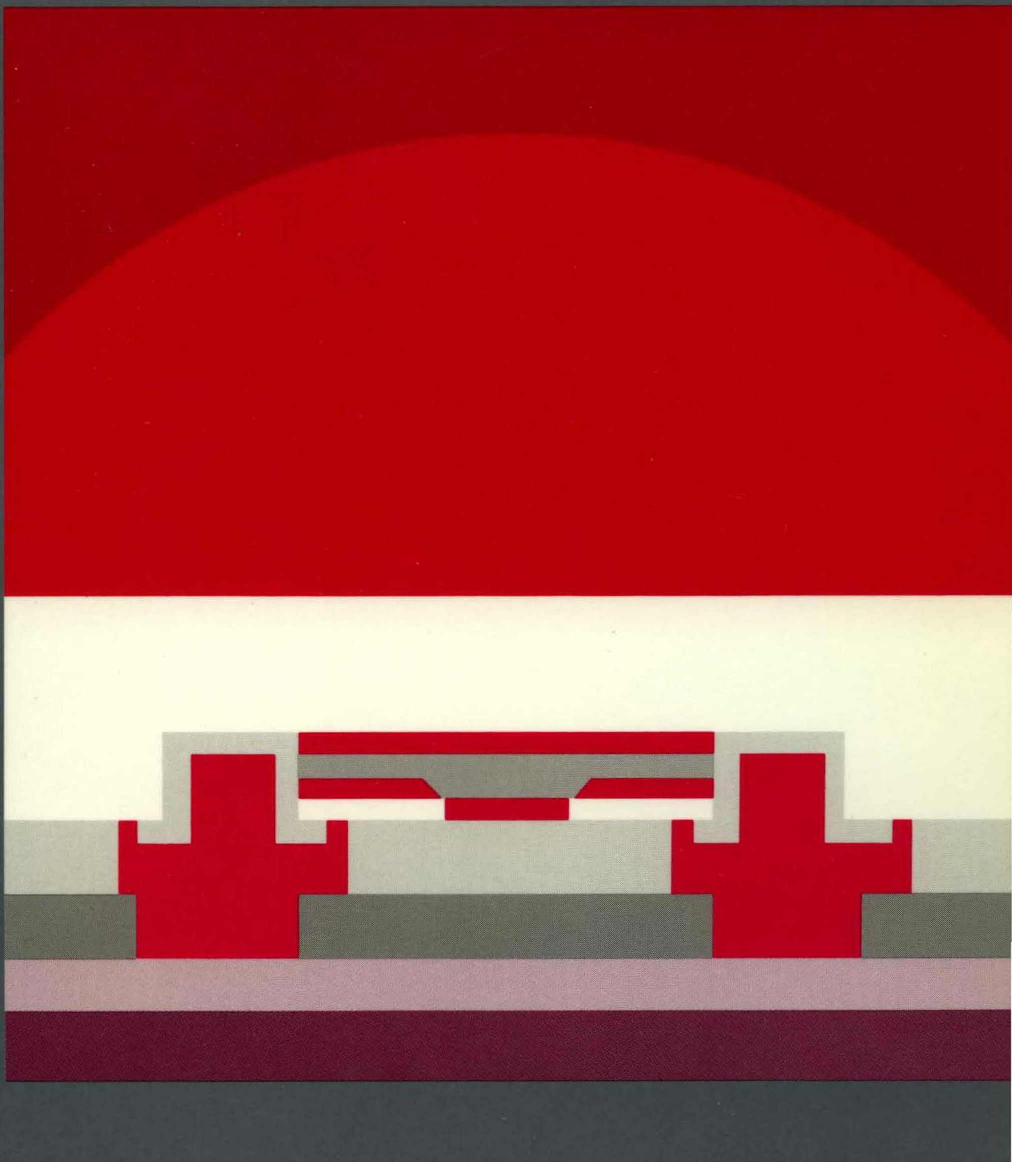
October, 1985

HITACHI

OPTOELECTRONIC DEVICES DATA BOOK



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INTRODUCTION

With the rapid progress that has been made in recent years, optoelectronic semiconductor applications have become commonplace in such optical systems as transmission equipment, information terminals, video/audio disc players, measurement equipment, medical apparatuses, and much more. Hitachi, for its part, has contributed to optimization of these systems by developing superior optoelectronic semiconductors that demonstrate compact size, light weight, low power consumption, high collimating efficiency, excellent monochromaticity, and high speed direct modulation capability. This data book contains product lineups, operational features as well as device characteristics, application hints, and data sheets for Hitachi laser diodes (LDs), infrared emitting diodes (IREDs) and photodetectors (PDs).

SAFETY CONSIDERATIONS

Be sure to avoid direct exposure of human eyes to high power laser beams emitted from laser diodes. Even though barely visible to the human eye, they can be quite harmful. In particular, avoid looking directly into a laser diode or collimated beam along its optical axis when the diode is activated. One simple way to determine the optical path is to use a phosphor plate or infrared sensitive camera.

Hitachi certifies compliance with US Safety Regulations (21 CFR Subchapter J) on laser products, as stipulated by the U.S. Department of Health and Human Services. The Hitachi products shown here correspond to the category "CLASS IIIb LASER PRODUCT" in this regulation.

DANGER

"INVISIBLE LASER RADIATION-AVOID DIRECT EXPOSURE TO BEAM"

PEAK POWER 30mW "CLASS IIIb LASER PRODUCT"
WAVELENGTH 760 ~ 1350nm

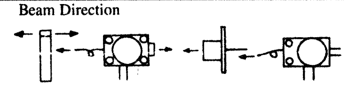
This product conforms to FDA regulations 21 CFR Subchapter J.

AVOID EXPOSURE—Laser invisible radiation is emitted from glass window and monitor-output guide, or from fiber-pigtail end and monitor-output guide, or from laser chip mounted on top of header. Before use, consult appropriate catalogs or manuals.

LASER SAFETY

This laser device in operation produces invisible laser radiation which may be harmful to the human eye. Avoid directly looking into the device or the collimated beam along its optical axis when the device is in operation.

Beam Direction



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When using this manual, the reader should keep the following in mind:

1. This manual may, wholly or partially, be subject to change without notice.
2.
3. Hitachi will not be responsible for any damage to the user that may result from accidents or any other reasons during operation of his unit according to this manual.
4. This manual neither ensures the enforcement of any industrial properties or other rights, nor sanctions the enforcement right thereof.
5. Circuitry and other examples described herein are meant merely to indicate characteristics and performance of Hitachi semiconductor-applied products. Hitachi assumes no responsibility for any patent infringements or other problems resulting from applications based on the examples described herein.

October 1985 Printed in U.S.A.

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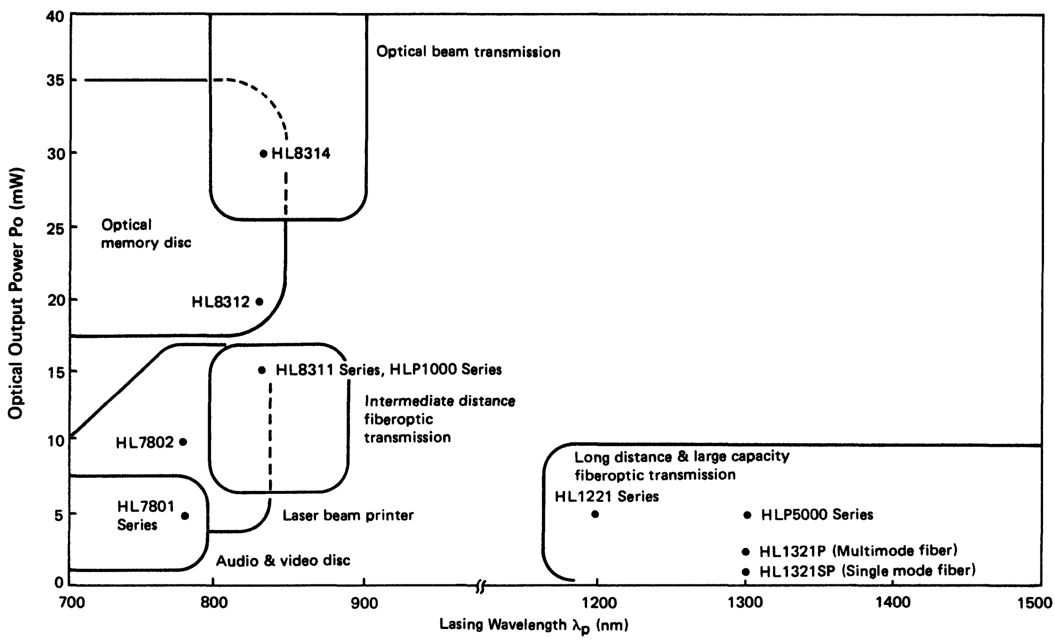
GENERAL INFORMATION

SELECTION GUIDE

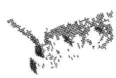
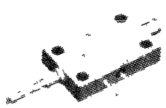
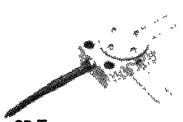
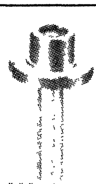
1. PRODUCTS LINEUP

1.1 Laser Diode (LD) Lineup and Main Characteristics

- **Lineup and Applications**



- **Package Variations**

Packages	λp / Product Series	760 ~ 800nm	800 ~ 850nm	1170 ~ 1230nm	1270 ~ 1330nm	Features
		HL7801 Series HL7802	HLP1000 Series HL8311 Series HL8312 HL8314	HL1221 Series	HLP5000 Series HL1321 Series	
Open-Air Type	 400-Type (A-Type)		HLP1400	HL1221A	HLP5400	o For experimental use o Small stray capacitance o Optics can be set close to laser facet
Fiber Pigtail Type	 500-Type (B-Type)		HLP1500	HL1221B	HLP5500	o For optical transmission o Laser output from fiber pigtail o Built-in photodetector for monitoring in P-and SP-types o Monitor output from monitor guide in 500-type o High reliability
Fiber Pigtail Type	 SP-Type				HL1321P HL1321SP*	
Hermetic Seal Type	 600-Type (C-Type)		HLP1600	HL1221C	HLP5600	o Built-in photodetector for monitoring in E-and G-types o Hermetically sealed with glass window for 600-type o Monitor output power from monitor guide in 600-type o For laser beam printer, beam transmission, optical disc and measuring system use
Hermetic Seal Type	 E-Typ**	HL7801E HL7802E	HL8311E HL8312E HL8314E			
Hermetic Seal Type	 G-Type***	HL7801G	HL8311G			

* Provided with a Single Mode Fiber Pigtail.

** E type package is divided into two types by taking into account the glass window's diameter. (ϕ 2.1 mm. . .HL7801E, HL7802E; ϕ 3.0 mm. . .HL8311E, HL8312E, HL8314E).

*** G type package is divided into two types by taking account the glass window's diameter (ϕ 2.1 mm. . .HL7801G; ϕ 3.0 mm. . .HL8311G).

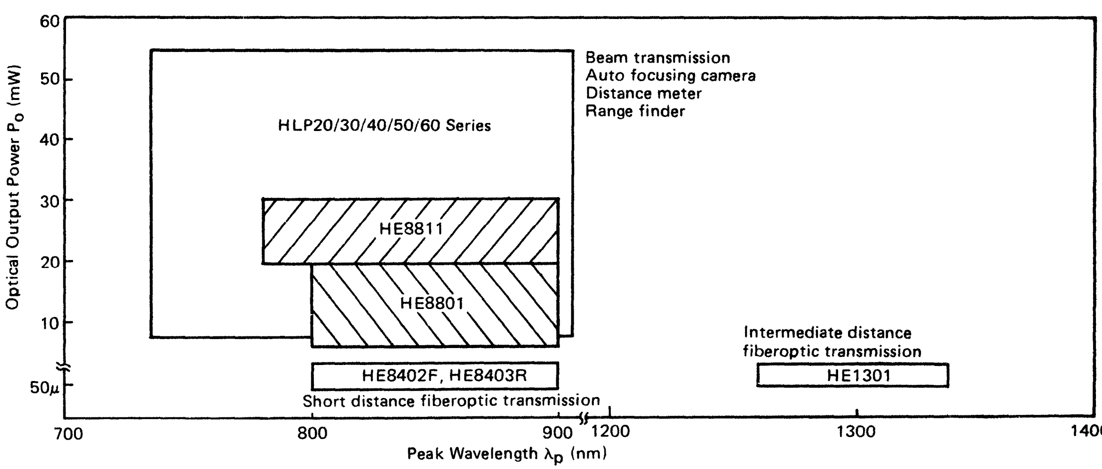
- **Main Characteristics (T_C=25°C)**

Part No.		Absolute Maximum Ratings: Optical Output Power P_O (mW)	Reverse Voltage V_R (V)	Operating Temperature T_{opr} (°C)	Storage Temperature T_{stg} (°C)	Optical and Electrical Characteristics: Lasing Wavelength λ_p (nm) min	typ	max	Beam Divergence $\theta_{//} \times \theta_{\perp}$ (deg.) typ	Test Condition P_O (mW)	Reference Page
HL7801 Series	HL7801E	5	2	-10 ~ +60	-40 ~ +80	760	780	800	15 x 30	3	57
	HL7801G										57
HL7802	HL7802E	10	2	-10 ~ +50	-40 ~ +80	770	785	800	11 x 30	10	60
HLP1000 Series	HLP1400	15	2	0 ~ +60	0 ~ +80	800	830	850	10 x 25	10	62
	HLP1500	6*			-40 ~ +70				–	4*	62
	HLP1600	15			-40 ~ +80				10 x 25	10	62
HL8311 Series	HL8311E	15	2	-10 ~ +60	-40 ~ +80	800	830	850	10 x 27	10	66
	HL8311G										66
HL8312	HL8312E	20	2	-10 ~ +50	-40 ~ +80	810	830	850	10 x 27	10	69
HL8314	HL8314E	30	2	-10 ~ +50	-40 ~ +80	810	830	850	10 x 27	30	72
HL1221 Series	HL1221A	5	2	0 ~ +50	0 ~ +60	1170	1200	1230	30 x 40	3	75
	HL1221B	1.2*			-40 ~ +60				–	0.5*	75
	HL1221C	5			-40 ~ +60				30 x 40	3	75
HLP5000 Series	HLP5400	5	2	0 ~ +50	0 ~ +60	1270	1300	1330	30 x 40	3	79
	HLP5500	1.2*			-40 ~ +60				–	0.5*	79
	HLP5600	5			-40 ~ +60				30 x 40	3	79
HL1321 Series	HL1321P	1.2*	2	0 ~ +50	-40 ~ +60	1270	1300	1330	–	0.5*	83
	HL1321SP**	1.0*								1.0*	86

* At the Fiber End
** Provided with a Single Mode Fiber Pigtail

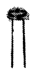
1.2 Infrared Emitting Diode (IRED) Lineup and Main Characteristics

- **Lineup and Applications**



1. PRODUCTS LINEUP

- **Package Variations**

Packages \ Product Series \ λ_p		735 ~ 905nm	780 ~ 1340 nm	Features
		HLP Series	HE Series	
Open-Air Type	 R-Type	HLP20R/30R/40R/50R/60R	HE8403R	o For experimental use o Optics can be set close to laser facet.
Hermetic Seal Type	 RG-Type	HLP20RG/30RG/40RG/50RG/60RG		o Hermetically sealed with flat glass o For auto focusing camera, beam or fiberoptic transmission and measuring system use o High reliability
	 SG-Type		HE8801 HE8811 HE1301	
	 F-Type		HE8402F	o Optical fiber rod inside ceramic ferrule o Easy coupling with external fiber

- **Main Characteristics (T_C=25°C)**

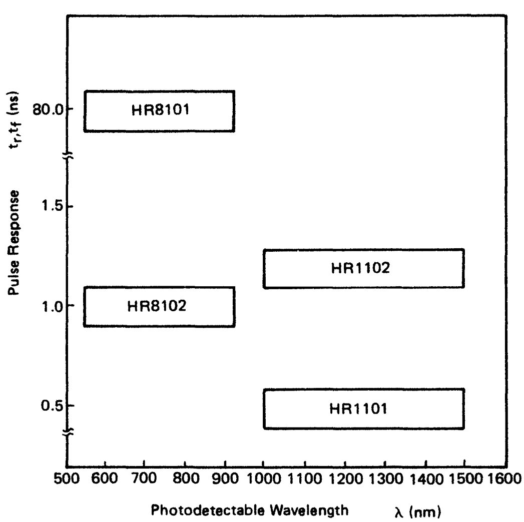
Part No.		Absolute Maximum Ratings				Optical and Electrical Characteristics										Reference Page
		Reverse Voltage V_R (V)	Power Dissipation P_d (mW)	Operating Temperature T_{opr} (°C)	Storage Temperature T_{stg} (°C)	Optical Output Power P_o (mW)	Peak Wavelength* λp (nm)				Spectral Width Δλ (nm)	Test Condition I_F (mA)	Capacitance C_j (pF)	Test Condition		
						min	A	B	C	D	typ		typ			
HLP Series	HLP20R	3	600	-20~+40	-40~+60	15	○				30	200	30	V_R=0, f=1MHz		91
	HLP30R					25	○	○	○	○						
	HLP40R					35	○	○	○	○						
	HLP50R					45		○	○	○						
	HLP60R					55		○	○	○						
	HLP20RG	3	600	-20~+60	-40~+80	7	○				30	200	30	V_R=0, f=1MHz		
	HLP30RG					12	○	○	○	○						
	HLP40RG					17	○	○	○	○						
	HLP50RG					22		○	○	○						
	HLP60RG					27		○	○	○						
HE Series	HE8801	3	400	-20~+60	-40~+90	6	800 ~ 900				30	150	10	V_R=0, f=1MHz		94
	HE8811	3	400	-20~+60	-40~+90	20	780 ~ 900				50	150	10			96
	HE8402F	3	350	-20~+60	-40~+90	40μ**	800 ~ 900				50	100	10			98
	HE8403R	3	350	-20~+40	-40~+60	50μ**	800 ~ 900				50	100	10			100
	HE1301†	0.3	300	-20~+60	-40~+90	15μ**	1260~1340				140	100	30			102

* HLP Series are grouped with peak wavelength as follows. ** At the fiber end † Preliminary specifications

Grade	λp (nm)		
	min	typ	max
A	735	760	785
B	775	800	825
C	815	840	865
D	855	880	905

1.3 Photodetector (PD) Lineup and Main Characteristics

- **Lineup**



- **Package Variations**

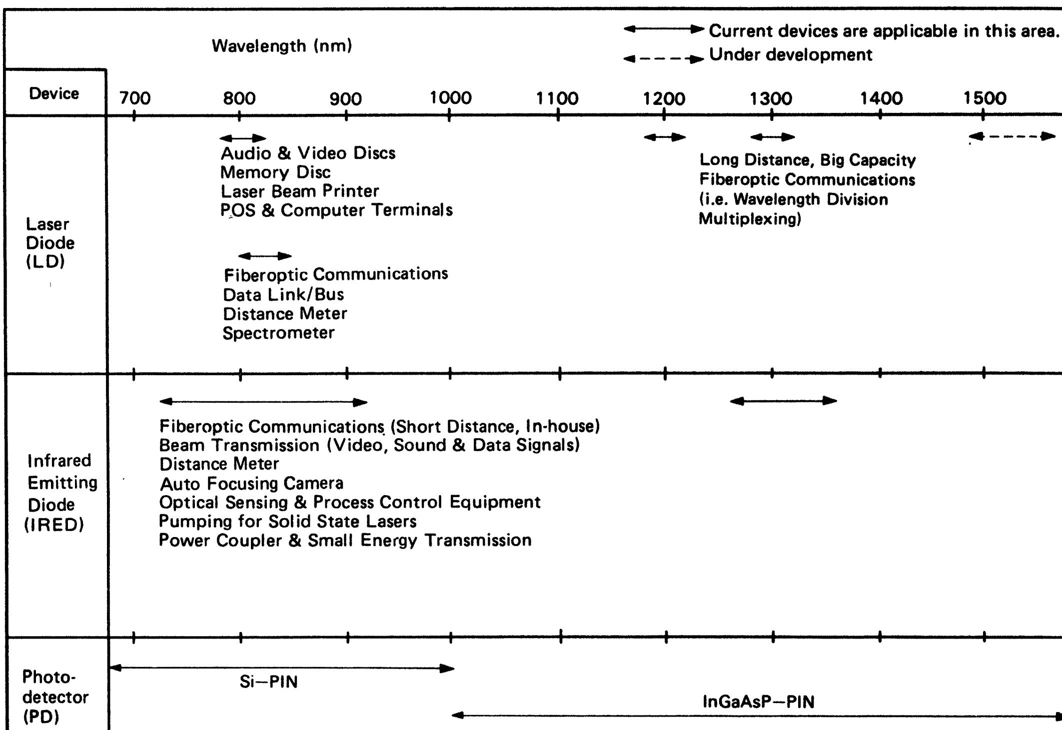
Part No.	HR8101	HR8102	HR1101	HR1102
Hermetic Seal Type Packages	 QG-Type	 TG-Type	 TG-Type	 TG-Type

- **Main Characteristics (T_C=25°C)**

Part No.	Absolute Maximum Ratings			Optical and Electrical Characteristics					Reference Page
	Reverse Voltage V_R (V)	Operating Temperature T_{opr} (°C)	Storage Temperature T_{stg} (°C)	Dark Current I_{DARK} (nA) typ	Capacitance C_j (pF) typ	Test Condition	Sensitivity S (mA/mW) min	Test Condition	
HR8101	100	-40 ~ +80	-45 ~ +100	2	10	V_R=10V, f=1MHz	0.4	V_R=10V, λp=830nm	107
HR8102	100	-40 ~ +80	-45 ~ +100	0.5	1.5	V_R=10V, f=1MHz	0.4	V_R=10V, λp=830nm	109
HR1101	20	-40 ~ +80	-45 ~ +100	7	2	V_R=10V, f=1MHz	0.45	V_R=10V, λp=1300nm	111
HR1102*	15	-40 ~ +80	-45 ~ +100	20	9	V_R=10V, f=1MHz	0.45	V_R=10V, λp =1300nm	113

* Preliminary specifications

1.4 Application Map of Opto Devices



2. SYMBOLS AND DEFINITIONS

2.1 The Absolute Maximum Ratings

The absolute maximum ratings specified in this data book are the values which should not be exceeded under any condition. They are defined at the case temperature (T_C) of 25°C unless otherwise specified.

The absolute maximum ratings of laser diodes (LDs), infrared emitting diodes (IREDs) and photodetectors (PDs) are defined individually as follows.

Table 1 Absolute Maximum Ratings

Item	Applied Device			Definition
	LD	IRED	PD	
Optical Output Power (P_O)	O			Maximum tolerable output power under continuous operation. The value with no kink phenomenon in light-current characteristics (Fig. 1).
Forward Current (I_F)		O	O	Maximum tolerable current under continuous operation.
Reverse Voltage (V_R)	O	O	O	Maximum tolerable value when the reverse bias is applied to a device. On a device with a built-in PD, the reverse voltages of PD ($V_{R(PD)}$) and LD ($V_{R(LD)}$) are specified respectively.
Allowable Power Dissipation (P_d)		O		Maximum power which a diode can dissipate under continuous operation. Derating is needed over room temperature. (For further details, see "3. Handling Instructions.")
Operating Temperature (T_{opr})	O	O	O	Case temperature range in which a device can safely operate. It differs with package types even if the same chip is built in.
Storage Temperature (T_{stg})	O	O	O	Ambient temperature range in which a device can be stored. It differes with package types even if the same chip is built in.

