FC-01PNW-(L)SMF	Assigned length Lm		
FC-01PN-(1)• PC-SMF	1m		Sphere (PC connector)
FC-01PN-(3)• PC-SMF	3m		
FC-01PN-(5)• PC-SMF	5m		
FC-01PN-(L)• PC-SMF	Assigned length Lm		
FC-01PNW-(1)• PC-SMF	1m		
FC-01PNW-(3)• PC-SMF	3m		
FC-01PNW-(5)• PC-SMF	5m		
FC-01PNW-(L)• PC-SMF	Assigned length Lm		
FC-01PN-(1)• SPC-SMF	1m		Sphere (Super-PC connector)
FC-01PN-(3)• SPC-SMF	3m		
FC-01PN-(5)• SPC-SMF	5m		
FC-01PN-(L)• SPC-SMF	Assigned length Lm		
FC-01PNW-(1)• SPC-SMF	1m		
FC-01PNW-(3)• SPC-SMF	3m		
FC-01PNW-(5)• SPC-SMF	5m		
FC-01PNW-(L)• SPC-SMF	Assigned length Lm		

FC-01PN, FC-01PN•PC, FC-01PN•SPC, FC-01RN

Optical Connector with Multimode Fiber

The optical fiber connector is used for optical fiber connections and also connections of optical fiber and various components.

FC-01PN-(L), FC-01PNW-(L), FC-01PN-(L)•PC, FC-01PNW-(L)•PC
FC-01PN-(L)•SPC, FC-01PNW-(L)•SPC, FC-01RN

FEATURES

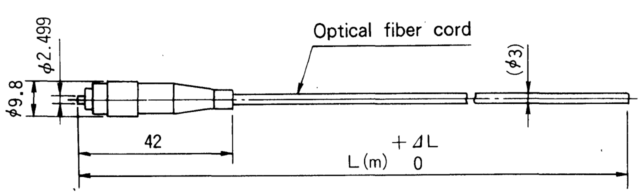
- ■ Low coupling loss
- ■ High reliability

CHARACTERISTICS

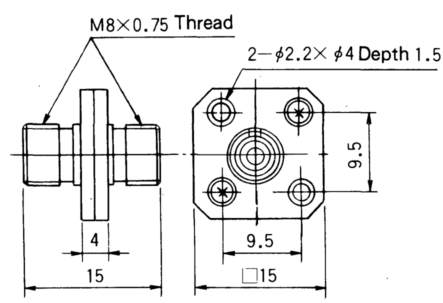
Items \ Name/type	Optical fiber connector plug with GI50/125 optical fiber						Adapter
	FC-01PN-(L) (Note 2)	FC-01PNW-(L)	FC-01PN-(L) • PC	FC-01PNW-(L) • PC	FC-01PN-(L) • SPC	FC-01PNW-(L) • SPC	FC-01RN
Coupling loss	1dB Max. (Note 1)		0.25dB Max. (Note 1)		0.25dB Max. (Note 1)		–
Return loss	–		27dB Max.		40dB Max.		–
Number of times for connection	> 1,000 times						
Temperature	– 20~60℃						
Humidity	< 95%						
End surface of ferrule	Flat		Sphere(PC connector)		Sphere(Super-PC connector)		–

Note 1 : This value is for two optical connectors connected with adapter.
The values corresponding to GI-50/125(core dia. 50 μm. clad dia. 125 μm. N.A.0.2)optical fiber.
Note 2 : L = optical-fiber cord length.

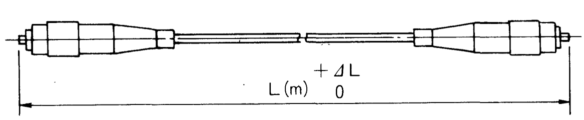
OUTLINE DRAWINGS Unit (mm)



FC-01PN-(L)
FC-01PN-(L)•PC
FC-01PN-(L)•SPC



FC-01RN



FC-01PNW-(L)
FC-01PNW-(L)•PC
FC-01PNW-(L)•SPC

L < 1m : ΔL = 100mm
1m ≦ L < 2m : ΔL = 200mm
2m ≦ L : ΔL = 0.1 × L

ORDERING METHOD

Details for ordering are shown below. Please, advise the length of optical fiber cord and the number of units.

Model No.	Optical fiber cord length	Kinds of optical fiber	End surface of ferrule
FC-01PN-(1)	1m	If not assigned, type GI-50/125 standard will be supplied.	Flat
FC-01PN-(3)	3m		
FC-01PN-(5)	5m		
FC-01PN-(L)	Assigned length Lm		
FC-01PNW-(1)	1m		
FC-01PNW-(3)	3m		
FC-01PNW-(5)	5m		
FC-01PNW-(L)	Assigned length Lm		
FC-01PN-(1)•PC	1m		Sphere (PC connector)
FC-01PN-(3)•PC	3m		
FC-01PN-(5)•PC	5m		
FC-01PN-(L)•PC	Assigned length Lm		
FC-01PNW-(1)•PC	1m		
FC-01PNW-(3)•PC	3m		
FC-01PNW-(5)•PC	5m		
FC-01PNW-(L)•PC	Assigned length Lm		
FC-01PN-(1)•SPC	1m		Sphere (Super-PC connector)
FC-01PN-(3)•SPC	3m		
FC-01PN-(5)•SPC	5m		
FC-01PN-(L)•SPC	Assigned length Lm		
FC-01PNW-(1)•SPC	1m		
FC-01PNW-(3)•SPC	3m		
FC-01PNW-(5)•SPC	5m		
FC-01PNW-(L)•SPC	Assigned length Lm		

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