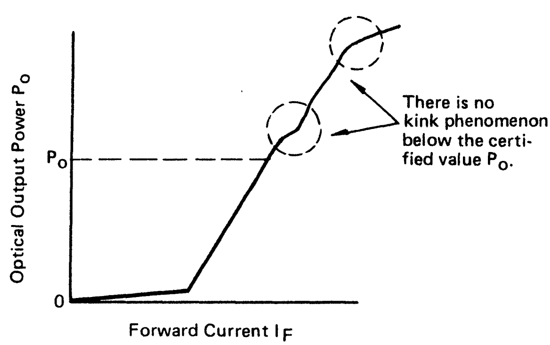


Figure 1 Light — Current Characteristics

2.2 Optical and Electrical Characteristics

The limit values and the typical values of optical and electrical characteristics are described in this data book as much as possible for user's convenience at the application to electrical circuits and optics.

The definitions of optical and electrical characteristics are listed below.

Table 2 LD Optical and Electrical Characteristics

Item	Definition
Optical Output Power (P_o)	Optical output power under the specified forward current (I_F). I_F is defined as the sum of I_{th} and a specified current value for each type (25 mA for HLP Series for example). This value (I_F) varies depending on each device because of difference of I_{th} (Fig. 2). For a device coupled with a fiber pigtail, P_o is shown as the output power at the fiber end.
Monitor Output Power (P_m)	Optical output power for monitoring at the specified forward current (I_F) or optical output power (P_o).
Threshold Current (I_{th})	Forward current at which a diode starts to lase (Fig. 2). Practically, this value is specified as the crossing point of x axis and the extention of line B, where "A" is spontaneous emission region and "B" lasing region.
Peak Wavelength (λ_p)	Maximum intensity wavelength in a spectral distribution (Fig. 3).
Beam Divergence (Parallel) ($\theta_{//}$) Beam Divergence (Perpendicular) ($\theta_{\perp}$)	Divergence of light beam emitted from a laser diode is described in Fig. 4 (a). Beam divergence (parallel) $\theta_{//}$ is the full angle at a half of the peak intensity in the parallel profile (Fig. 4 (b)). Beam divergence (perpendicular) $\theta_{\perp}$ is the full angle at a half of the peak intensity in the perpendicular profile (Fig. 4 (c)).
Slope Efficiency (η)	Optical output power increment per unit drive current in lasing region (B region) of Fig. 2. When P_o is the optical output power at $I_F=I_{th}+25mA$ (for HLP1000 Series for example), slope efficiency η is expressed as: $\eta = \frac{P_o\ (mW)}{25\ (mA)}$
Monitor Current (I_s)	Current of a photo detector operated at the specified optical output power (P_o). It applies only to a device with a built-in PD.
Dark Current (I_D)	Leakage current of PD when the specified reverse voltage is applied without any light input to a PD chip.
Rise Time (t_r) Fall Time (t_f)	Rise time (t_r) is the time required to raise the output power from 10% to 90% of the maximum optical output power when drive current is switched on with sharp enough speed. Fall time (t_f) is the time required to fall from 90% to 10% of the maximum optical output power when drive current is switched off with sharp enough speed. (Fig. 5)

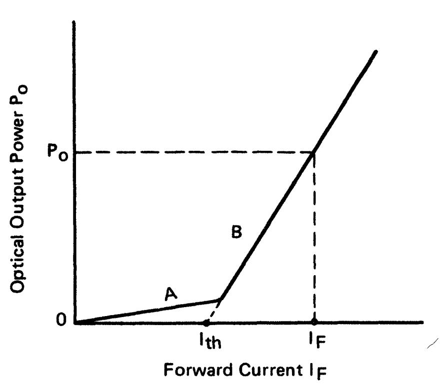


Figure 2 Light — Current Characteristics

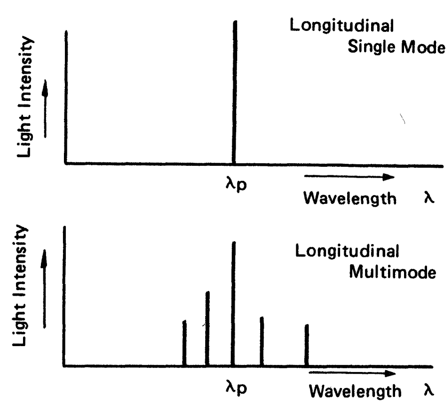


Figure 3 Lasing Spectrum

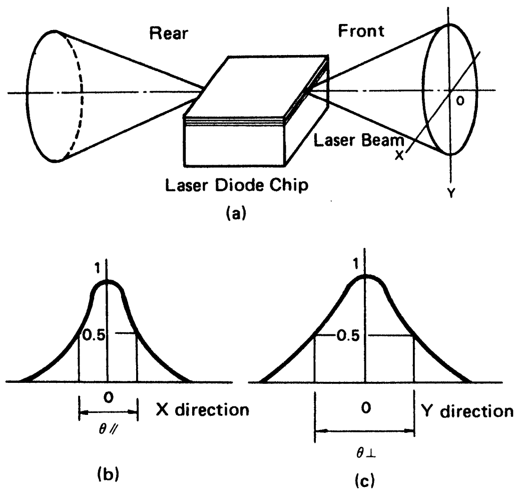


Figure 4 Beam Divergence

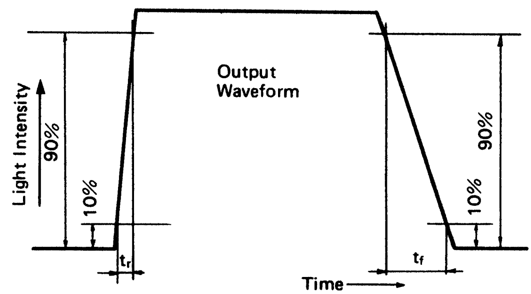


Figure 5 Definition of Rise & Fall Time

Table 3 IRED Optical and Electrical Characteristics

Item	Definition
Optical Output Power (P_o)	Total output power from a package operated at the specified forward current (I_F) (Fig. 6). For a device coupled with a fiber, P_o is shown as the output power at the fiber end.
Peak Wavelength (λp)	Peak wavelength (λp) is maximum intensity wavelength in a spectral distribution (Fig. 7).
Spectral Width ($\Delta\lambda$)	Spectral width ($\Delta\lambda$) is wavelength width at a half of the peak intensity in a spectral distribution (Fig. 7). $\Delta\lambda$ depends on junction structures — a single hetero (SH) or a double hetero (DH) structure.
Beam Divergence (θ_H)	Full angle at a half of the maximum peak value when optical power is plotted against the angle.
Forward Voltage (V_F)	Forward voltage drop at the specified forward current (I_F).
Reverse current (I_R)	Leakage current when the specified reverse voltage (V_R) is applied.
Capacitance (C_j)	Junction capacitance when the specified bias voltage is applied.
Rise Time (t_r)	Rise time (t_r) is the time required to raise the output power from 10% to 90% of the maximum optical output power when current is switched on sharply.
Fall Time (t_f)	Fall time (t_f) is the time required to fall from 90% to 10% of the maximum optical power when drive current is switched off sharply. (Fig. 5)

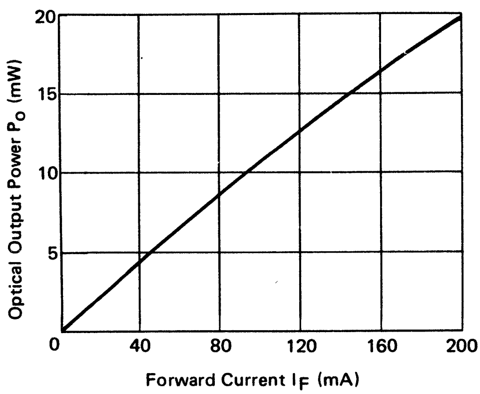


Figure 6 Light — Current Characteristics

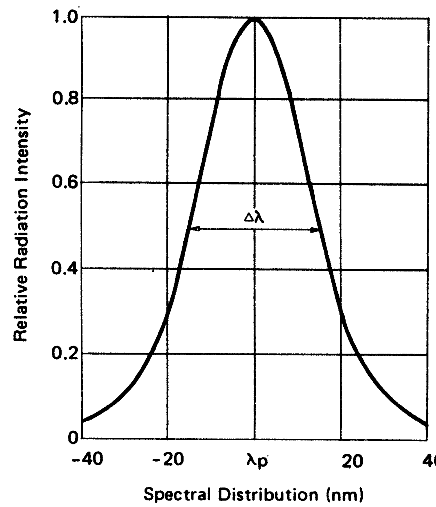


Figure 7 Spectrum Characteristics (HLP30RG)

Table 4 PD Optical and Electrical Characteristics

Item	Definition
Dark Current (I_{DARK})	Leakage current of PD when the specified reverse voltage is applied without any light input to a PD chip.
Capacitance (C_j)	Junction capacitance when the specified reverse voltage is applied.
Sensitivity (S)	Photo voltaic current increment per unit light power input in this data book.
Rise Time (t_r)	Rise time (t_r) is the time required to raise the output power from 10% to 90% of the maximum optical output power when drive current is switched on sharply.
Fall Time (t_f)	Fall time (t_f) is the time required to fall from 90% to 10% of the maximum optical output power when drive current is switched off sharply. (Fig. 5)

3. HANDLING INSTRUCTIONS

Suitable handling precautions during device measurement and system design must be taken as described below for high performance of a device with high reliability.

3.1 The Absolute Maximum Ratings

Be careful never to exceed, even momentarily, the absolute maximum ratings specified in the data sheets herein.

Pay particular attention to the following points.

(1) It is possible for diodes to be damaged by spike current, generated when switching the power ON or OFF or when adjusting its output voltage. Before activating diodes, check the transient state of the power supply to assure that it does not exceed the maximum voltage rating.

(2) Operate the diodes under the maximum optical output power rating in order to prevent mirror facet damage and resultant loss in reliability. Operation at under 2/3 of the maximum optical output power is recommended.

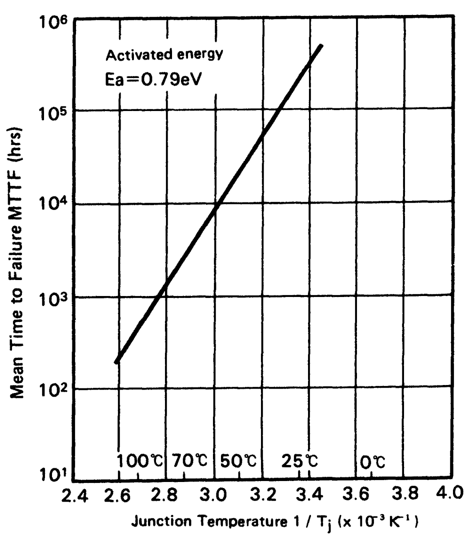


Figure 8 Example of LD Junction Temperature Dependency of Mean Time to Failure

3.2 Derating

The reliability of laser diodes (LDs) and infrared emitting diodes (IREDs) largely depends on junction temperature during operation, as shown in Fig. 8 and Fig. 9. As temperature raises, diodes deteriorate exponentially, therefore, the junction temperature should be kept as low as possible by derating, at the same time, effective heat sinking should be performed.

The reliability is also influenced greatly by optical output power. Therefore, diodes should be activated after they have been derated.

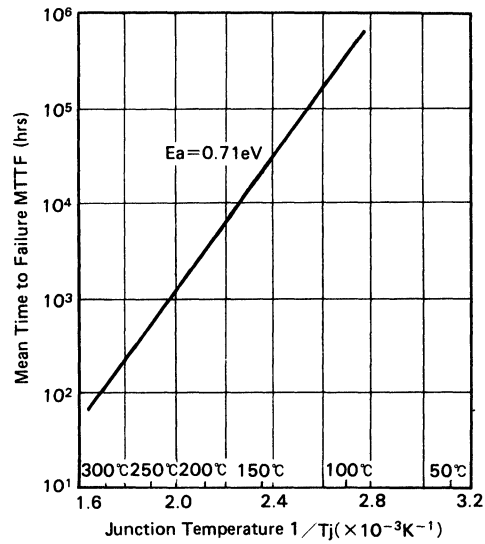


Figure 9 IRED Junction Temperature Dependency of Mean Time to Failure

3.3 Surge Energy

Electrostatic discharge and electric spike input which may damage the diodes should be prevented. The main causes of undesirable surge energy are static electricity on the human body, shipping containers made of unsuitable materials, abnormal pulses generated from test equipment, and voltage leakage from soldering irons.

Precautions below should be taken when using diodes.

(1) The human body should be grounded through a high resistance of 500 kΩ to 1 MΩ while handling diodes in order to prevent diode destruction due to static electricity contained in the body and clothes.

(2) Soldering irons should be grounded to prevent voltage leakage from transferring to the diodes.

(3) Suitable materials should be chosen for shipping containers and jigs so that they will not become charged with static electricity by rubbing during transportation. Use of electro-conductive materials or aluminum foil is effective.

3.4 Storage

(1) Store diodes in temperature of between 5 and 30°C and relative humidity of below 40%. Lower values of both are preferable. Avoid sharp drops in temperature in order to prevent condensation. It is recommended to store diodes in an atmosphere of dry nitrogen with a dew point of -40°C.

(2) Assure that the storage atmosphere is void of dust and gases harmful to diodes.

(3) Use a storage case which can not easily be charged with static electricity.

3.5 Safety Considerations

Even though barely visible to the human eye, laser beams can be harmful to the eye. Do not look at the beam through lenses when the diode is activated. When aligning the optical axis of a laser beam and an external optical system, use an ITV camera (e.g. a silicon-vidicon type) which can detect infrared rays to observe the laser beam.

3.6 LD Packages

3.6.1 400-Type (A-Type)

The 400-type package is designed for experimental use only and absolutely not recommended for commercial applications. An LD chip is mounted on a submount on a heat sink and the mirror facets are exposed to the air. Special care is required as follows due to this structure.

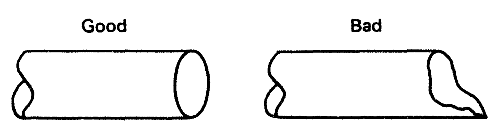
(1) Never touch the bonding wire on the upper part of a device.
(2) Prevent mechanical contact to an LD chip, because the stress peels off the chip from the heat sink or deteriorates the device properties such as beam divergence, far field pattern and reliability.
(3) Cleanest atmosphere is strongly desired to handle a device, to keep mirror facets free from dust and scratch, because a light emitting source is extremely small. As a result, this precaution prevents degradation of optical output power and far field pattern.
(4) Hold the copper heat sink in handling a device. Do not drop the device or give any other mechanical shock.
(5) Do not process or deform a heat sink.
(6) Use a good thermal radiator to mount a device on. The temperature of an LD chip rises highly owing to the high current density unless a good heat sinking is provided. As a result, this precaution prevents lower optical output power and device deterioration. Notice the following cautions in using a thermal radiator.
   (i) Never use silicone grease because it creeps up and adheres to the mirror facets, resulting in a degradation of optical output performance.
   (ii) Use a copper or an aluminum plate as a thermal radiator. The radiator should be larger than $30\times 40\times 2mm^3$.
   (iii) Polish up the thermal radiator surface to have a good thermal conductivity with the device heat sink. Finish the radiator surface to keep bump, twist or bend below 0.05mm.
   (iv) Chamfer all screw holes. The diameters of the chamfered holes should be smaller than that of a screw cap.
   (v) When mounting a device to a radiator, do not allow the device to be turned by screwing down or the chip to contact the thermal radiator.
(7) Soldering:
   Notice the following precautions when soldering the electrode ribbon of a device to the circuit.
   (i) Do not exceed the heat sink temperature of 80°C and finish process within 30 seconds, because a low melting point solder is used for chip mounting.
   (ii) Use the fine tipped soldering iron commercially available or a common soldering iron with the copper coil around the tip. At the time, earth the tip of the iron. A battery operation type is best to use.
   (iii) Do not allow the solder to flow into the pad of bonding wire.
   (iv) Do not allow the scattered flux to adhere to the mirror facets.
   (v) Do not wash out flux after soldering, because it contaminates the mirror facets.
(8) Hermetic seal:
   Hermetically seal a device to extend its life time.
   As noted before, 400-type is not recommended for commercial application.

3.6.2 500-Type (B-Type)

The 500-type package is designed for fiberoptic communications. It is provided with an optical output fiber and a monitor output guide (a glass rod).

An LD chip is mounted on a heat sink and the fiber and the chip are aligned then it is hermetically sealed. Pay attention to the following precautions in handling this device.

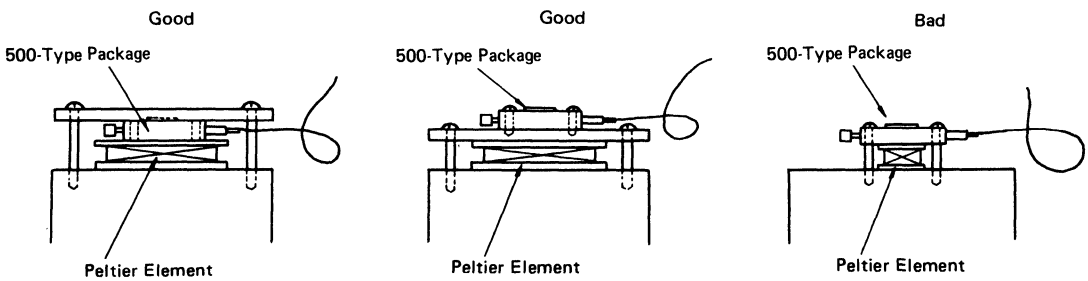
(1) Excessive force to an optical fiber disconnects the fiber at a moment or deforms it partially. Do not pull, crook or twist the fiber because it deteriorates fiber characteristics. Do not bend the optical fiber within 30 mm radius.
(2) Do not apply excessive stress between the package and the optical fiber, to prevent a fiber from breaking, falling out and reducing optical output power. Lift both of the package and the optical fiber at the same time not to bend the fiber bottom.
(3) Do not contaminate or damage a monitor output guide.
(4) Do not apply excessive stress in tightening the screw of the monitor guide when attaching an external monitor PD, because it breaks the monitor glass. The torque should be $1 \sim 2$ kg·cm.
(5) Do not apply excessive stress by bending or pulling the pins, because it deteriorates hermeticity.
(6) Do not process or deform a package.
(7) Processing the optical fiber:
   Do not contaminate or damage the tip of an optical fiber to prevent the loss of optical output power or of coupling efficiency. Follow the instructions below in processing the fiber tip.
   (i) Remove the appropriate length of the nylon jacket from the fiber tip with a proper stripper.
   (ii) Remove the fiber coating remedy from the peeled fiber with aceton.
   (iii) Scratch the cutting point of the fiber with a diamond cutter.
   (iv) Hold the fiber tip with a pair of tweezers and bend to snap, then expose the clean surface. When the surface of the fiber cannot be snapped flatly, try again.



   Take enough care when processing a fiber, because the extremely thin core of a fiber may easily pierce human skin.
(8) Mounting a device on a thermal radiator:
   Use an LD with a thermal radiator.
   (i) When screw mounting a device on a radiator, torque should be $1 \sim 2$ kg·cm. Too small torque may result in excessive thermal resistance and excessive torque may damage the diode on the other hand.

(ii) Use a screw of 2 mm dia.
Use a spring washer and apply lock paint to tapping holes or nuts to prevent turning or relaxation of the screw.

(iii) Avoid to give deformation stress to a laser package when attaching a peltier cooler to the package.
Especially when mounting the peltier element between a laser package and a thermal radiator, deformation stress tends to be applied to the package and loses device reliability.



(iv) For other considerations, follow the instructions described in the previous section 3.6.1 (6).

(9) Soldering:
Follow the instructions described in the previous section 3.6.1 (7).

3.6.3 E-Type and G-Type (Hermetically Sealed with a Glass Window)

(1) Take care not to touch the window glass directly. Contamination and scratches on the window surface will result in decreased optical power output and distorted far field patterns. Contamination can usually be wiped off using a cotton swab with ethanol.

(2) Do not squeeze the cap tightly, as it will cause the window glass to crack and package hermeticity to deteriorate.

(3) Do not bend the bottom of the lead wire, as it will cause the glass area to crack and the hermeticity to deteriorate.

(4) Do not cut or process packages.

(5) Mounting a diode on a thermal radiator:
Laser diodes must be mounted on thermal radiators. For higher reliability, it is necessary to minimize mechanical stress to the packages and achieve sufficient heat sinking. Attention should be paid to the followings when mounting diodes on thermal radiators.

(i) Use a copper or aluminum plate for the thermal radiator. The plate should be larger than 30 x 40 x 2 mm^3.

(ii) To give it good thermal conductivity, polish the thermal radiator surface so it will lie flat with the diode heat sink. Finish the radiator surface to keep bumps, twists or bends below 0.05 mm.

(iii) Chamfer all screws. The diameter of chamfered holes should not be larger than that of the screw heads.

(iv) When screw mounting diodes on radiators, torque should be applied at 2.0±0.5 kg·cm. Insufficient torque may result in excessive thermal resistance, where excessive torque may damage the diodes.

(v) Use screws with diameters of 2 or 2.5 mm for the E-type package. Use spring washers and apply lock paint.

(vi) Do not solder packages to thermal radiators, as this may result in excessive temperature to the assemblies inside the packages or loss of package hermeticity.

(vii) When mounting the diodes, do not touch or hit them against the caps, in order to prevent the window glass from becoming contaminated or cracked.

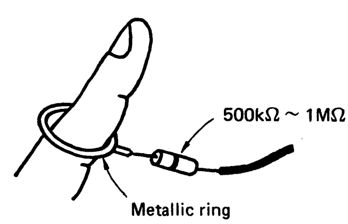
(viii) Do not use heat sink grease, as it may contaminate the window glass.

3.7 Handling Instructions of LD for a Beginner

(1) Avoiding surge energy:
Laser diodes are easily destroyed by static electricity. To prevent electrostatic discharge, pay attention to the following precautions as well as Table 5 when handling diodes and designing application circuits.

(i) Set the electric potential of the work bench to be the same as that of the power supply ground line.

(ii) Ground the operator's body by placing a metallic ring on his/her finger with a resistance of 500 kΩ ~ 1MΩ, and connect it to the same potential as the power supply ground line.



(iii) Do not operate equipment which may generate high frequency surge energy near diodes. The lead wires of drive circuits pick up surge electricity which may destroy diodes in the induced electric field.

Table 5 Ways to prevent LDs from electrostatic discharge

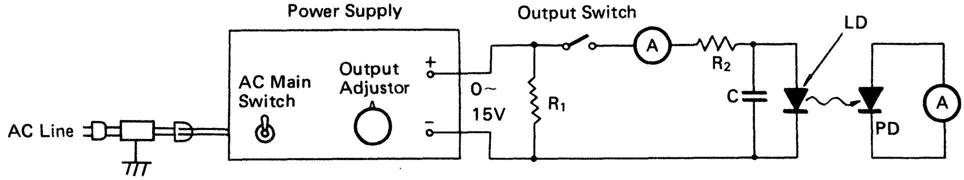
No.	Items	Check points	Remarks
1.	Human body	1 To ground operator's body	By placing metallic ring on a finger with a resistance of 500 kΩ ~ 1MΩ
		2 To commonly ground measuring and inspection equipment and working table	Same manner should be taken in shielded room.
		3 To control ground level	Under 10 Ω
2.	Power supply	1 To distribute power through noise filter from main power supply to individual measuring and testing equipment	
		2 To insert noise filter into individual power supply unit	
		3 To set main power supply on-state at any time and to switch power on or off with external switch	
3.	Working conditions	1 To interrupt your working when switching power supply of lightening or any other equipment connected with the same power line	
		2 To pack or measure diodes in atmosphere of weak minus ion	
4.	Jig and circumstances	1 To conduct carrier container and packing case	
		2 To equip conductive carpet on working floor	Under 300 Ω
		3 To control room temperature and humidity	Humidity should be 50 ± 10%.

(2) Operating laser diodes:

(i) Mount a diode on a thermal radiator. The radiator size depends on operating time and output power. When there is no condition set, use a relatively large radiator (50 x 50 x 2 mm^3) of copper or aluminum.

(ii) The drive circuits preferred are ones with APC (Automatic Power Control) function. However, a simple constant current source is recommended when merely testing performance, because adjustment miscalculation can result when circuits are too complex, leading to destruction of the diodes.

(iii) Before connecting a laser diode to the power supply in the ON-state as shown in Fig. 10, set the output level at minimum. Also, before disconnecting a laser diode from the power supply, set the output voltage at minimum. After disconnecting, turn off the main switch.



P.S: 0 ~ 15V constant voltage power supply
R_1 = 100Ω 2W
R_2 = 50Ω 2W
C = 0.05μF
PD: Solar cell

Figure 10 Simple Drive Circuit

(3) Experimental LD drive circuit:
The optical output power from an LD is affected easily by the fluctuation of ambient temperature. APC (Automatic Power Control) function is generally recommended for a drive circuit to achieve stable operation. The function to monitor beam and feed it back to drive current is useful to achieve constant optical output power against temperature change. Figure 11 shows an experimental APC circuit example. A_1 provides constant voltage. A_2 converts photovoltaic current of a photodetector to voltage. By adjusting R_1, optical output power from an LD is controlled to obtain the desired value through a differential amplifier, A_3. The integral circuit of C_1 and R_2 is a slow starter to prevent surge input from the power supply into the diode. The terminal, T, applied about 1V has the standby function to minimize the idling current while an LD is not operated, by switching off the drive circuit. Figure 12 shows that optical power output stability is achieved even when diode case temperature varies significantly.

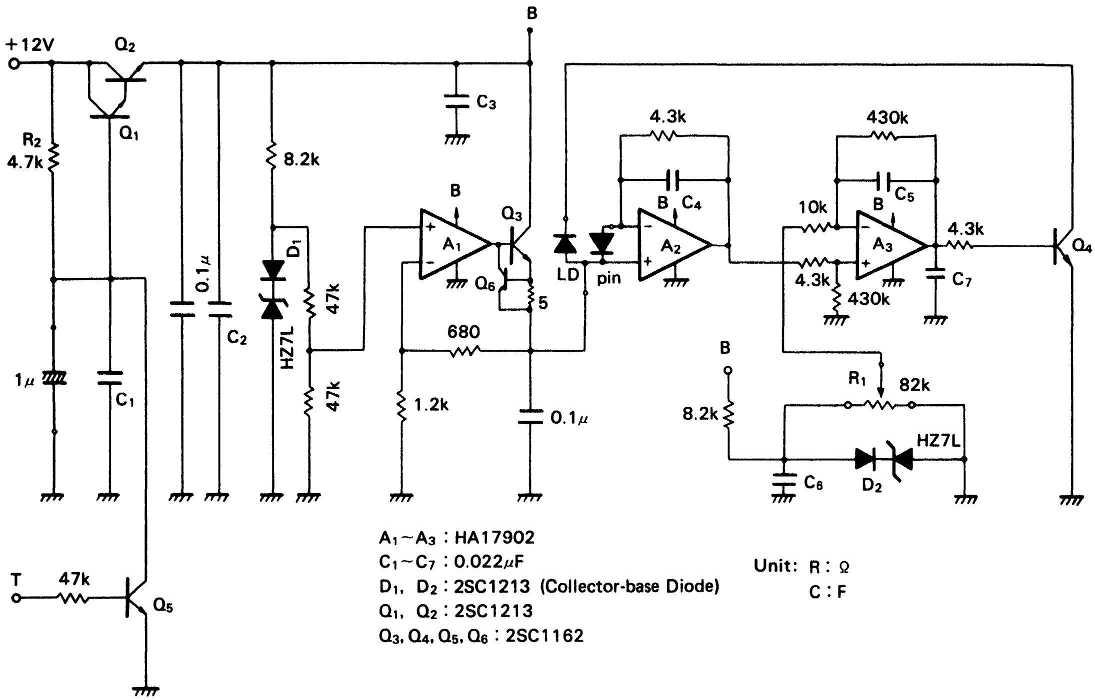


Figure 11 LD Experimental APC Circuit

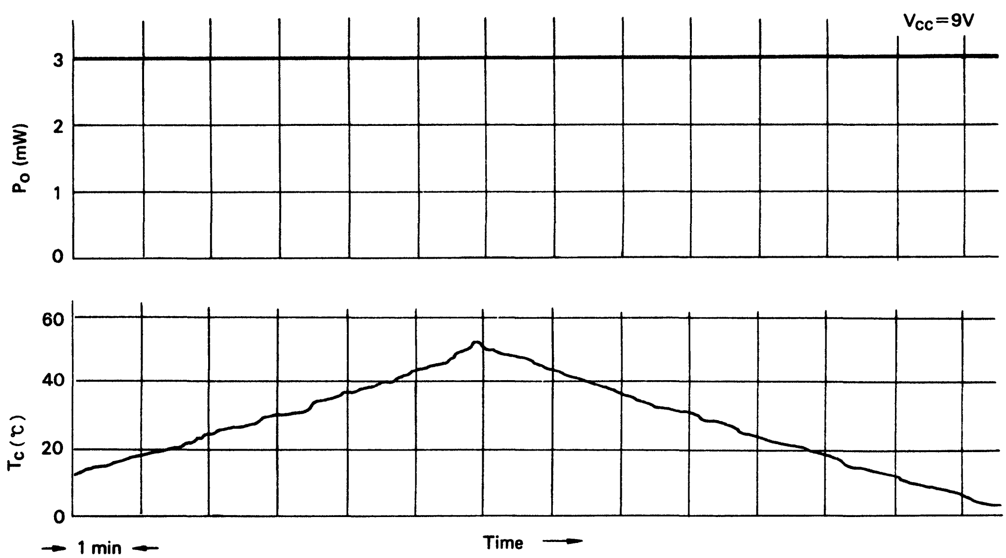


Figure 12 Temperature Characteristics of LD with APC Circuit (HL7801E)

3.8 IRED Packages

3.8.1 R-Type (Open-air Type)

An IRED chip on R-type package is exposed to the air for the convenience of coupling to the fiber or external optics. The following particular care must be taken for the open-air type package.

(1) Never touch the extremely thin gold bonding wire which is bare.
(2) Never apply mechanical stress to an IRED chip, or it peels off the chip from a diode base and deteriorates the properties and reliability. Also do not contaminate the chip surface, because it deteriorates optical properties and output power.
(3) Do not process or deform a diode base.
(4) Mounting a device on a thermal radiator:
An IRED must be mounted on a thermal radiator to reduce the temperature rise because it is usually driven at high current density. Without a radiator, specified optical output power cannot be obtained and the device may be degraded due to the chip temperature rise. When mounting a device on a radiator, follow the instructions below.
   (i) The appropriate size of a thermal radiator differs with operating conditions, but a large plate than 20 x 30 x $20mm^3$ of copper or aluminum is usually recommended.
   (ii) Polish up the thermal radiator surface to have a good thermal conductivity with the device heat sink. Finish the radiator surface to keep bump, twist or bend below 0.05 mm.
   (iii) Use of silicone grease is absolutely prohibited as described in the previous section 3.6.1(6) for 400-type LD heat sink.
(5) Soldering:
   (i) Use a low melting point (below 200°C) solder.
   (ii) Soldering should be done in 10 seconds and at below 260°C.
   (iii) Do not allow the scattered flux to adhere to the chip surface.
(6) Hermetic seal:
Hermetically seal a device to extend its life time.

3.8.2 RG-Type and SG-Type (Hermetically Sealed with a Glass Window)

These packages are well dampproof and easy to handle because of the hermetic seal. Pay attention to the following precautions in handling a device.

(1) Keep the glass surface of a device clean to have uniform optical output available.
(2) Do not process or deform a package. Especially do not nip the cap hard or bend the bottom of a lead wire forcibly, or it cracks the glass area and deteriorates the hermeticity.
(3) Mounting a device on a thermal radiator:
Use of a thermal radiator is recommended for higher reliability. Do not apply silicone grease to the contact area of the thermal radiator even for effective heat sinking, because it creeps up and adheres to the window glass as temperature increase, resulting in a degradation of optical properties and output power. For further details, see the previous section 3.8.1 (4).
(4) Soldering:
   (i) Soldering point must be away by 1.5 mm or more from the bottom of lead wires.
   (ii) Use a low melting point (below 200 °C) solder.
   (iii) Soldering should be done in 10 seconds and at below 260 °C.

3.8.3 F-Type (Hermetic Seal Type)

The F-type package is designed for fiberoptic communications. The GI type fiber rod of 50/125 μm dia. in a precision ceramic sleeve is provided with this type, which couples effectively with the output fiber through a receptacle.

The fiber rod and the sleeve are designed to fit the standard FA connector. This package is completely hermetically sealed with a cap ring-welded to a stem and a fiber rod soldered to a cap inside. Pay attention to the following precautions in handling a device.

(1) Never touch the tip of the fiber rod not to contaminate the tip, or it reduces the optical output power. It is hard to clean it once adhered.
(2) Do not apply the mechanical stress to the bottom of a ceramic ferrule and a lead wire, because it deteriorates the hermeticity and the optical coupling efficiency.
(3) Mounting a device on a thermal radiator:
Use of a thermal radiator is recommended for longer device life. For further details, see the previous section 3.8.1 (4).
(4) Soldering:
Follow the instructions described in previous section 3.8.1 (5).

OPERATIONAL FEATURES AND RELIABILITY

1. OPERATION PRINCIPLES OF LDs, IREDs AND PDs

1.1 Emitting Principles

Each electron in atoms and molecules has a specific discrete energy level, as shown in Fig. 13. The transition of electrons between different energy levels is sometimes accompanied by light absorption or emission of the wavelength λ expressed as:

$$\lambda = \frac{C}{f_0} = \frac{C}{|E_2 - E_1|/h} = \frac{1.2398}{|E_2 - E_1|}$$

C: Light Velocity
E_1 : Energy Level before Transition
E_2 : Energy Level after Transition
h : Planck Constant (6.625×10^{-34} joul. sec.)
f_0 : Emission Frequency

There are three types of electron transitions, as shown in Fig. 14.

Firstly, Fig. 14 (a) shows what is known as resonant absorption. An electron transits from the stable low energy level E_0 to the higher energy level E_1 through absorbing light.

Secondly, Fig. 14 (b) shows spontaneous emission. An electron transits from the high energy level E_1 to the stabler low energy level E_0. At the time, the energy balance of $|E_1 - E_0|$ is released in the form of light. Since each electron in the level E_1 transits independently, light is emitted at random and out of phase. Such light is referred to as incoherent light and one of the typical characteristics of spontaneous emission. The light from IRED is of such spontaneous emission light.

Under thermal equilibrium, probability of electrons to exist in the lower level E_0 is higher than that in the higher energy level E_1. Therefore, electron transition to higher energy level ($E_0 \rightarrow E_1$) by absorbing light is more likely to occur than light emission as shown in Fig. 14 (a). In order to emit light, electrons must exist in E_1 with high probability, which is referred to as inversed population.

Thirdly, Fig. 14 (c) shows stimulated emission. The electrons in the higher energy level E_1 are forcibly transferred to the lower energy level E_0 by incident light. The light generated this time is referred to as stimulated emission light. Its phase is the same as that of incident light, because the stimulated emission light is emitted with resonating to the incident light. Such stimulated emission light is referred to as the coherent light.

Similarly to the electric circuit, laser oscillation requires the feedback function in addition to the gain which exceeds the loss. Laser beam is oscillated by amplification of stimulated emission and positive feedback with mirrors.

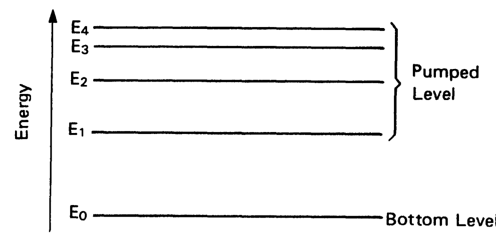
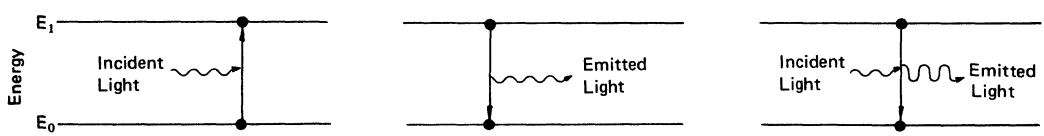


Figure 13 Energy Level



(a) Resonant Absorption (b) Spontaneous Emission (c) Stimulated Emission

Figure 14 Transition Process

Figure 15 shows a Fabry-Pérot resonator which is the most fundamental optical resonator.

The structure of an LD, in principle, is the same as shown in Fig. 15, which has the both surfaces of the chip with reflection mirrors by cleaving.

The light heading to the reflection mirror among incident spontaneous emission light, is amplified by stimulated emission and comes back to the initial position after reflection. This process accompanies the loss by passing through or diffraction of light at the reflection mirrors and scattering or absorption in the cavity. When the loss is higher than the amplification gain, the light attenuates. Injected current strengthens amplification gain in an LD and at the condition that the gain and the loss are balanced, initial light intensity becomes equal to that of returned. This condition is referred as threshold. A laser oscillates above the threshold when the gain increases enough.

Injection pumping is mainly taking place at the p-n junction in a semiconductor laser diode. A semiconductor crystal can obtain higher gain than a gas laser (HeNe for example) due to the higher density of atoms available with a cavity. Therefore a laser can oscillate with such a short resonant cavity of 300 μm and low reflectivity of 30%.

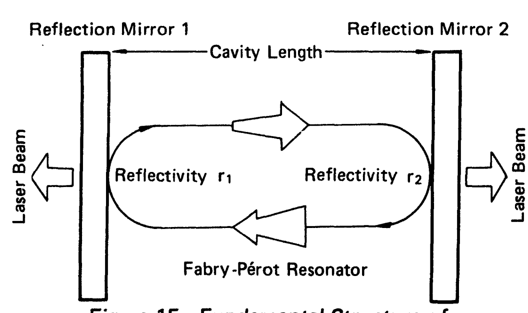


Figure 15 Fundamental Structure of Fabry-Pérot Resonator

1.2 GaAlAs LD Structure

The p-type active layer is processed first in which stimulated emission enforces optical amplification (Fig. 16 (a)). The p-n junction is made here to inject minority carriers (the p-n hetero junction). With forward current applied to the junction, electrons in n-type region are injected into p-type region. With a p-type semiconductor of wide band gap on the other side of p-n junction (hetero isolation junction), the injected carriers are much confined within the p-type active layer. This carrier confinement makes population inversion easily and the light emission intensity is then increased.

The active layer of the GaAlAs LD is made of GaAs or $Ga_{1-y}Al_yAs$ (Fig. 17). The thickness of the layer is 0.05 ~ 0.2 μm. p-type $Ga_{1-x}Al_xAs$ and n-type $Ga_{1-x}Al_xAs$ ($x > y$) sandwitch the active layer (x and y here are the mixture ratio of aluminum). When x is 0.3, the band gap of the sandwitch layers is 1.8 eV and there is balance of 0.4 eV against 1.4 eV of GaAs. When forward bias is applied here, the hetero barrier confines carriers within the 0.05 ~ 0.2 μm active layer, carrier population is inverted and the gain increases. The refractive index of GaAs is higher by some percents than that of $Ga_{1-x}Al_xAs$, which confines the generated light within the GaAs active layer. The light penetrating into Al_xAs layer is not absorbed because of its wide band gap. So laser oscillates effectively there (Fig. 16). The thinner GaAs layer can do with less threshold current density for laser oscillation. At present, the threshold current density of as low as 1 ~ 2 kA/cm^2 is achieved, which realizes the continuous oscillation (CW) stably at room temperature.

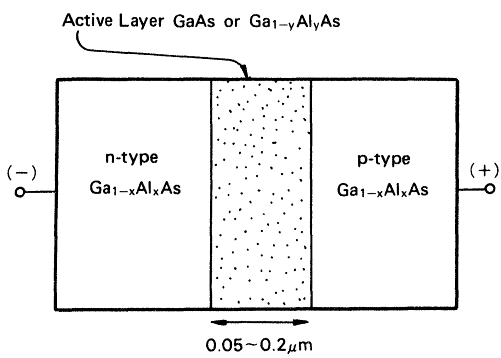


Figure 17 GaAlAs DH Structure LD

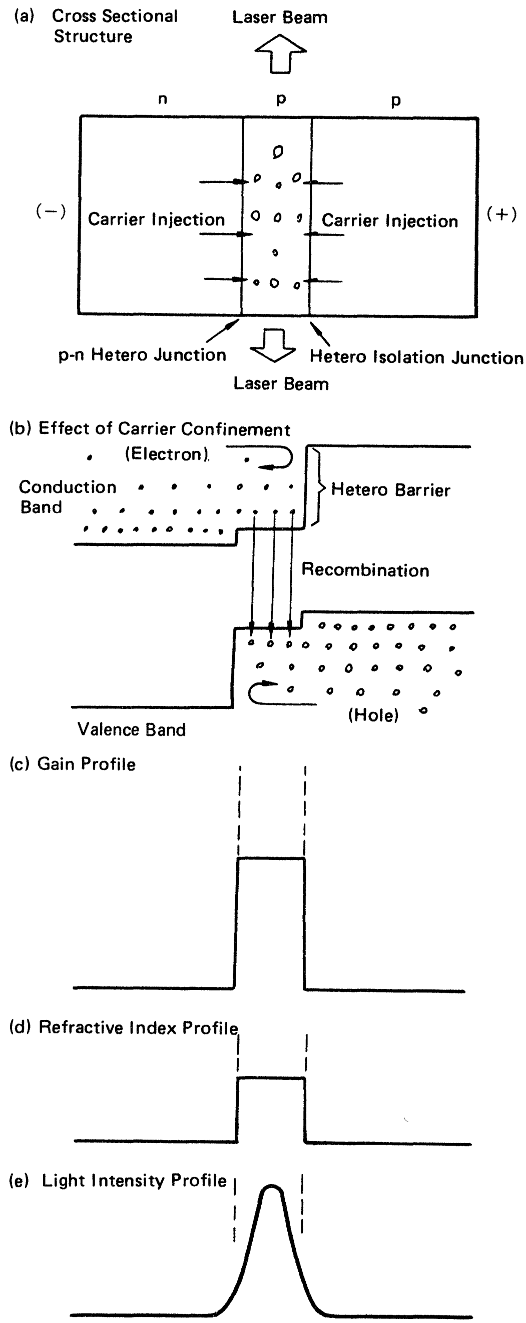


Figure 16 Operation Principle of Double Hetero Junction LD

1.3 Lasing Mode of GaAlAs LD

Under the laser oscillation, the light standing wave forms with wavefront parallel to mirror facets while light is traveling back and forth within the laser cavity. This standing wave consists of longitudinal mode and transverse mode (Fig. 18). Longitudinal mode expresses the condition in the direction of cavity length (z direction). Transverse mode expresses the condition of the perpendicular axis to the cavity length direction. And the transverse mode is devided into perpendicular transverse mode which is perpendicular to the active layer and parallel transverse mode which is parallel to the layer.

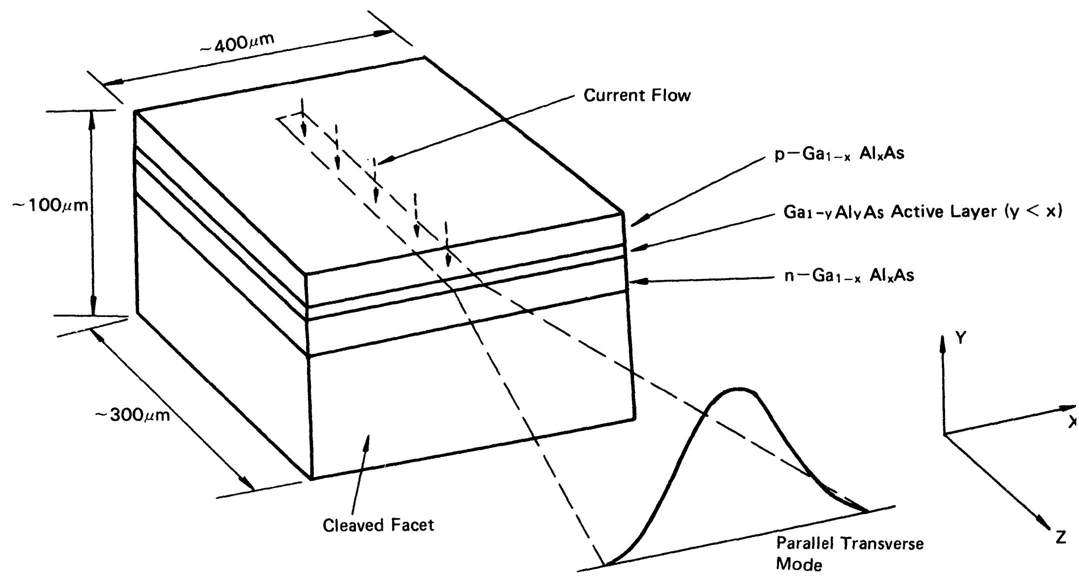


Figure 18 Lasing Mode of LD

(1) Longitudinal Mode

Fig. 19 shows that a standing wave of the half wavelength multiplied by an integer q forms in the direction of laser cavity length (z direction). When the refractive index of the medium is n and the wavelength in the vacuum is λ, the wavelength of light λ' is expressed as:

$$\lambda' = \lambda/n$$

So the half wavelength is expressed as:

$$\frac{1}{2}\lambda' = \frac{\lambda}{2n}$$

As described at the beginning, since the half wavelength multiplied by an integer q equals to the cavity length L:

$$q \cdot \frac{\lambda}{2n} = L$$

For a semiconductor laser diode, when λ is 850 nm, n is 3.5 and L is 300 μm, q is about 2500. This q is referred as a mode number.

When a mode number q changes by 1, the wavelength change $\Delta\lambda$ is expressed as:

$$|\Delta\lambda| = 0.34 \text{ nm}$$

Since a cavity length is incomparably longer than a wave length, cavity resonance can take place at multiple wavelengths. The particular wavelength area where the cavity gain becomes maximum will then be chosen to have a stable standing wave.

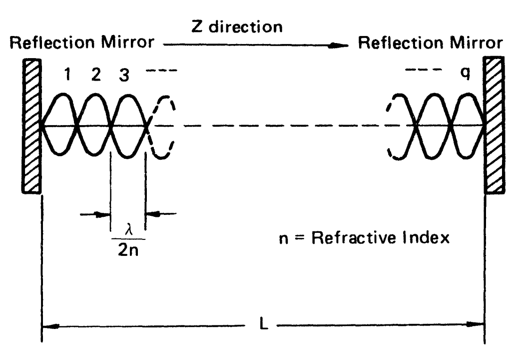


Figure 19 Longitudinal Mode of LD

In a semiconductor laser diode, when the temperature changes, the band gap energy changes then the wavelength where the maximum gain is achieved changes. As for the GaAlAs DH structure laser, this temperature coefficient is about 0.25 nm/deg. So the temperature rise makes the oscillation wavelength jump upward at intervals of $\Delta\lambda$ ($\approx$ 0.34 nm). The same phenomenon takes place because of temperature rise in the active layer when the injection current increases for the higher optical output power under the continuous operation (CW).

(2) Perpendicular Transverse Mode

In a GaAlAs laser diode, the active layer is sandwitched by hetero junction (Fig. 20). Light is confined within the active layer because of the higher refractive index here than that of sandwitching layer GaAlAs, although it is a matter of some percents. The amount of light confined here depends on the thickness of the active layer. A thicker layer confines more light. On the other hand, light penetrates into the sandwitching layers in case of a too thin layer. The width of laser beam divergence depends on the thickness of an active layer and when it is 0.3 ~ 0.4 μm, the width becomes narrowest. At this width, the radiation angle of laser beam emitted from the cleaved facet becomes widest (Fig. 21). In general, in a semiconductor laser, the radiation angle of laser beam out of the device becomes very wide because the laser beam profile width in the device is the same as or less than the lasing wavelength. This is very the different characteristic from that of a conventional gas laser or solid state laser.

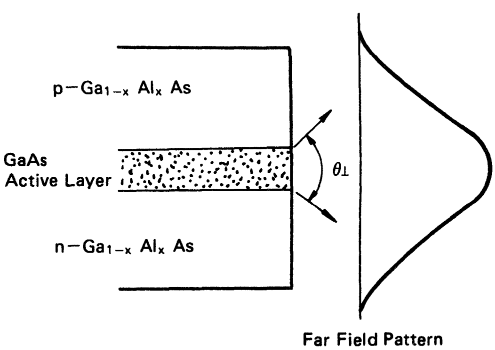


Figure 20 Perpendicular Transverse Mode

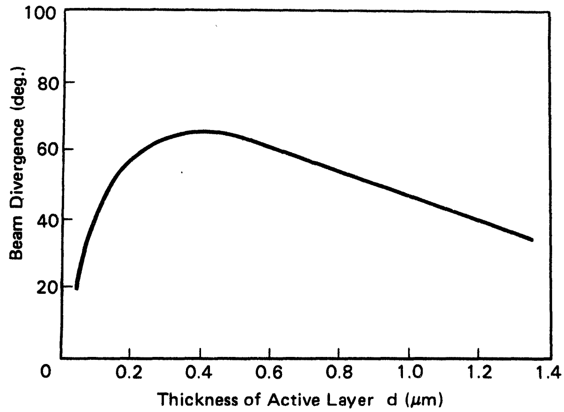


Figure 21 Thickness of Active Layer – Beam Divergence

(3) Parallel Transverse Mode

Waveguide must be formed by some means because there is nothing to guide light in the active layer in parallel to the junction. When the current injection is limited to a narrow enough region with a full cavity length, laser oscillation can then take place in the region (Fig. 18). Fig. 22 shows the basic stripe structure which can limit current pass only.

In order to control the transverse mode more effectively, the refractive index profile or the optical loss profile should be built in structurally to the stripe structure additionally. Fig. 23 shows examples of this structure.

Fig. 23 (a) describes a CSP (Channeled Substrate Planar) laser. Outside of the channel fabricated in the base, the light penetrated from the active layer reaches the base and suppresses the lasing due to absorption loss. Fig. 23 (b) describes a BH (Buried Heterostructure) laser. In the both directions of perpendicular and parallel, the double-heterostructure is made.

These structural waveguides stabilize the single fundamental transverse mode. All of Hitachi LDs have the stable single transverse mode.

A GaAlAs laser diode is described above.

HLP1000, HL7801, HL8311 Series, HL8312 and HL8314 employ basically the same material; GaAlAs. HLP5000 Series employ InGaAsP in an active layer and InP in sandwitching layers, and the fundamental lasing principle and the lasing mode are the same as the former.

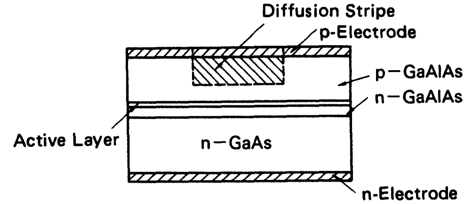


Figure 22 Basic Stripe LD

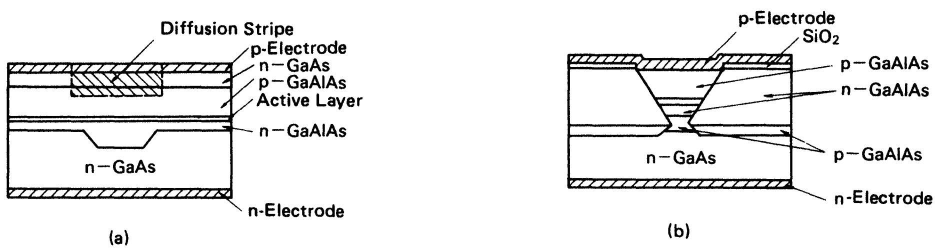


Figure 23 Various Stripe Laser Built-in Waveguide

1.4 IRED Structure

High efficiency of current-light conversion is achieved, using GaAs crystal which is a direct transition type material. Hitachi shapes the chip surface hemispherically to best utilize the emitted light out of a chip (Fig. 24).

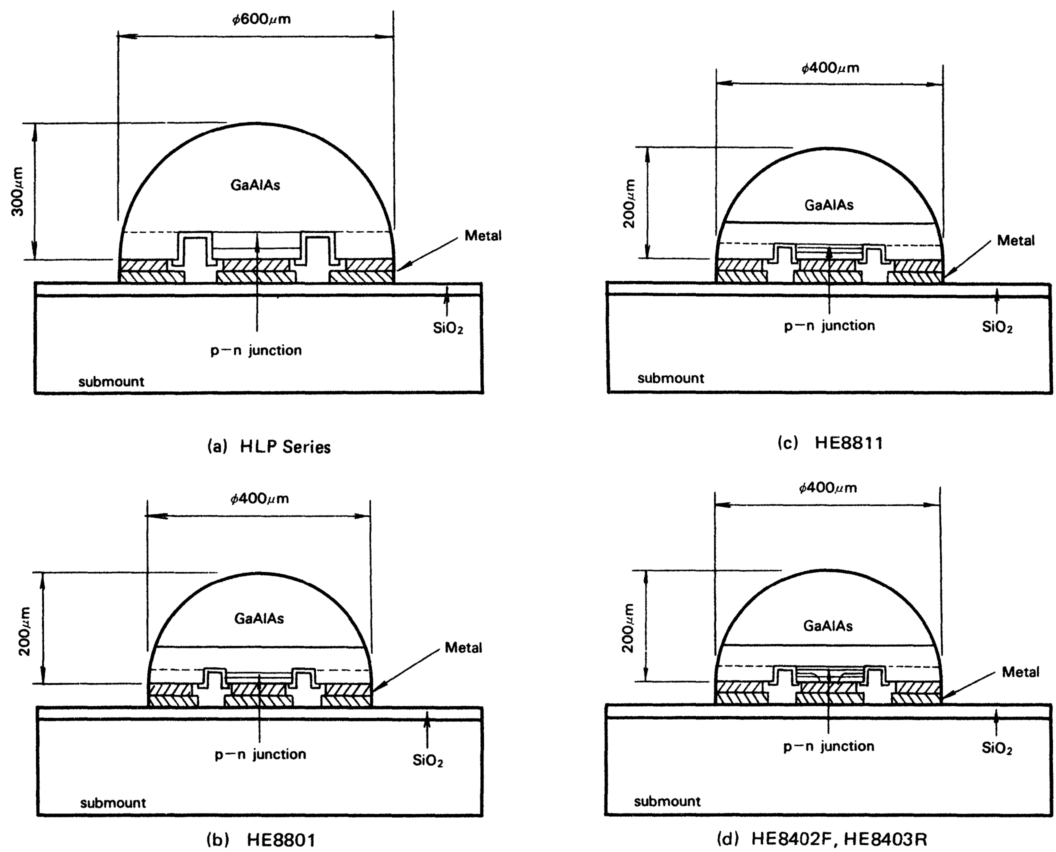


Figure 24 Structure of IRED

1.4.1 Heterostructure

The p-n junction barrier of the diode confines the injected current to the active layer. The hetero junction (Fig. 25 (a)) consists of p-type and n-type whose band gap energy are different from each other. This hetero junction structure increases the confinement effect and realizes high power output with high speed. Practically $Ga_{1-x}Al_x$ As is used, controlled band gap energy by changing the mixture ratio x.

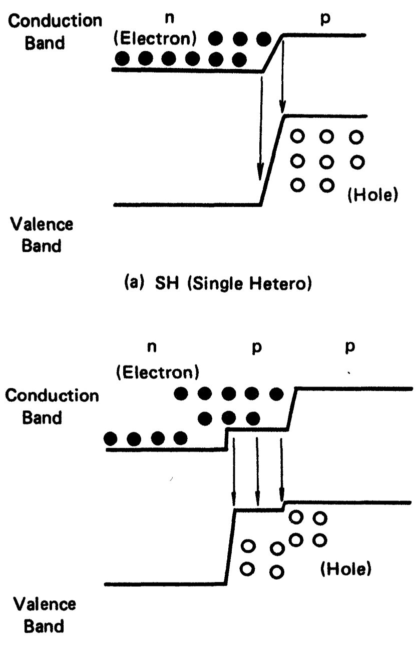
Hitachi IREDs are devided into two structures: SH (Single Hetero) structure which has only one hetero junction and DH (Double Hetero) structure which has two hetero junctions (Fig. 25 (b)) and realizes high power output with high speed. Table 6 shows the structure of each type number.

1.4.2 Dome Type Chip

The dome type is effective to take out emitted light.

It is important to pay attention to the refraction at the boundary of a GaAlAs chip surface and the air, in taking out the light emitted from the chip. Since the refractive index of GaAlAs is about 3.4, light output power which hits the crystal surface with an incident angle of more than 17 degrees will be reflected within the chip and not taken out (Fig. 26). With the dome shaped chip surface, emitted light from the center area of a chip will hit the surface with about 90 degrees of an incident angle so that refractive loss is minimized (Fig. 27).

Hitachi IREDs are all dome shaped. Table 7 shows the dome diameter and the junction diameter of each part number.



(b) DH(Double Hetero)

Figure 25 Junction Structure

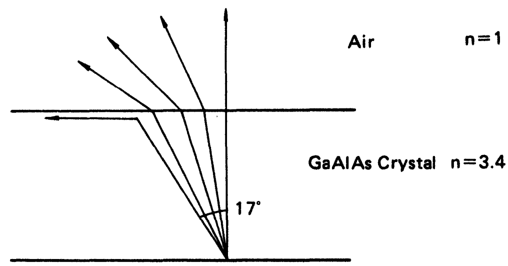


Figure 26 Light Refraction at Boundary Layer

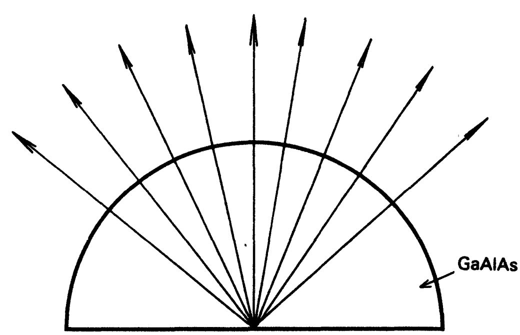


Figure 27 Light Radiation by Hemispherical Shape

Table 6 Structure of Hitachi IRED

Part No.	Structure
HLP Series	SH
HE8801	SH
HE8811	DH
HE8403R	DH
HE8402F	DH
HE1301	DH

Table 7 Dome Diameter and Junction Diameter of Each Part Number

Diameter / Part No.	Dome Dia. (μm)	Junction Dia. (μm)
HLP Series	600	160
HE8801	400	100
HE8811	400	100
HE8403R	400	30
HE8402F	400	30
HE1301	400	30

1.5 Photo-Detection Principles

Photodiodes make use of a photovoltaic effect resulting from application of voltage to both ends of a p-n junction at the time light exposes the junction. Under reverse-voltage conditions at the p-n junction, a depletion region is generated to which an electric field has been applied (see Fig. 28). Incident light with the same energy as the bandgap energy is absorbed in the depletion region. This absorption of light produces electron-hole pairs. The electrons and holes then drift, under electric field action, in opposite directions across the depletion region. Electrons move forward to the cathode electrode, and holes move to the anode. As a result, a current flows through the load resister, and light signals are converted to electric signals. Carriers produced in the depletion region move at high speeds due to acceleration by the electric field. Carriers generated in the diffusion region, however, move slowly due to diffusion in accordance with the concentration gradient.

In optical fiber or information terminal equipment systems, a high speed response and high quantum efficiency are essential photodiode capabilities. Accordingly, Hitachi has been employing PIN structures for photodiodes to achieve higher quantum efficiency and reduce junction capacitance for a faster response. "PIN" signifies a structural configuration whereby an intrinsic layer with high resistance is sandwiched between p-type and n-type semiconductors. The electric field is applied to the intrinsic region, and most incident light is absorbed in this region, producing a great many electron-hole pairs.

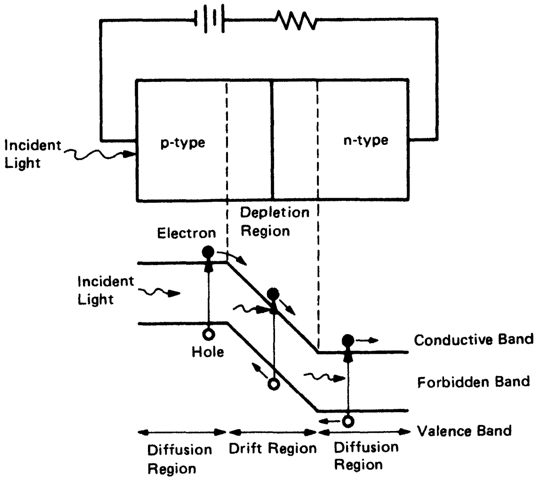


Figure 28 Photo-Detection Principle

1.6 Photodiode Structures

1.6.1 Si PIN Photodiodes

PIN photodiodes are characterized by high quantum efficiency and a high speed response under low voltage operations. To operate photodiodes at low voltages, it is necessary that impurities in the intrinsic layer be limited to the greatest extent possible, thus leading to a wide depletion region and a high light-absorption coefficient.

Hitachi Si PIN photodiodes achieve their depletion regions with less than a 5V bias voltage. This is brought about Hitachi's high-purity epitaxy processes. A cross-section of Hitachi Si PIN photodiodes is illustrated in Fig. 29.

These photodiodes are sensitive over wavelength ranges from 450nm ~ 1000nm, and quantum efficiency at 830nm is as high as about 70%. Figure 30 shows frequency response under conditions of 830nm incident light, 50Ω load resistance and use of a network analyzer. As can be seen in this figure, a cut-off frequency of more than 300 MHz can be obtained at a 5V bias voltage.

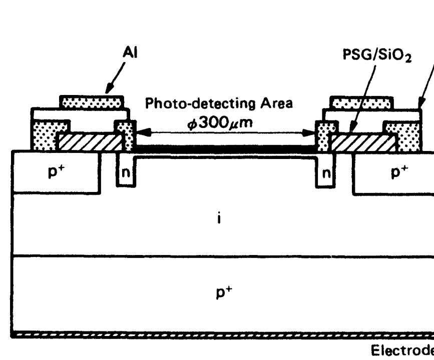


Figure 29 Si PIN Photodiode Structure

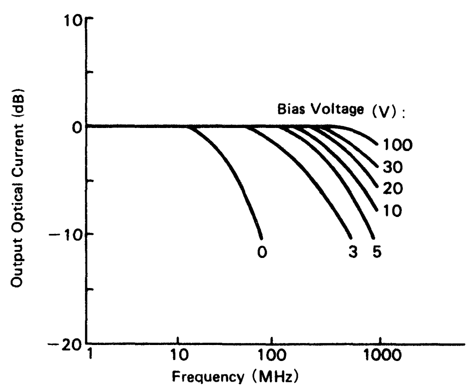


Figure 30 Frequency Response for Si PIN Photodiode

1.6.2 InGaAsP/InP PIN Photodiodes

To optimize InP compound semiconductors for photodiode use, a unique light absorption structure is employed to gain high quantum efficiency. This is necessary because the absorption coefficient of InP compounds is so large for light of greater than band gap energy.

Electron hole pairs also recombine and are annihilated easily when there are defects at the chip surface.

Hitachi InGaAsP/InP photodiodes make use of a planar structure (Fig. 31). In them, incident light is absorbed into the InGaAsP layer through the InP diffusion layer.

The absorption edge of the InP has a wavelength of about 900nm. Light with longer wavelengths can pass through the InP layer to the InGaAsP layer. One attractive characteristic of this structure is that the spectrally sensitive region can be set easily by changing the mixture ratio of the $In_{1-x}Ga_xAs_yP_{1-y}$ light-absorbing layer.

Quantum efficiency is about 65% at 1300nm when the spectrally sensitive region is set at 1000nm ~ 1500nm.

Frequency response is flat up to around 1 GHz. Thus, this area is suitable for signal detection use in high speed fiber-optic transmission systems.

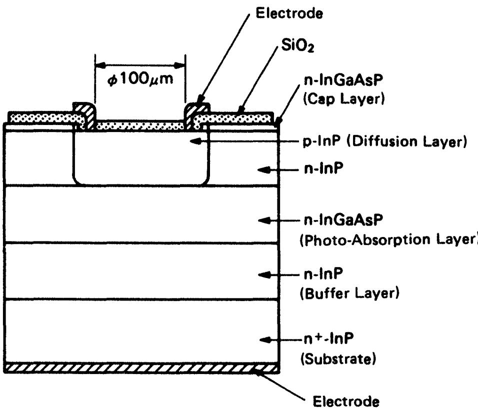


Figure 31 InGaAsP/InP PIN Photodiode Structure

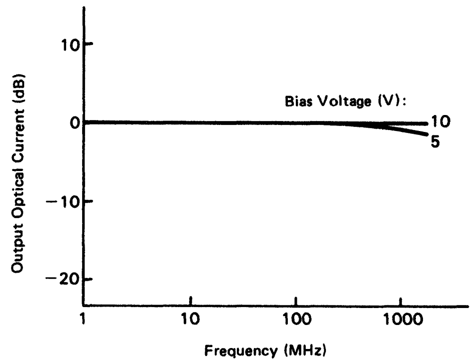


Figure 32 Frequency Response for InGaAsP/InP PIN Photodiode

2. OPTICAL AND ELECTRICAL CHARACTERISTICS

2.1 Measurement of Fundamental Characteristics

2.1.1 Measurement of Light-current Characteristics

(1) Light-current Characteristics of LD

The photo detector with proper response and effective photo sensitive area is first required for measuring LD's optical characteristics.

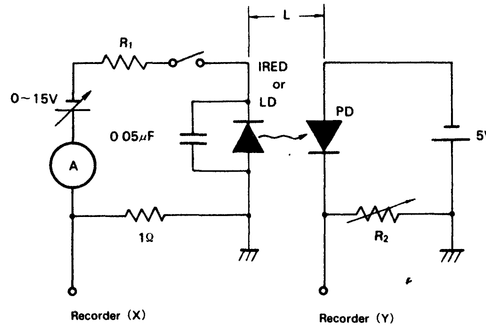
The measurement setup for light-current characteristics under CW operation is shown in Fig. 33. A photo cell of more than 20 mm dia. is recommended which is provided with enough photo sensitive area to take-in full light power without a lens. The suitable distance between a photo cell and a LD chip is 5 ~ 10 mm. Since photo voltaic sensitivity differs with devices, each photo cell must be calibrated with a standard cell and R_2 must be adjusted accordingly before this setup is actually used. A device must be mounted on a copper or aluminum heat radiator of about 30x40x2 mm^3 especially for CW testing. Because the heat generated from a chip itself degrades the device characteristics and life time.

The measurement setup example for light-current characteristics under low frequency up to several 10 kHz with low duty (about 1%) pulsed operation is shown in Fig. 34, which employs a PIN photo diode as a photo detector. Sampling measurement of photo voltaic current should be made when it becomes stabilized.

The measurement setup for fast-pulse response needs to employ a high speed PIN photo diode or APD (Avalanche Photo Diode) which can respond up to several GHz (Fig. 35).

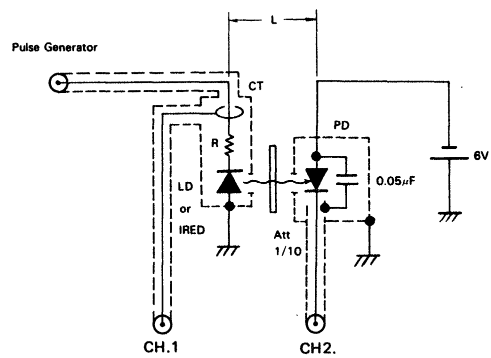
Delay time of optical output pulse appears against drive current pulse, when DC bias is set below the threshold. Delay time depends on bias point and temperature as shown in Fig. 36 as an example.

One of the typical light-current characteristics of HLP1400 is shown in Fig. 37. The average threshold current I_{th} is about 60 mA at the room temperature and the slope efficiency η is about 0.3 mW/mA. Although there is some light emission at the bias point below the threshold current, it is not laser light but spontaneous emission which is the same as that of LED. The optical output power at the threshold current is less than 0.2 mW for HLP1400. The characteristics temperature T_0, which represents temperature dependence of threshold current, is between 160 K and 250 K (typ. 200K). Slope efficiency tends to lower against temperature rise (Fig. 38).



D : Large area Si-Solar Cell
R_1 = 10 ~ 50Ω for HLP1000, HL7801, HL8311
= 100 ~ 300Ω for HLP5000
R_2 ≃ 20Ω for 10mV output at 1mW optical power
L ≃ 1 cm

Figure 33 Measurement Setup for Light-Current Characteristics under CW Operation



Sampling Oscilloscope (Dual Trace Input Impedance 50Ω)
PD : Si-PIN Detector.(UTD PIN-10DP)
CT : Current Transformer (Tektronix CT-1)
R ≃ 47Ω for HLP1000, HL7801
≃ 43Ω for HLP 5000 and IRED
L ≃ 6mm

Figure 34 Measurement Setup for Light-Current Characteristics under Low Frequency Pulsed Operation

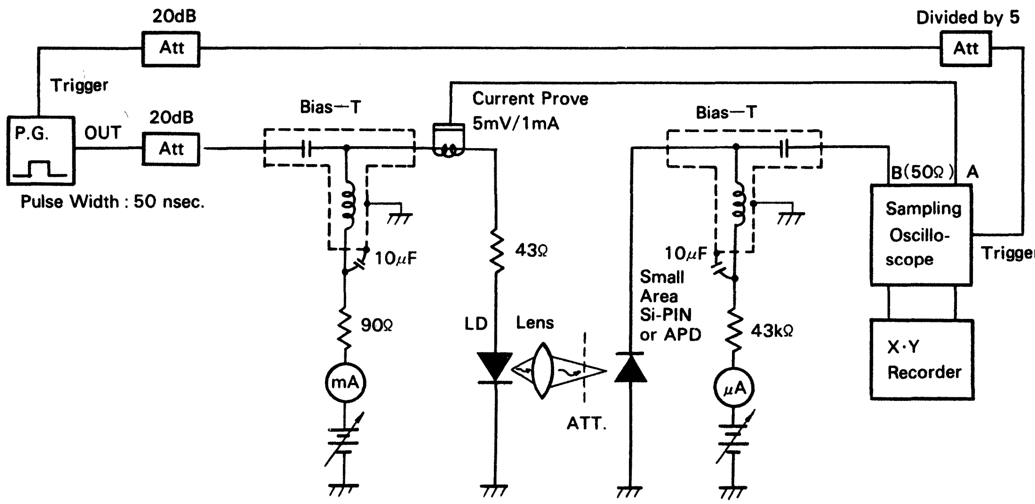


Figure 35 Measurement Setup for Fast Pulse Response

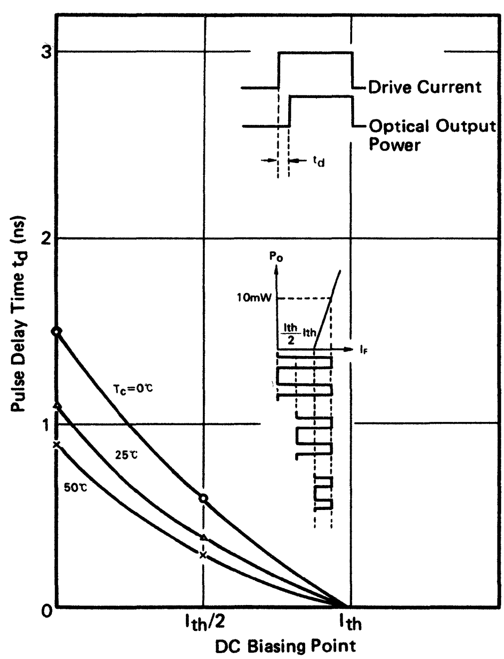


Figure 36 Bias Dependence of Pulse Delay Time (HLP1400)

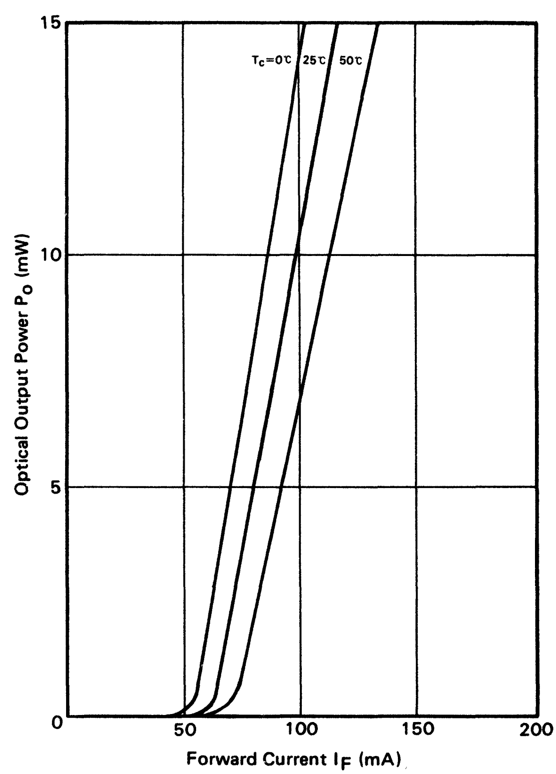


Figure 37 Light-Current Characteristics (HLP1400)

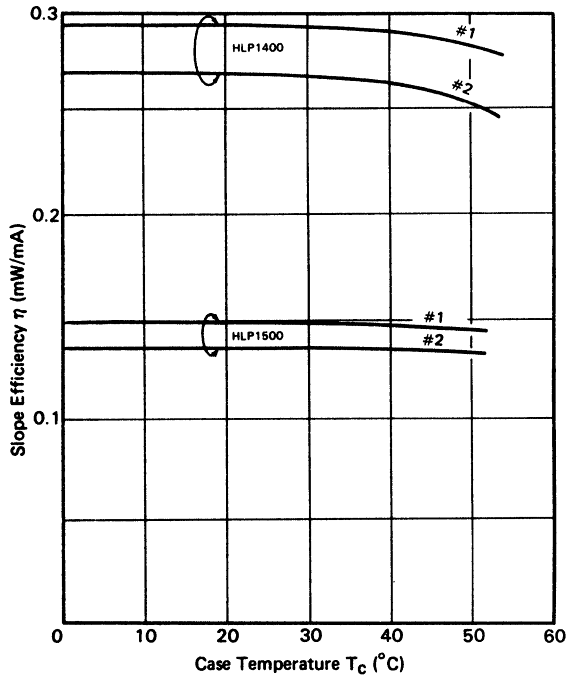


Figure 38 Temperature Dependence of Slope Efficiency

(2) Light-current Characteristics of IRED

The measurement setup of Fig. 33 for light-current characteristics is also used under CW operation. An optical cone described in Fig. 39 is needed for leading whole light to a photo cell. Calibration of the setup is also required for photo voltaic sensitivity variation of each photo cell as described in the previous section. A device must be mounted on a copper or aluminum heat radiator which is larger than 30x40x2 mm^3 especially for CW testing. Because the heat generated from a chip itself heavily reduces optical output power.

The measurement setup of Fig. 34 is also used for light-current characteristics under low frequency up to several 10 kHz with low duty (about 1%) pulsed operation. The light-current characteristics of HLP30RG under various pulsed operations are shown in Fig. 40.

Since junction temperature rise under pulsed operation is lower due to the small average current, light-current linearity and peak optical output power are improved against those under DC operation.

However, attention must be paid to the pulse peak current not to exceed the destructive current to be described in "2.2.4 Current Destruction of IRED". Also confirmation of device degradation by experiement under the designed pulse condition is recommended before the actual use.

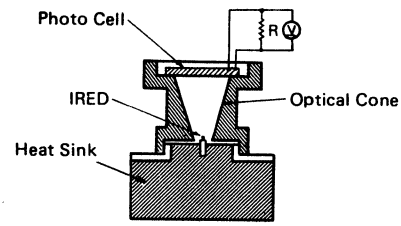


Figure 39 Measurement of Optical Output Power (P_O) under CW Operation

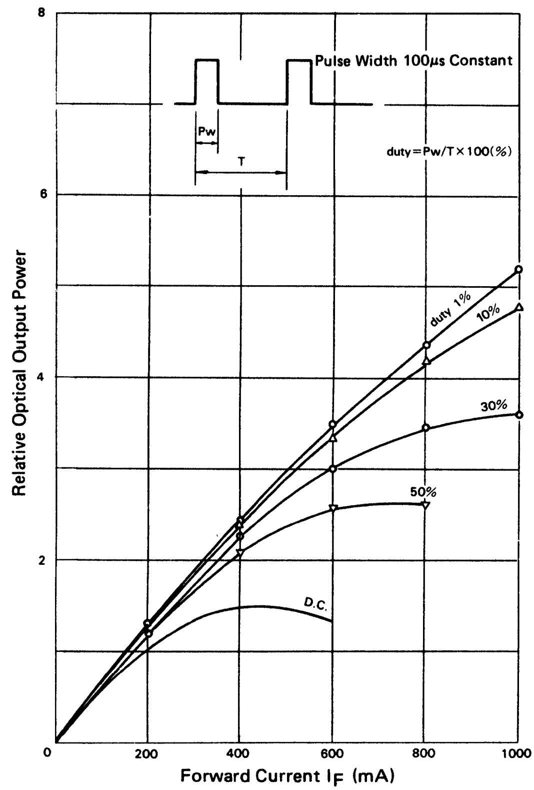


Figure 40 Light-Current Characteristics under Pulsed Operation

2.1.2 Measurement of Far Field Pattern (FFP)

FFP is the light intensity profile measured in two directions as function of angle: parallel and perpendicular to a device (the active layer on LD and arbitrary on IRED). The measurement setup for FFP is shown in Fig. 41, which employs the same drive circuit as that for light-current characteristics measurement under CW operation. Use a PIN photo diode with small photo sensitive area or a APD as a photo detector. The distance between the detector and LD is about 10 cm. Set the emitting point of LD at the center of the turn table. Use of a potentiometer is effective to translate the rotation angle to voltage.

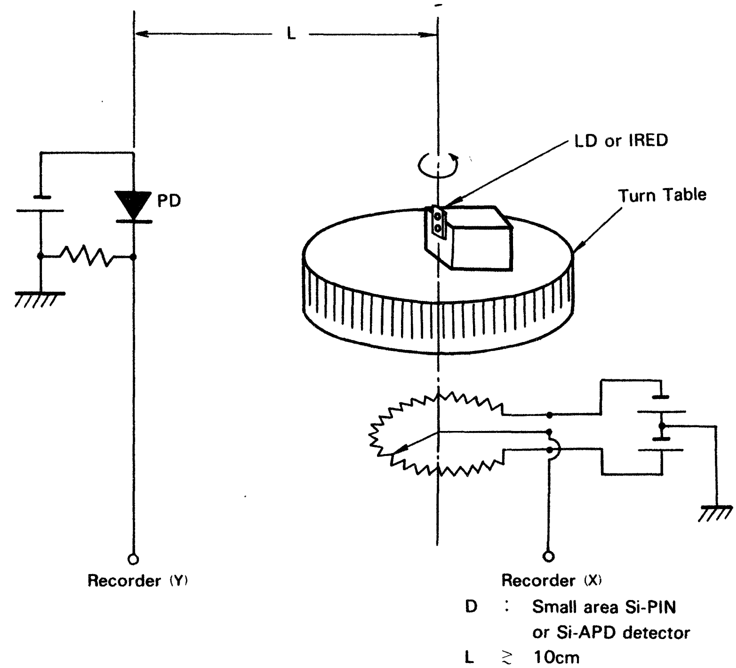


Figure 41 Measurement Setup for Far Field Pattern (FFP)

(1) FFP of LD

FFP of HLP1000 Series is shown in Fig. 42 for various power output.

HLP Series lase with stable transverse fundamental mode, namely with single peak FFP quite close to the gaussian curve. FFP grows its height proportionally to optical output power and has no peak point steering or no light distribution width change within the maximum ratings.

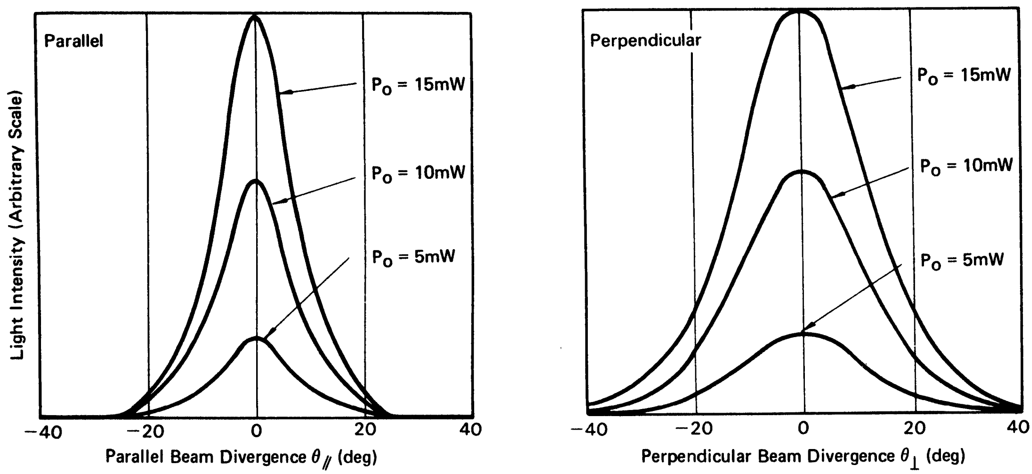


Figure 42 Light Dependence of Far Field Pattern (FFP) (HLP 1000 Series)

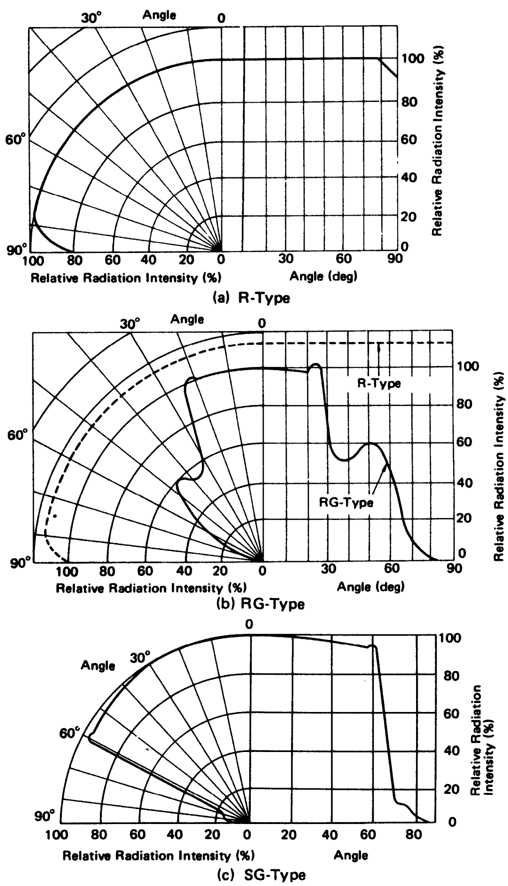


Figure 43 Far Field Pattern (FFP) of IRED

(2) FFP of IRED

Since Hitachi IREDs have their chip surfaces hemispherically polished, FFP of an IRED chip (R type) exhibits a quite flat appearance against angle as shown in Fig. 43 (a). However, the flat area is limited on RG (Modified TO-18) and SG (Modified TO-46) types because of their cap interference as shown in Fig. 43 (b) and (c).

2.1.3 Measurement of Polarization Ratio of LD

The measurement setup for polarization ratio is shown in Fig. 44. An objective lens collimates the light emitted from LD to form parallel beam. In this case, use of an infrared phosphor plate is helpful to detect light. Choose the measurement equipments with appropriate aperture and photosensitive area not to disturb the parallel beam input. Polarization ratio is calculated with the maximum and the minimum value of a power meter while turning a polarization prism.

Polarization phenomenon of LD is illustrated in Fig. 45. Electric field oscillates in parallel to the active layer, and magnetic field in perpendicular.

Polarization ratio depends on optical output power and numerical aperture. The polarization ratio vs. power output of HL7801 Series and HLP1400 is shown in Fig. 46 (a) and Fig. 46 (b) respectively. Polarization ratio is larger when optical output power is higher or NA (numerical aperture) of an objective lens is smaller. For the 600 type package, polarization ratio is still kept high due to its optical isotropic window glass.

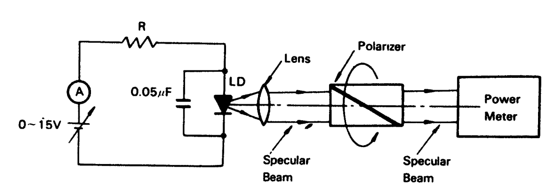


Figure 44 Measurement Setup for Polarization Ratio

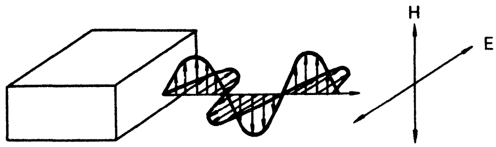
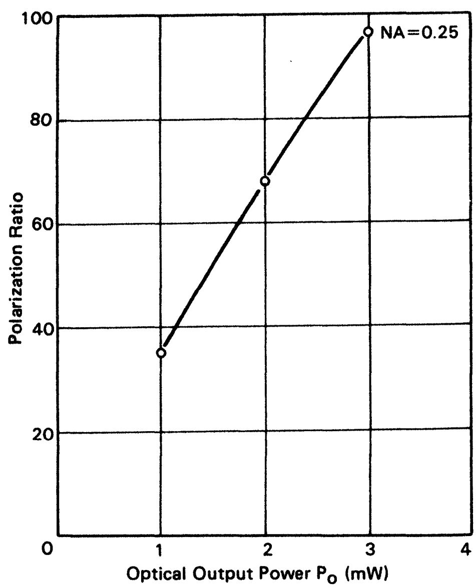
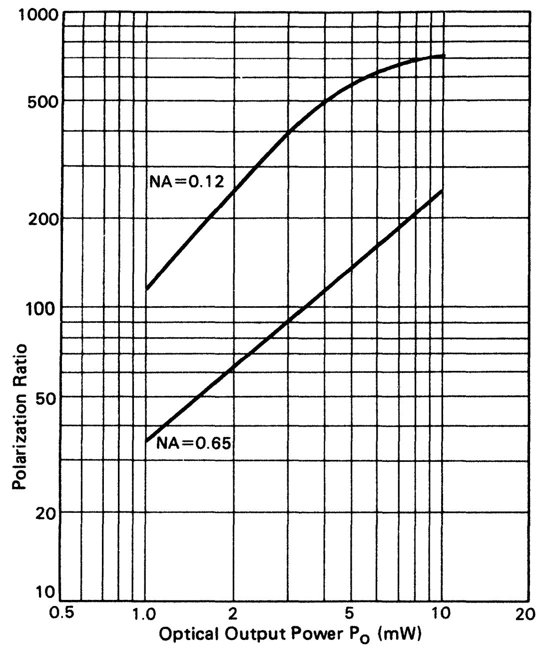


Figure 45 Polarization of LD



(a) HL7801 Series



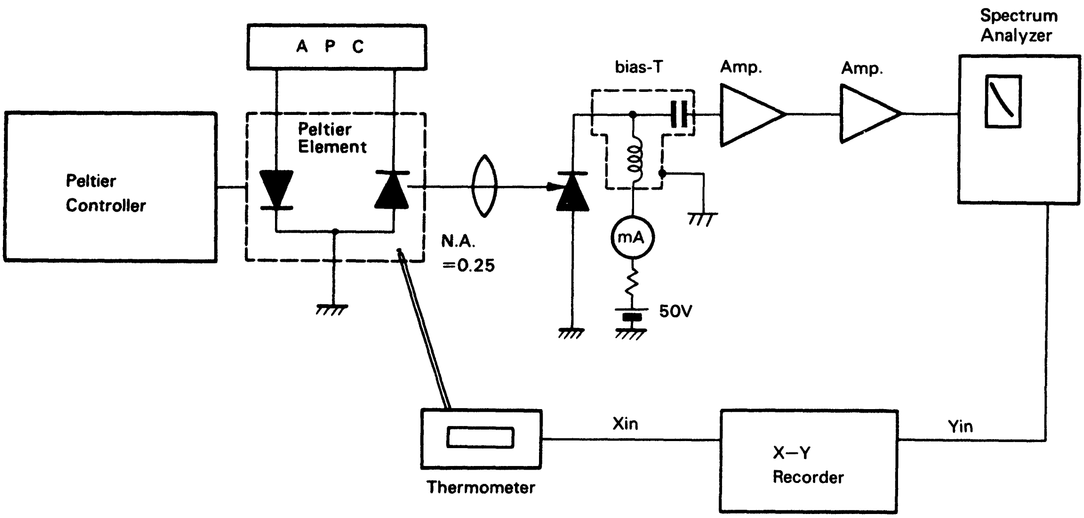
(b) HLP1400

Figure 46 Output Power Dependence of Polarization Ratio

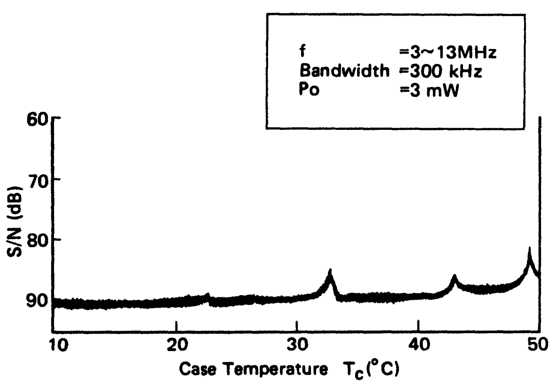
2.1.4 Measurement of LD Noise

Measurement setup for LD noise is shown in Fig. 47 (a). Set the frequency range to be measured suitable for each device application.

Fig. 47 (b) shows an example of noise characteristic vs. case temperature.



(a) Measurement Setup for Noise



(b) An Example of Noise Measurement

Figure 47 LD Noise

2.1.5 Observation of Radiation Pattern

Observe radiation pattern with an infrared camera, in operating a device under CW and collimating the emitted light to parallel beam with a lens (Fig. 48). Control the amount of incident light into an infrared TV camera with an optical attenuator, for overflow of light into the camera causes halation.

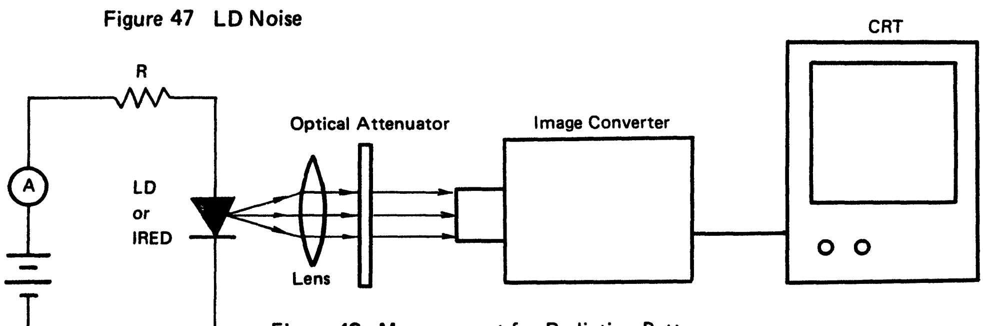


Figure 48 Measurement for Radiation Pattern

2.1.6 Photo-detection sensitivity (S)

An example is given in Fig. 49 of a method for measuring photo-detection sensitivity. A laser beam of specified wavelength is input from an LD into an optical fiber. The optical axis is ajusted so that the light quantity is maximum at the photodiode surface. The APC circuit is then adjusted so that there is a specified level, Pin, of optical input power into the photodiode. It is necessary at this time to adjust the position of the photodiode so as not to change the saturation current, I_s. The photo-detection sensitivity, S, can then be calculated using the formula:

$$S = I_s/P_{in} \text{ (mA/mW)}$$

When measuring spectral sensitivity characteristics, values calculated for spectral sensitivity are usually compared against wavelengths. Here, several wavelengths that have issued from monochromatic light sources and have the same spectral width are usually employed.

Figure 50 shows the relation between saturation current, I_s, and reverse voltage, V_R, for Si PIN and InGaAsP/InP PIN photodiodes. Spectral sensitivity characteristics are listed in the individual product data sheets.

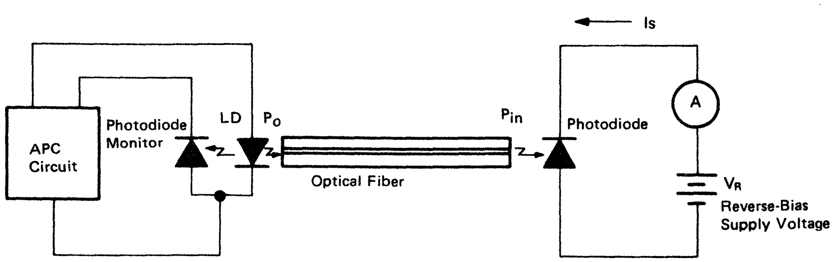
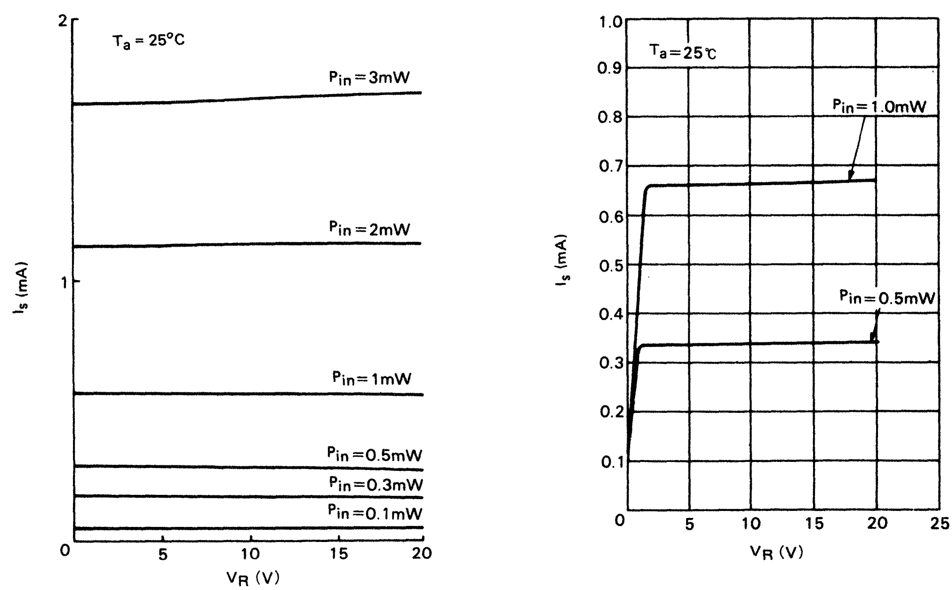


Figure 49 System for Measuring Photo-Detecting Sensitivity



(a) Si PIN Photodiode (HR8102) (b) InGaAsP/InP PIN Photodiode (HR1101)

Figure 50 Relationship between Saturation Current and Voltage

2.1.7 Photo-detection response characteristics

Photo-detection response can be observed by measuring rise time, t_r, and fall time, t_f, for a photodiode output-current pulse when a pulse is input into the photodiode (Fig. 51). A measurement setup example is presented in Fig. 52. A high speed response capability is required for precise measurement of photodiode response when a monochromatic light source, LD, is employed. Optical power output from an LD is focused using a lens, and the axis of the LD and the photodiode is adjusted so the focused spot is within the photo-detection area of the photodiode. LD optical output power is then set by adjusting the pulse generator so that a specified volume of light is incident on the photodiode. A photo-detection response example is shown in Fig. 53.

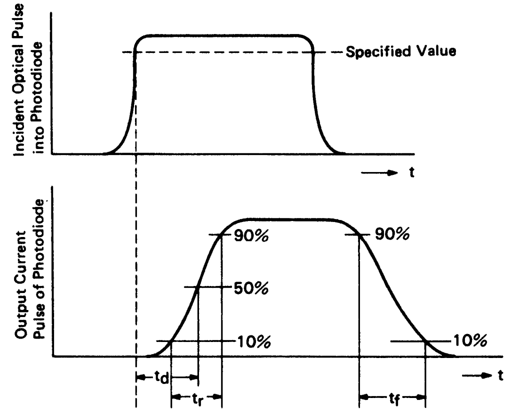


Figure 51 Definition of Photo-Detection Response time

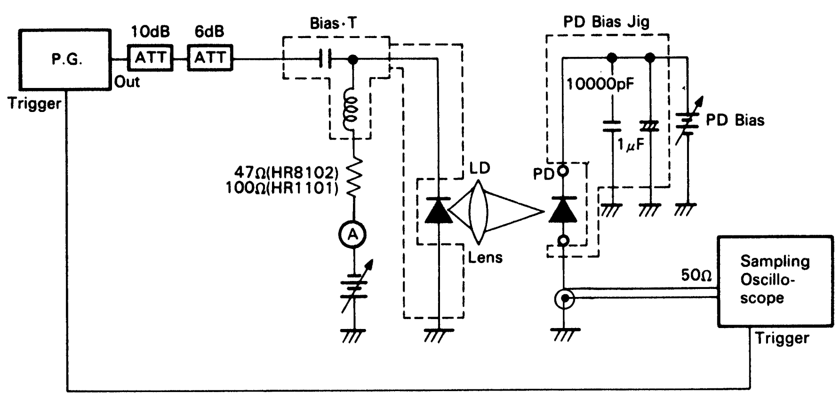
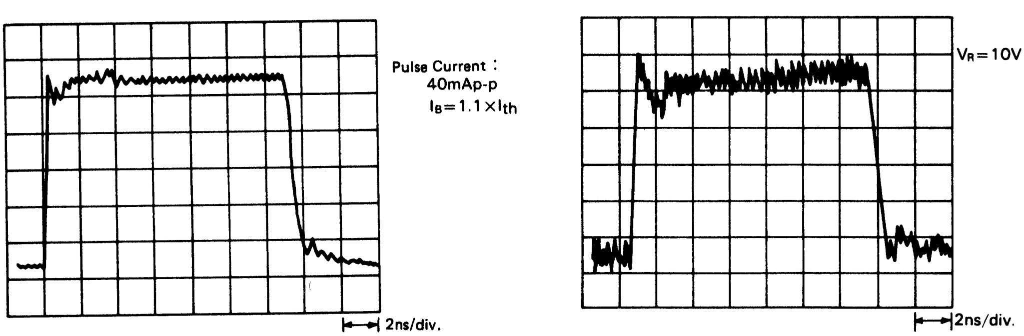


Figure 52 Setup for measuring Photo-Detection Response



(a) LD Drive Current Waveform

(b) Photodiode Photo-Detecting Current Waveform

Figure 53 Photo-Detecting Response Wave for InGaAsP/InP PIN Photodiode (HR1101)

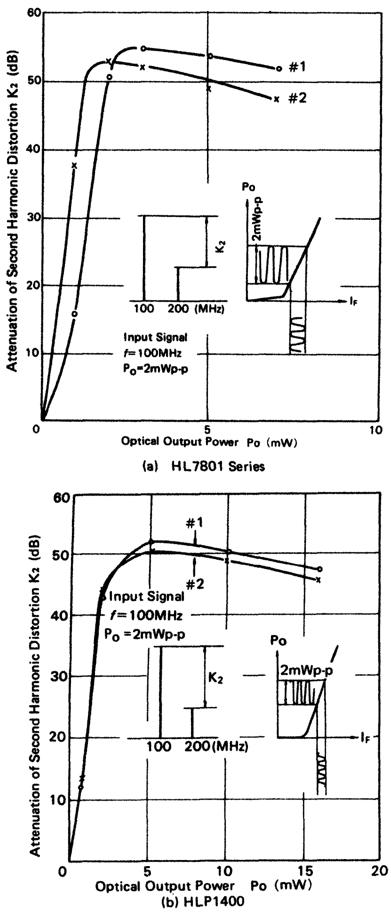


Figure 54 Second Harmonic Distortion of LD

2.2 Reference Data

2.2.1 Second Harmonic Distortion of LD

The ratio of 200 MHz second harmonic component to 2 mWp-p of 100 MHz input signal and optical output power is shown in Fig. 54 (a) and (b).

2.2.2 Temperature Dependence of Lasing Spectrum of LD

Lasing spectrum hops as the combined result of axis mode number change (0.2 ~ 0.3 nm/°C) and active layer's refractive index change (≃0.05 nm/°C) vs. temperature (Fig. 55).

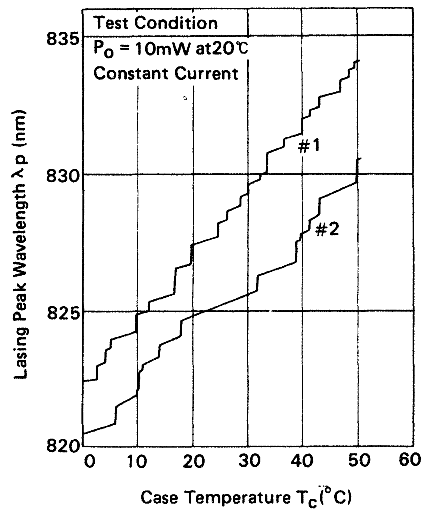


Figure 55 Temperature Dependence of Lasing Spectrum (HLP1400)

2.2.3 Fiber Coupling Characteristics of IRED

Fig. 56 shows launched power vs. fiber dimensions on various IREDs with about 5 μm gap between a fiber tip and a chip surface.

Fig. 57 shows effective far field pattern of HE8403R as relative intensity vs. horizontal fiber positioning.

Fig. 58 shows coupling stability of HE8402F which fits to the standardized connector with a fiber. Reproducibility at multiple coupling trials and coupling stability at device rotation against a connector are favorable and within ±0.5 dB.

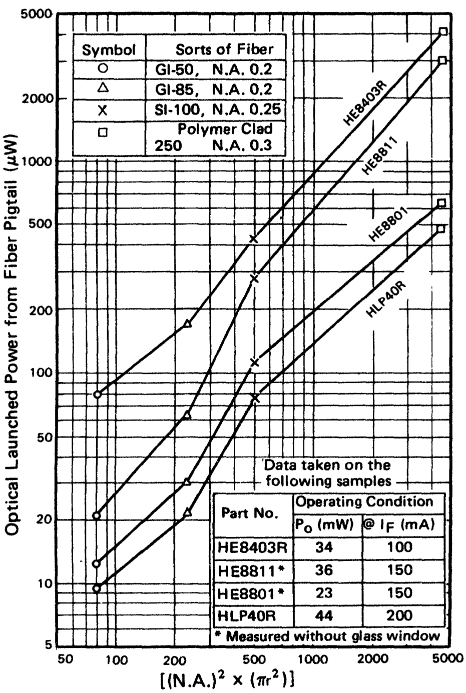


Figure 56 Typical Launched Power Characteristics

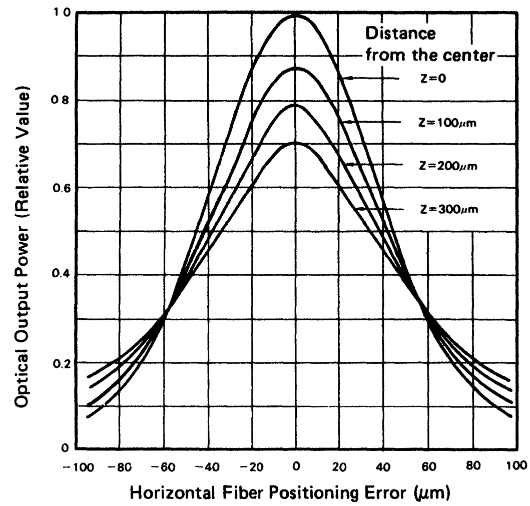


Figure 57 Relative Intensity vs. Horizontal Fiber Positioning

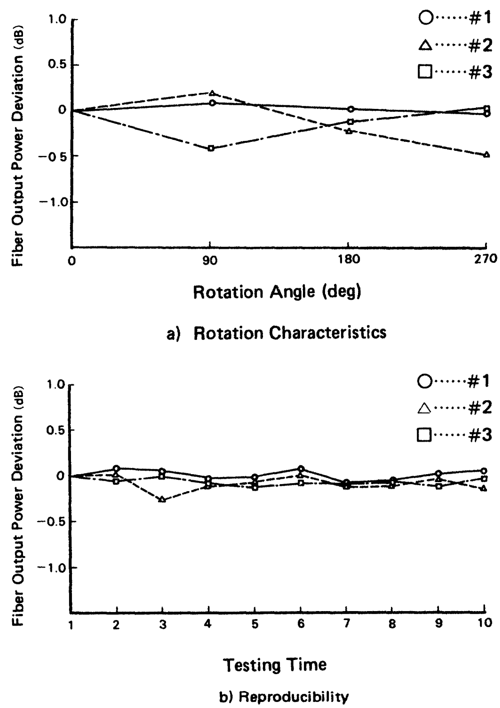
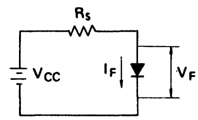


Figure 58 Reproducibility of Fiber Connection

2.2.4 Current Destruction of IRED

The absolute maximum ratings should not be exceeded under DC operation. Do not allow excessive current to flow, even at switching-on or under pulsed operation. The destruction current value for each product type is shown against pulse width in Fig. 59. Operating current should be below a half of the destruction current level and the value at which the optical output is saturated in light-current characteristics curve.

Insert series protection resistance R_S to limit excessive current in DC operation. When a constant voltage supply is to be used, design a drive circuit to use high enough voltage V_{CC} to reduce current deviation due to the forward voltage drop variation among diodes. When a constant current source is to be used, use high enough series resistance R_S to limit excessive current before a current limitter starts functioning.



a) **On Using Constant Voltage Power Supply**

$$R_S = \frac{V_{CC} - V_F}{I_F} \quad (\Omega)$$

V_{CC} : Supply Voltage (V)
V_F : Forward Voltage (V)
I_F : Forward Current (A)

b) **On Using Constant Current Power Supply**

$$R_S = \frac{V_{CO} - V_F}{I_{F\,max}} \quad (\Omega)$$

V_{CO} : Unroaded Supply Voltage (V)
V_F : Forward Voltage (V)
I_F max : Absolute Maximum Rating (A)

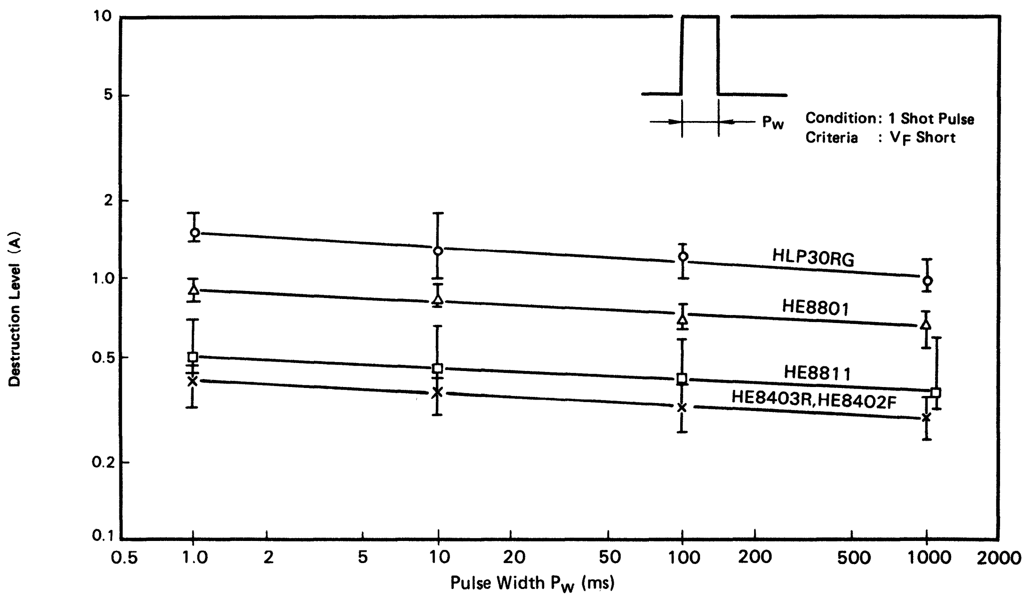


Figure 59 Destruction Level

2.2.5 Thermal Resistance of IRED

The best heat sink design is required, for IRED's life time heavily depends on junction temperature. 10,000 hours of device life (degraded to a half of the initial output power) is expected in operation at T_j = 100°C with an effective thermal radiator as shown in Fig. 60.

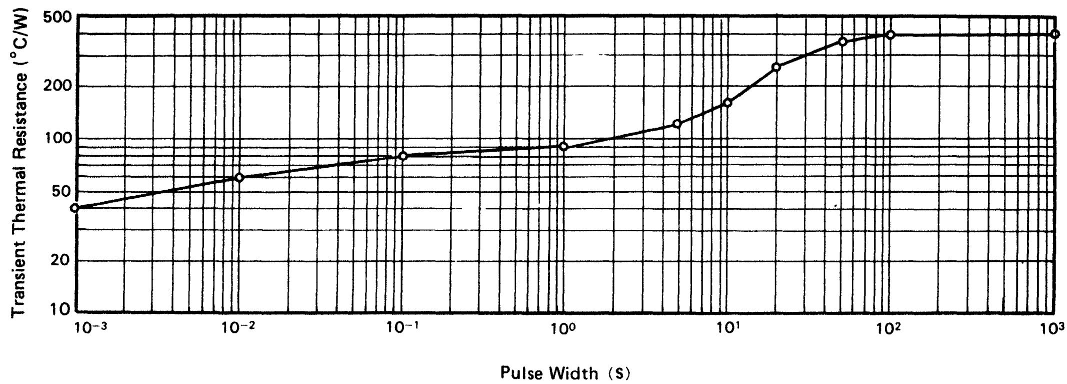


Figure 60 Thermal Resistance Characteristics (HLP30RG)

2.2.6 Near Field Pattern (NFP) of IRED

Light intensity is highest at the edge of light emitting area due to the current concentration at the junction boundary. The light intensity profile becomes as shown in Fig. 61.

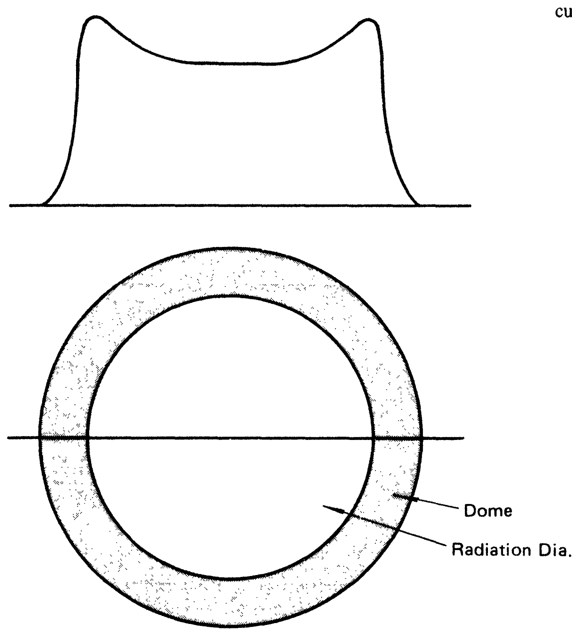


Figure 61 Near Field Pattern

2.2.7 Radiation Diameter of IRED

Effective radiation diameter differs with chip structures. The effective radiation diameter of HLP Series (600 μm dome dia.) is about 520 μm and HE8801 and HE8811 (400 μm dome dia.) is about 360 μm (Fig. 62). The effective radiation diameter of HE8402F and HE8403R whose chip structures are current concentration type is about 150 μm.

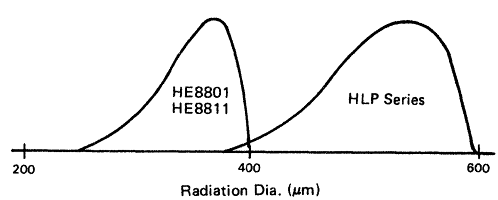


Figure 62 Effective Radiation Dia. Profile

APPLICATION HINTS

1. APPLICATIONS

1.1 Applications of LD

Laser beam is characterized by its excellent monochromacy, directionality, good collimation capability and coherency which gives much interference characteristics. In addition to these properties, semiconductor LD has various advantages such as small size, light weight, and capability of low voltage drive and direct high speed modulation. Laser technology is to control these properties in respect of time and space for LD applications.

Table 8 shows application examples and suitable LD products for them.

Table 8 LD Applications

Application Field		Application	Feature	Suitable Product
Fiberoptic Communication	Long Distance	Telephone Trunkline Undersea Cable Terrestrial Communication Network	Low Dissipation Wide Bandwidth No Cross Talk Light Weight	HLP1500 HLP5500 HL1221B HL1321P HL1321SP
	Short and Intermediate Distance	LAN CATV Data Highway and Freeway Subscriber Line Computer Process Control		HLP1500 HL1321P
Optical Beam Communication		Intersatellite Communication Video Data Transmission	No Radio Wave Interference	HL8312E HL8314E
Information Terminal Equipment		Laser Beam Printer	High Speed and High Resolution Printing	HLP1400 HLP1600 HL7801E/G HL7802E HL8311E/G HL8312E HL8314E
		POS Terminal	Office Automation	
		Optical Memory Disc	Semi-permanent Storage High Bit Rate High Density Information	
Consumer Equipment		Video Disc		HL7801E/G
		PCM Audio Disc	Wide Dynamic Range Excellent Frequency Performance	
Measuring Equipment		Laser Dust Monitor	Small Size Light Weight High Precision	HLP1600 HL7801E/G HL8311E/G HL8312E HL8314E
		Precision Surface Inspection Equipment	Non Contact Non Destructive Inspection	
		Interferometer Spectrometer Distance Meter Range Finder Laser Speedometer Laser Current Transformer	High Precision Non Contact	

1.1.1 Fiberoptic Communication

The communication with an optical fiber has the following advantages compared with the conventional coaxial cable.

1) Higher bit rate and longer distance communication for its lower loss and wider bandwidth performance.
2) Smaller diameter and lighter weight.
3) Free from electroinductive noise from high voltage transmission line or thunderbolt.
4) Free from spark, electric shock or heat when a fiber is broken.
5) Potential cost advantage and material saving in future.

Various applications have materialized up to now for these advantages. The transmission loss of a fiber mostly depends on the amount of water component (OH radical) included in the silica glass as impurity. Fig. 63 shows the typical transmission loss characteristics of a silica fiber vs. wavelength. The fiber at the early stage of development had its high absorption peaks of OH radical in 0.9 μm to 1.7 μm range and the minimum transmission loss in 0.8 μm band. The wavelength area in which the transmission loss becomes least is referred as a fiber window. Major efforts in the research and development have been concentrated to minimize the transmission loss and the fiber window has been widened to achieve transmission loss of 2 ~ 3 dB/km in 0.8 μm band.

Further progress of the purification technology of a silica fiber achieved transmission loss minimization which made it very close to the theoretical curve as shown in Fig. 63.

Hitachi HLP5000 Series are developed to utilize 1.3 μm window, and they are the most suitable for high bit rate and long distance fiber communication.

Fiberoptic transmission falls into two signal patterns: the analog system and the digital system. Analog transmission equipments such as VHF or IF band TV signal and base band picture signal strongly requires wide band width, low noise and low distortion. Therefore, extremely good linearity of light output characteristics is required against a light signal source. On the other hand, the digital transmission system has various modulation methods and can easily achieve the bit error rate of 10^{-9} bit/sec. This transmission system can realize far higher transmission quality than the conventional coaxial cable system by four or five digits.

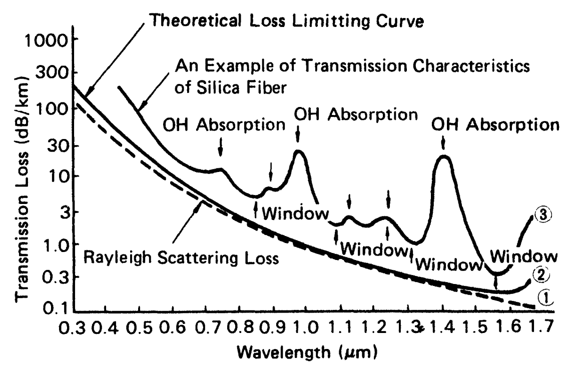


Figure 63 Transmission Loss of Typical Fiber

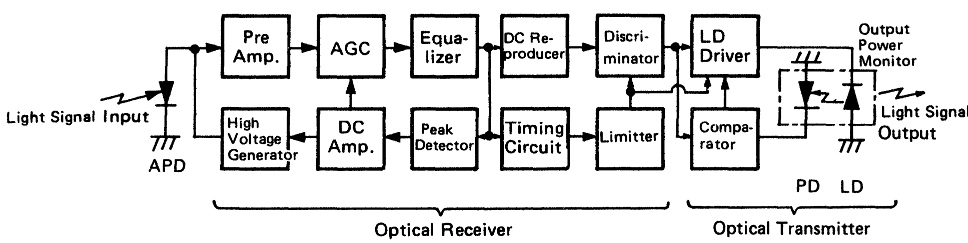


Figure 64 Block Diagram of Repeater for Digital System

Long distance transmission may need a repeater. Fig. 64 shows the block diagram of the repeater for digital system. The feedback loop controls the laser driver, which compensates fluctuation of LD output power. A circuit to compensate non-linearity of LD may be added for analog modulation.

The Wavelength Division Multiplexing (WDM) system which adopts the multiple wavelengths for one fiber is commonly used to increase transmission capacity at low cost. The WDM system is widely spreading not only for public subscriber line but for long distance terrestrial trunk line and intercontinental communication. As advancement of network systemization, frequency division multiplexing against a specific wavelength which is referred as super division multiplexing will be required further.

The problems with the analog modulation system are distortion and noise due to the non-linearity of a light signal source as described before. These problems, however, do not arise unless direct amplitude modulation is applied to a light source. An applicable method is to pre-modulate carrier frequency with pulse signals in a preceding electric circuit and to carry out only pulse transmission in an optical signal processor. PPM, PIM, PFM, PWM and others are available for pre-modulation and contribute to extend the bandwidth of communication systems.

1.1.2 Optical Printer

A laser beam printer was commercialized for the computer off-line printer. Printing speed of 10,000 ~ 18,000 lines per a minute is achieved, using a HeCd or HeNe gas laser as a light source and electrophotography technique. Office automation equipments developing rapidly these days need such a printer as can print out with high quality and high speed. Responding to this requirement, use of LD is becoming more popular, which realizes printers of small size, light weight, high speed operation and low energy consumption.

Fig. 65 shows the principle structure of laser printer system. After LD drive current is modulated with recording signals, Polygon mirror or Galvano mirror scans laser beam horizontally to the photo sensitive drum which spins with constant speed and forms a kind of electrostatic latent image on the drum. The surface of the photo sensitive drum (an insulator) is charged with positive electricity initially by the corona discharge method. Then negative electricity is charged between a conductive substrate and an insulator. After the surface electricity is discharged by alternative electric field applied, the resistance of the area where laser beam is applied lowers and electricity discharges. This is electrostatic latent image, developed by adhering toner (colored particles charged with opposite electricity) to the area of charged surface. Then the image is printed secondarily to a paper by cornoa discharge and settled by pressure and heat. This is the procedure of printing.

An organic photo conductor is usually used as a photo sensitive medium whose spectro-sensitivity is higher at shorter wavelength. Therefore development of LD with short wavelength and improvement of a photo sensitive medium with good spectro-sensitivity at longer wavelength are two areas of key technology.

High power LDs HL8311 Series (15 mW), HL8312 (20mW) and HL8314 (30 mW) at 830 nm, and short wavelength LDs HL7801 Series (5mW) and HL7802 (10 mW) at 780 nm are available for this application.

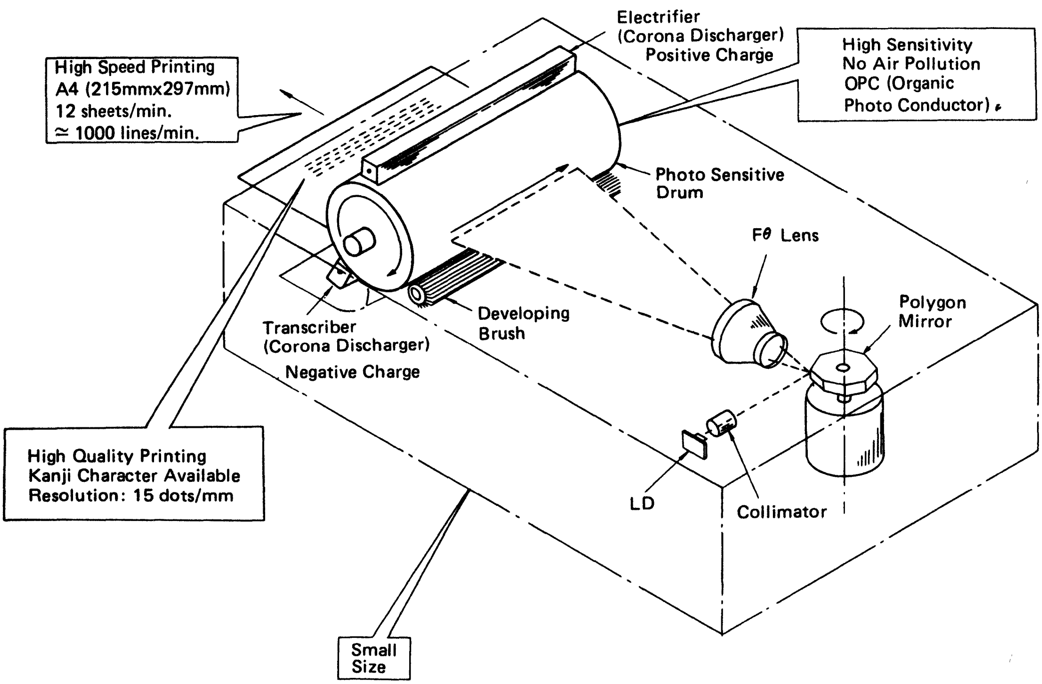


Figure 65 Structure of Laser Printer System

1.1.3 Optical Disc Memory System

The optical disc memory system writes and reads data with laser beam focused to a spot of 1 ~ 2 μm dia. through optics. This minute spot corresponds to one bit. The one side of a 30 cm LP size disc can record $10^{10} \sim 10^{12}$ bits (10 Gb ~ 1000 Gb). An optical disc system includes DRAW (Direct Read After Write) system developed mainly for computer terminal equipments and audio disc and video disc systems for commercial use. The optical disc is formed with the acrylic resin coated with Al and Te, etc., and is written by heat of focused laser beam. The system does not have rewriting capability. Opto thermal magnetic recording system is under intensive research and development for the rewritable optical disc memory.

(1) PCM Digital Audio Disc and Video Disc

A digital audio disc is standardized to a compact disc (CD) type and equipments are widely commercialized. Fig. 66 shows optics of CD system with tracking function. At the information signal pickup, tracking deviation and defocusing are also detected, then each signal is led into a servo control circuit. A coupling lens collimates laser beam to parallel beam. The λ/4 wave plate turns the poralization direction by 90 degrees. When the laser beam hits a pit, the reflected lights interfer each other and are diffracted to the outside of the aperture of an objective lens, resulting in decrease of the light amount which returns to a lens. When the laser beam hits a mirror facet (concave portion), all the light reflect to return to the inside of the aperture and enter the detecting system. A polarized beam splitter leads the beam reflected from a mirror facet to a photo detector through a lens. In CD system a program source is sampled at 44.1 kHz and encoded with 16 bit linear quantization then recorded on a disc as a chain of pits. The source information is reproduced by reversing this order, using a 16 bit D-A converter, a sample and hold and a bit error correction LSIs. LD couples strongly with reflection objects located within a matter of some cm such as a disc surface forming an external cavity, which brings reflection light back into the laser cavity and causes fluctuation of lasing mode and optical output power. The phenomenon is referred as SCOOP Noise (Self Coupled Optical Pickup) and enough care as well as for Mode Hopping Noise is required on designing a player equipment.

A video disc system handles analog signals, on the other hand, length of a pit on a disc corresponds to analog signal amplitude, unlike the pit of CD which expresses "1" or "0" as a chain of pits. A video disc needs much tighter noise level by 20 ~ 30 dB compared with CD, because of its wide signal bandwidth of 1.7 ~ 9 MHz.

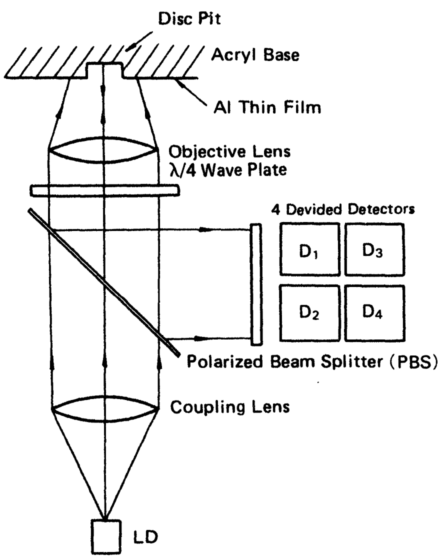


Figure 66 Optics of CD System

The family tree chart of optical memory system is shown in Fig. 67 as an example.

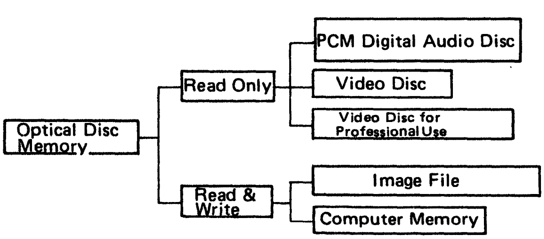


Figure 67 Family of Optical Disc Memory System

An office video disc has basically the same functions as for home use. It has been enforced usually with microcomputer softwares to have more versatile features such as random access still pictures or their programmed display. It is going to be widely accepted by information service markets of education, fashion product marketing and others.

(2) Image File and Computer Disc Memory Systems

Expected relative positioning of various memory systems is shown in Fig. 68 on cost per bit vs. access time. The optical memory disc system is located in lower cost region by about 3 digits than the magnetic system. This is because the memory density which is now about 10^{10} bits achieved is higher by this figure. It means that a single side of a 30 cm LP size disc can record or memorize enormous information of about 50,000 tracks or 10,000 sheets of A4 size (215 x 297 mm^2) still pictures. On writing signals, beam of 15 ~ 25 mW focuses to a spot of 1 ~ 2 μm dia. through a lens and a disc surface can obtain optical power of 8 ~ 10 mW. On reading signals, the pickup system similar to that for other optical disc system is employed with about 1 mW of focused beam power.

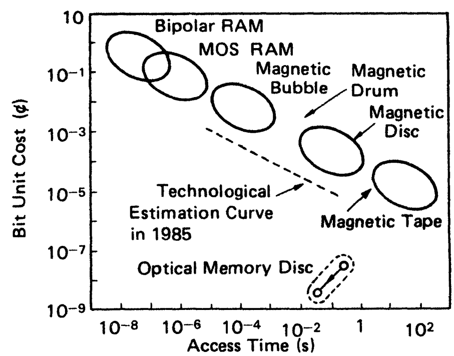


Figure 68 Access Time vs. Bit Unit Cost in Various Memory

Fig. 69 shows the document filing system using an optical disc memory system and a laser beam printer. Since the present general trend is to minimize the bulky papers especially in offices where huge volume of information is handled, the document filing system is getting much footlights.

Hitachi LDs HL8311, HL8312, HL8314 and HL7802 are recommended for read and write and HL7801 for read only.

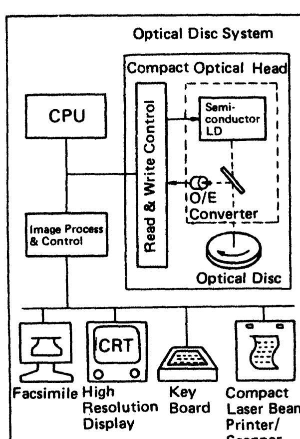


Figure 69 Document Filing System

1.1.4 Application for Measuring and Control Equipments

Various measuring equipments using laser beam are commercialized. Most of them require rather high output power and the use of LD is limited due to its relatively low power output. So LD application started from the field where the LD's advantageous characteristics of small size, high efficiency and coherency are best utilized.

(1) Distance Meter

Fig. 70 shows the principle of a light wave distance meter using modulated light. Distance is computed with detected phase difference between the radiated light and the reflected light. Measurement error depends on the wavelength of a signal light, modulation frequency and temperature change.

A range finder, which measures a distance to a target such as a moving object, geographical features and a building, penetrates into markets because of the LD's advantages of small size, light weight and high efficiency.

A high sensitivity photo detector is required to detect scattered weak light from objects because the corner mirror cannot be sometimes used for this kind of measurement.

High power LDs HL8311 Series, HL8312 and HL8314 are recommended for this application.

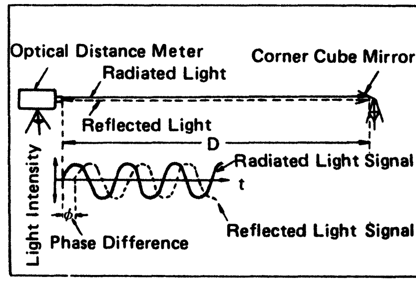


Figure 70 Light Wave Distance Meter

1.2 Application of IRED

Hitachi IRED has the advantages of high efficiency, high power output, high speed response and choice of variable emission wavelength from 760 nm to 880 nm. And the availability of the ample packages variation realizes applications for various kinds of systems.

Examples of application and recommended products are described in Table 9.

Table 9 IRED Applications

Application Field	Application	Feature	Suitable Product
Fiberoptic Communication (Short Distance)	Data Bus Link Computer Link	Low Dissipation Wide Bandwidth No Cross Talk Light Weight	HE8403R HE8811 HE8402F
Optical Beam Communication	Space Transmission Optical Repeater System	No Need of Cable and Pole No Radio Wave Interference	HLP20R ~ 60R HLP20RG ~ 60RG HE8811
Information Terminal	Facsimile	Small Size High Reliability	HLP20R ~ 60R HLP20RG ~ 60RG HE8811
Measuring Equipment	Distance Meter	High Precision	HLP20R ~ 60R HLP20RG ~ 60RG HE8801 HE8811
	Auto Focus Camera	High Precision	
	Alarm System	Small Size, No Radio Wave Interference	
	Medical Appliance	Small Size, High Reliability	
	Smoke Detector	No Error, High Reliability	

1.2.1 Fiberoptic Communication

Fiberoptic communication has two methods to transmit data signals: the digital transmission method and the analog transmission method. And there are two methods to modulate light intensity with electric signals: the direct moodulation method in which a light source device is driven with the modulation signals directly and the external modulation method in which constant optical output power from a light source is modulated through an external modulator.

Optical output power from IRED changes proportionally with the drive current as shown in Fig. 71.

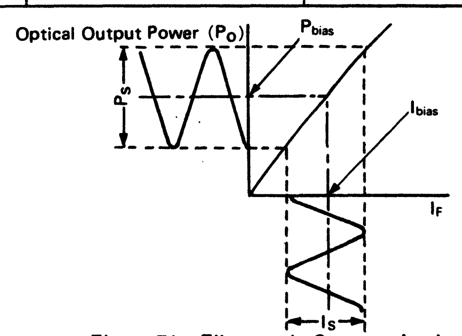


Figure 71 Fiber-optic Communication

The simplest analog transmission system with the direct modulation method is described in Fig. 72. The electric circuit of a repeater needs amplification function only in this sytem. However, the linearity of a light signal source becomes an important factor. For the nonlinearity distortion level required for analog communication, the second nonlinearity distortion is over -45 dB and the third is over -55 dB in general.

HE Series meet these system requirements sufficiently.

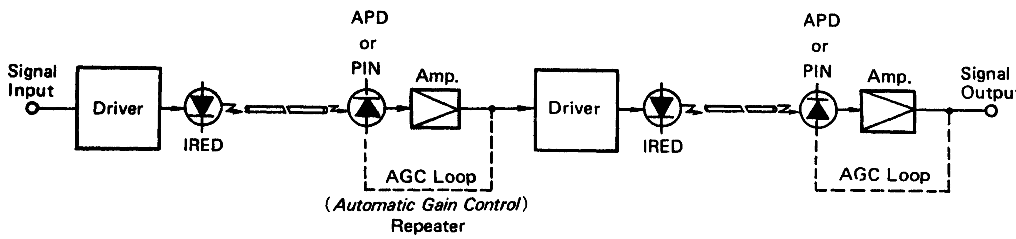


Figure 72 Direct Modulation Method Analog Transmission System

A digital transmission system with a typical repeater complex with an equalizer, a discriminator and retiming function is described in Fig. 73. Despite the fact that the electric circuit is complicated compared with the analog transmission system, transmission bandwidth is wider and more accurate information transmission capability in the digital transmission system is much advantageous. Efficient coupling of IRED optical output to a fiber is extremely important in any of fiberoptic communication systems.

HE Series such as HE8402F and HE8403R designed to have a small emitting area to achieve highest frequency response and light intensity are highly recommended for the fiberoptic communication.

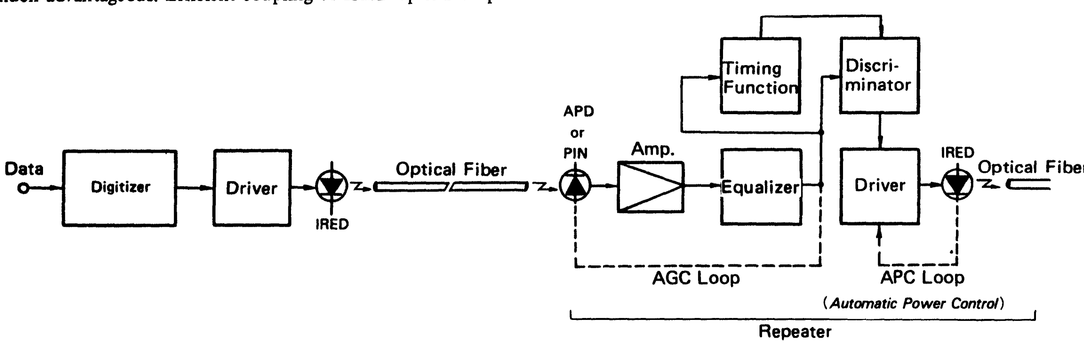


Figure 73 Digital Transmission System

1.2.2 Facsimile

IRED is also used as a light source to illuminate objects. High power capability with hemispherical chip surface of Hitachi IRED enables it to be used as a light source of the reading head in information terminals such as a facsimile equipment.

Fig. 74 shows the principle of a contact type facsimile pick-up head. The sensor part (a pick-up head) of a contact type facsimile consists of an IRED array (a light source), a contact fiber, a sandwitched fiber and a photo detector array. The emitted light from IRED reflected at the original picture with some absorption input into a photo detector array sensor through a contact fiber and a sandwitched fiber then converted to electric signals. Vertical scanning information is picked up along with the direction of the original picture move and horizontal scanning information is picked up along with the direction of IRED and PD which are arrayed.

High power IREDs HLP20 ~ 60 Series and HE8811 are recommended for this type of application.

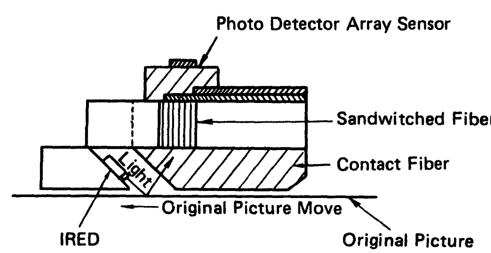


Figure 74 Principle of Contact Type Facsimile Pick-up Head

1.2.3 Auto Focus Camera

An auto focus camera is penetrating the market due to their easy-to-handle features with its auto focus and shutter control function. There are two methods of auto focusing: the one way is to use the reflected natural light from an object and the other is to use the reflected light from an object but emitted from the light source built in a camera. The light source built-in type camera causes no focus error which often rises in the natural light system, because the light from the built-in light source hits the specified object and only the light reflected from the target is used to measure the distance. Fig. 75 describes the operation principle of an auto focus camera with a built-in light source. The intensely modulated light is emitted from IRED mounted at the center of a camera then collimated by a lens and hits an object. The light scatters in all directions at the surface of the object then a part of it is received by photo sensors through rotating lenses set at the both edges of the camera. When the reflected light from the object is focused to the photo sensors through L_1 and L_2, the shutter of a camera is released.

Hitachi IREDs HLP20 ~ 60 Series are recommended for this type of application.

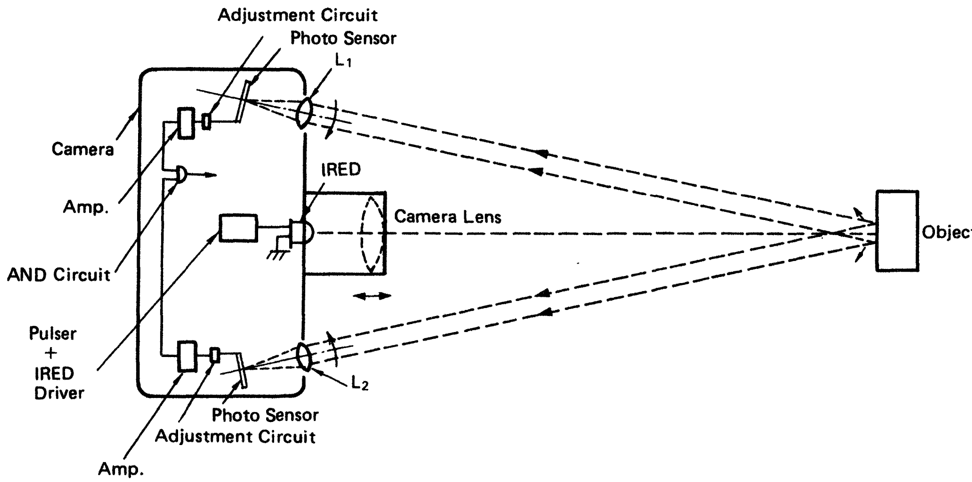


Figure 75 Operation Principle of Auto Focus Camera

2. SUPPLEMENTARY INFORMATION

2.1 Light Wave Modulation

Coherency of an optical carrier wave used for optical communication largely depends on a light source, and it ranges from good monochromatic (coherent) light of a single mode LD to quasi-monochromatic light of LED. General description of various light is given in Fig. 76. A carrier wave in radio frequency is a purely coherent sinusoidal wave, phase and amplitude (or envelope) of a light wave, on the contrary, usually exhibits random fluctuation even with good laser light. The amplitude of light is expressed in the following formula and it is picturized as shown in Fig. 77.

$$C(t) = E(t) \cdot \exp j[2\pi f(t) \cdot t + \phi(t)]$$

Here, E(t) is the amplitude envelope of a light wave oscillating at frequency f(t) in electric field and $\phi(t)$ is phase. A coherent pure sine wave has constant, E(t) and $\phi(t)$ against time.

Light wave emitted from IRED or LD has difficulty in frequency modulation or phase modulation, because its f(t) and $\phi(t)$ change against time by some nm to some 10 nm in wavelength. Therefore, intensity modulation or pulse modulation is only an applicable method to modulate a light wave carrier. These methods are sometimes called direct modulation because the modulation signal is directly superimposed to the light source drive current. Modulation speed of laser light is basically limited by the factors such as the carrier life time which is the period required to recombine electrons and holes and to induce spontaneous emission, the photon life time within the resonator and the ratio of bias current and the threshold current.

The carrier life time mostly limits the maximum modulation speed among these factors. Since the carrier life time of a GaAlAs laser diode is less than 1 ns, the high speed modulation of some 100 Mbit/s can be easily achieved. When the modulation speed of more than Gbit/s order is required, the external modulation method is effective. Fig. 78 describes the principle of the direct modulation method. Good light linearity vs. drive current is extremely important for analog signal modulation.

For the high speed direct pulse modulation of some 100 Mbit/s, best care to minimize extra resonance phenomenon, relaxation oscillation of an optical output pulse and carrier storage effect is required. Table 10 describes modulation systems applied for optical communication.

Table 10 Classification of Light Wave Modulation Methods

1. Analog Light Wave Modulation Methods
   - Direct Intensity Modulation with Baseband Signal
   - Modulated Sub-carrier Intensity Modulation
2. Analog Pulse Light Wave Modulation Methods
   - Pulse Phase Modulation
   - Pulse Width Modulation
   - Pulse Interval Modulation
3. Digital Light Wave Modulation Methods
   - Pulse Coded Intensity Modulation
   - Pulse Position Modulation
   - Pulse Amplitude Modulation

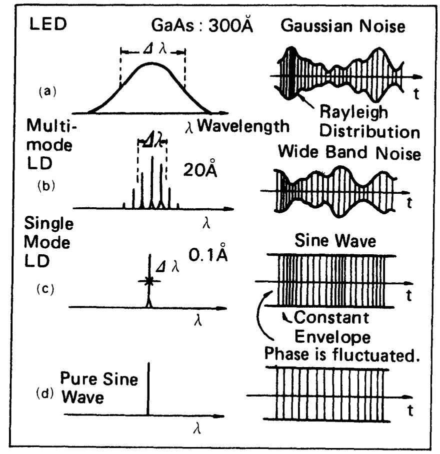


Figure 76 Spectrum of Light Carrier Wave and Modeling of Instant Waveform

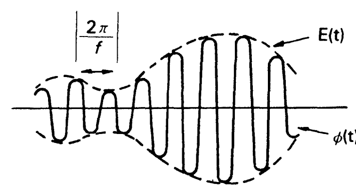


Figure 77 Oscillation of Light Wave

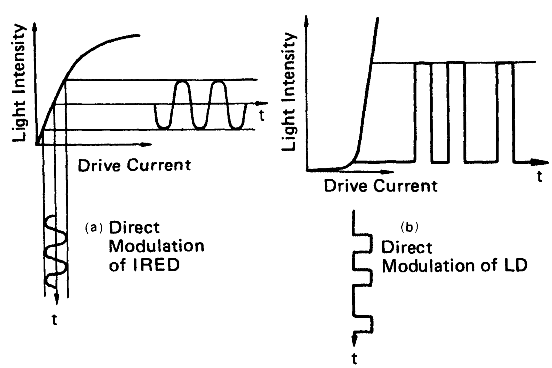


Figure 78 Principle of Direct Modulation

Besides direct modulation method of a light signal source, the external modulation method with an external device is also useful. Since this method can achieve high sensitivity, wide bandwidth and high speed modulation, it is particularly used for specialized fields where extremely high speed calculation and data processing are required.

OEIC (Opto Electronic IC) is introduced for measurement or communication system fields. Light wave modulation is to modulate or change material constants such as dielectric constant, absorption constant and reflectivity of light. These are also related to physical effects such as electro-optical effect, acousto-optical effect, magneto-optical effect, mechanical transformation and rotation. A light wave is modulated with combination of these effects by giving diffraction, reflection phase shift, wave front change, interference, absorption and scattering. The material of OEIC is usually dielectric crystal such as $LiTaO_3$. Recent attempt is to process an optical waveguide and LD on a GaAs substrate.

2.2 Optical Beam Deflection

Optical beam deflection, a kind of indirect modulation method, controls beam spatially. An optical beam deflector is indispensable to an optical information terminal, a recorder and a display equipment using laser. The technology used for this system is similar to light wave modulation and falls into two groups on grounds of availability, cost and performance: one is to use mechanical rotation or displacement and the other is to use acousto-optical effect and electro-optical effect.

A Galvano mirror or a Polygon mirror is a conventional deflector using mechanical rotation, which has advantage of wide deflection angle and many digits of deflection. But the mechanical rotation limits the scanning frequency only up to several 10 kHz. The optical compensation is needed against instability of scanning position which may be caused by inaccurate fixing.

A deflector using electro-optical effect or acousto-optical effect is also available and proper choice is required based on each characteristics of scanning time and deflection digit number (Fig. 79).

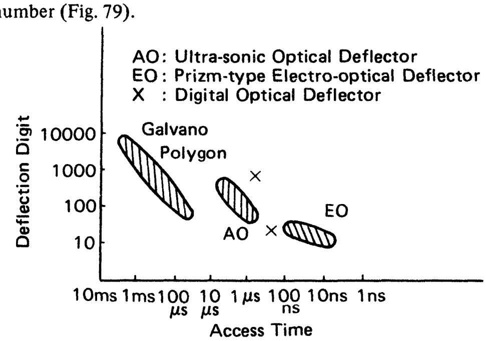


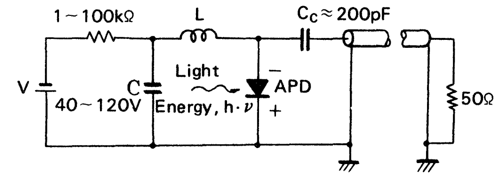
Figure 79 Diagram of Deflection Digit vs. Access Time

2.3 Photo-Detection

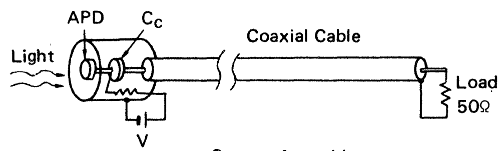
A PIN photodiode and an avalanche photodiode (APD) are typical photodetectors (PD). APD has multiplication function. Its gain is around 100, the photo sensitive area is 100 ~ 200 μm dia. and the pulse response is about 100 ps. Ge–APD is suitable for the wavelength of 0.9 ~ 1.7 μm and Si–APD 0.4 ~ 0.9 μm.

The theoretical limit of Si-APD is expressed by the product of gain M and the bandwidth B, $M \cdot B \simeq 450$ GHz for example. This is referred as the gain bandwidth product and its gain (varies with bias voltage) is chosen by referring to S/N and minimum detection signal level required for photo detection. Of course, the gain and the excessive noise figure are related each other due to avalanche multiplication expressed as $F(M) = M^x$ (x = 0.35 for Si-APD).

Fig. 80 shows a simple example of a power source (a) and a system assembly (b) for APD.



(a) Power Source



(b) System Assembly

Figure 80 Receiving Unit Used with APD

2.4 Peripheral Technology of Fiber Optics Application Status

A light wave path of a fiber consists of a center portion (core) which has a higher refractive index surrounded by a layer (clad) with a less refractive index. A light wave traveling in the core is totally reflected at the boundary of these two layers, with extremely low transmission loss. Silica glass, composite glass or plastic are chosen for a fiber (core and clad) and it is coated with nylon or plastic material.

2.4.1 Basic Structure of Optical Fiber and Light Wave Propagation

Fig.81 shows the basic structure of an optical fiber. The light should incident within a critical angle so that all the incident light can be reflected at the boundary and kept within a core. The numerical aperture is expressed as a function of the photo sensitive angle, 2θ max as follows.

$$NA = \sin\theta max = n_1 \sin\theta c \cong \sqrt{n_1{}^2 - n_2{}^2} \qquad \theta c; \text{critical angle}$$

Detail of optical waveguide theory is much complicated and propagation mode, group velocity and phase speed should be taken into consideration to be exact.

The refractive index profile of optical fibers falls into two kinds: step index and graded index. Light wave propagation mode in a fiber is also categorized into two: single mode and multimode. The single mode fiber with 5 ~ 10 μm core dia. has wide transmission bandwidth and is applied for high bit rate and long distance communication system.

Fig. 82 shows typical optical fiber characteristics.

The wavelength regions of the lowest dissipation in transmission characteristics of an optical fiber are referred as fiber windows. Recent remarkable progress in research and development realizes the extremely low transmission loss characteristics close to the theoretical limit even in longer wavelength area.

Information speed (transmission capacity) of optical transmission system and repeater span depends on the performance of a light signal souce, an optical fiber and a photo detector, etc.

So optical parts must be selected properly to match the system requirement. Fig. 83 shows the general domain of optical transmission. Fig. 84 shows the characteristics of an optical fiber and its application.

Improvement of an optical fiber has realized various new applications such as sensing or energy transfer and in addition transmission of power energy will be realized in future.

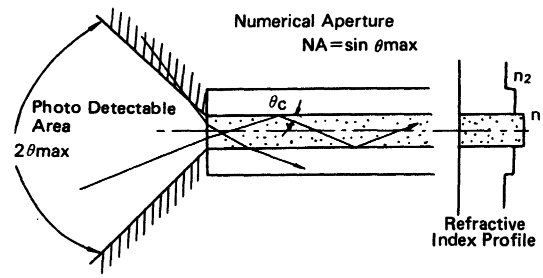


Figure 81 Structure of Step Index Fiber

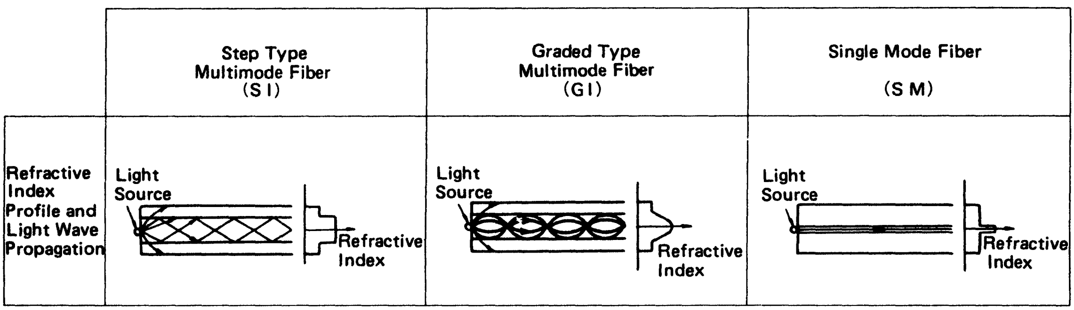


Figure 82 Classified Optical Fiber into Refractive Index Structure

Table 11 Main Optical Fiber Characteristics

		Multimode Fiber				Single Mode Fiber
		Silica Graded Type Fiber	Silica Step Type Fiber	Polymer Clad Fiber	All in Polymer Fiber	
Core Dia.		50 ~ 100 μm	50 ~ 150 μm	100 ~ 150 μm	200 ~ 1,000 μm	~ 10 μm
Clad Dia.		125 ~ 150 μm	125 ~ 200 μm	300 ~ 500 μm	~ 1 μm	125 μm
Trans-mission Loss	0.8 μm	3dB/km	3dB/km	10dB/km	~ 1,000dB/km	3dB/km
	1.3 μm	~ 1 dB/km	~ 1dB/km	—	—	~ 1dB/km
Transmission Bandwidth		~ 2GHz·km (LD, 1.3 μm LED) ~ 100MHz·km (0.8 μm LED)	10 ~ 30MHz·km	~ 10MHz·km	~ 5MHz·km	~ 40GHz·km

Note: Polymer fiber or step index type silica fiber is suitable for low speed and short distance transmission from cost stand point. Graded index type silica fiber or single mode fiber is suitable for high speed and long distance system from performance requirement.

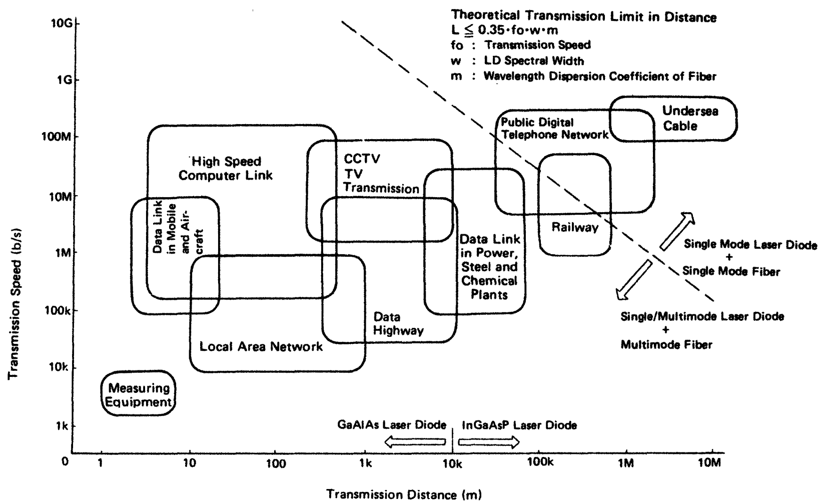


Figure 83 Light Transmission Domain Map

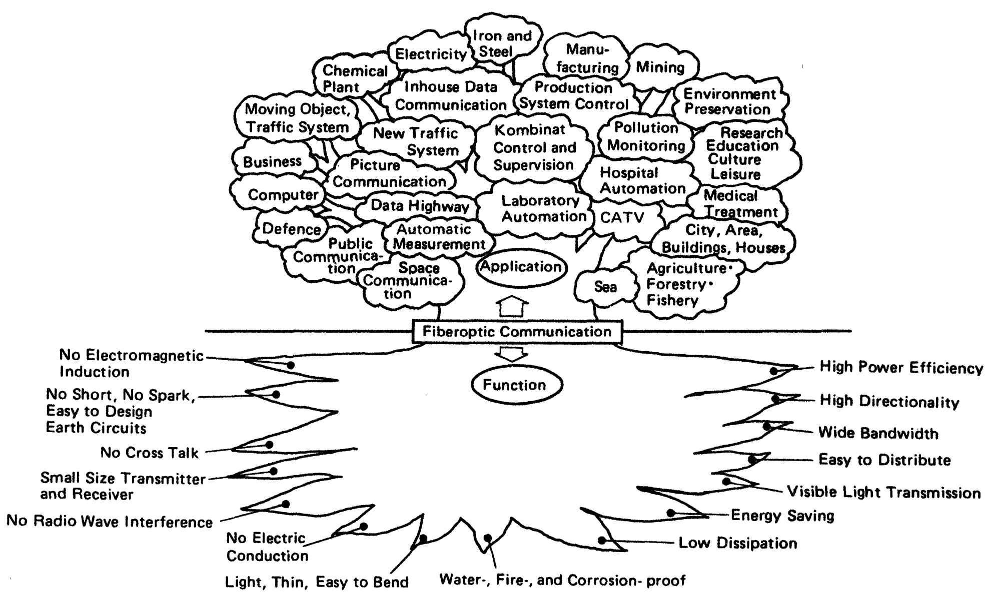


Figure 84 Optical Fiber Functions and Applications

DATA SHEETS

LASER DIODES

PRELIMINARY data sheets herein contain information on new products. Specifications are subject to change without notice.

ADVANCED INFORMATION data sheets herein contain information on products under research or development. Specifications are subject to change without notice, and Hitachi also reserves the right to discontinue these products without notice.

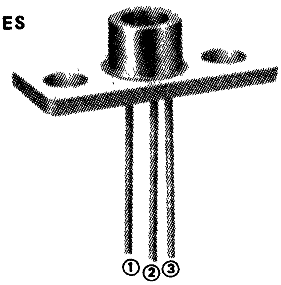
HL7801E, HL7801G

GaAlAs LD

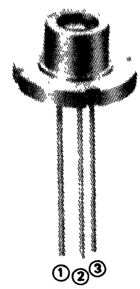
■ **APPLICATIONS**
- Audio disc, Video disc.
- Laser beam printer.
- Light source for any other optical equipment.

■ **FEATURES**
- Short wavelength: Visible band is from 760 to 800nm.
- Photodetector built in for monitoring.
- High reliability, Long life.

■ **PACKAGES**

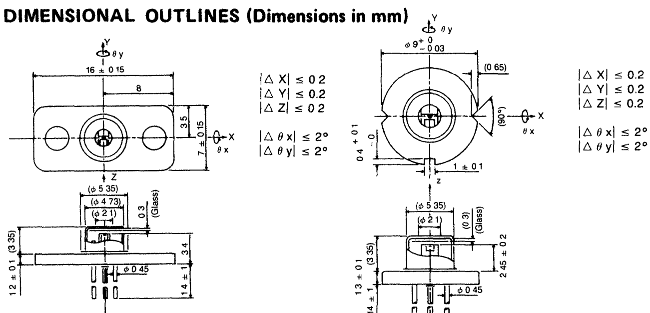


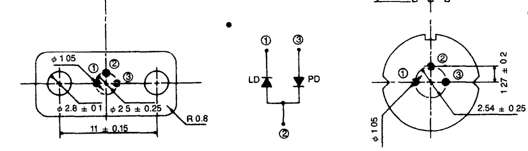
HL7801E



HL7801G

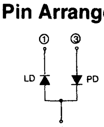
■ **PACKAGE DIMENSIONAL OUTLINES (Dimensions in mm)**





HL7801E　　HL7801G

● **Pin Arrangement**

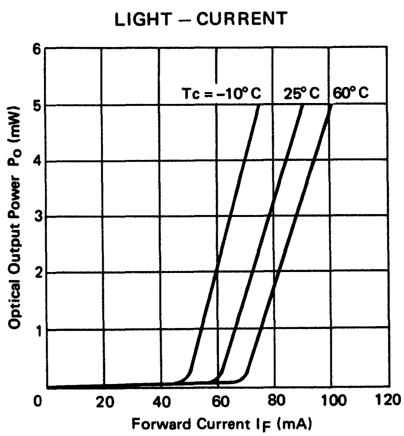


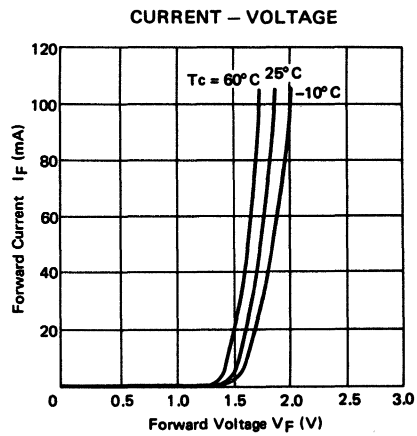
■ **ABSOLUTE MAXIMUM RATINGS (Tc=25°C)**

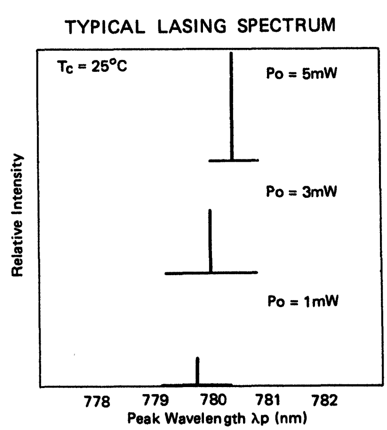
Item	Symbol	HL7801E, HL7801G	Unit
Optical Output Power	P_O	5	mW
Laser Diode Reverse Voltage	$V_{R(LD)}$	2	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	30	V
Operating Temperature	T_{opr}	-10 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

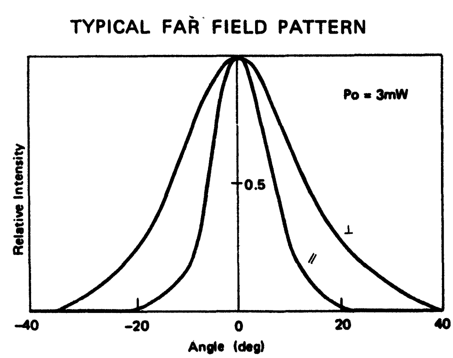
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)**

Item	Symbol	Test Condition	HL7801E, HL7801G			Unit
			min	typ	max	
Optical Output Power	P_O	Kink free	5	-	-	mW
Slope Efficiency	η		0.13	0.25	-	mW/mA
Threshold Current	I_{th}		-	60	90	mA
Peak Wavelength	λp	P_O = 3mW	760	780	800	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 3mW	10	15	20	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 3mW	20	30	40	deg.
Monitor Current	I_S	P_O = 3mW	0.1	0.3	–	mA



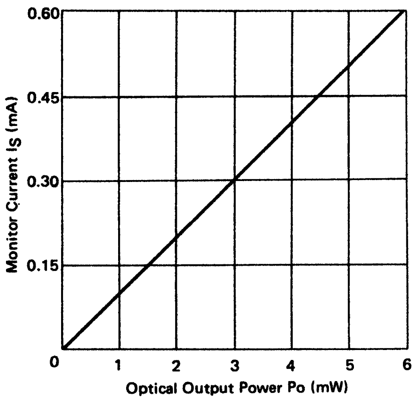




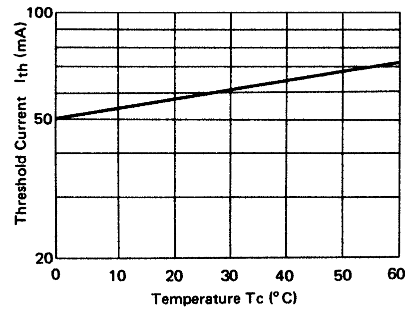


HITACHI

TYPICAL MONITOR CURRENT — OPTICAL OUTPUT POWER



TYPICAL THRESHOLD CURRENT — TEMPERATURE



HL7802E

GaAlAs LD

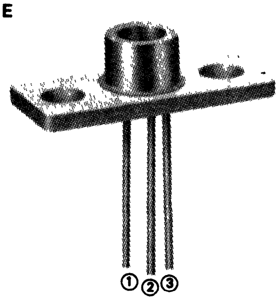
■ APPLICATIONS

- Audio disc, Memory disc.
- Laser beam printer.
- Light source for any other optical equipment.

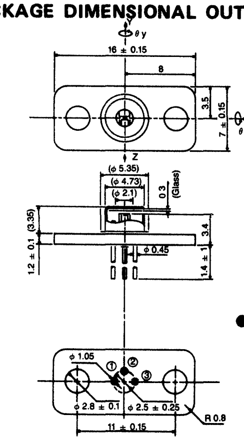
■ FEATURES

- Short wavelength: Visible band is from 770 to 800nm.
- Photodetector built in for monitoring.

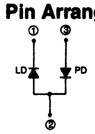
■ PACKAGE



■ PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)



● Pin Arrangement



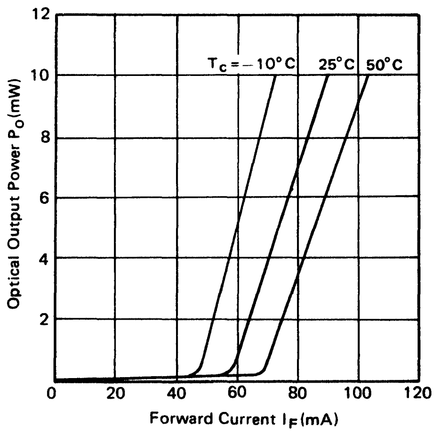
■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

Item	Symbol	HL7802E	Unit
Optical Output Power	P_O	10	mW
Laser Diode Reverse Voltage	$V_{R(LD)}$	2	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	30	V
Operating Temperature	T_{opr}	-10 ~ +50	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

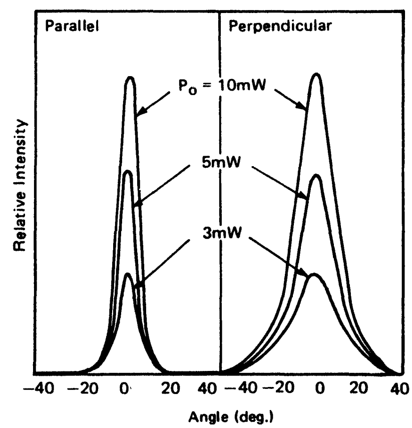
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

Item	Symbol	Test Condition	HL7802E			Unit
			min	typ	max	
Optical Output Power	P_O	Kink free	10	-	-	mW
Slope Efficiency	η		0.13	0.25	-	mW/mA
Threshold Current	I_{th}		-	60	90	mA
Peak Wavelength	λp	P_O = 10mW	770	785	800	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 10mW	6	11	16	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 10mW	20	30	40	deg.
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O =10mW	0.35	–	–	mA

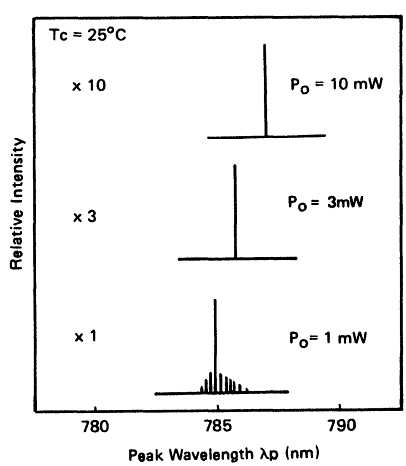
LIGHT – CURRENT



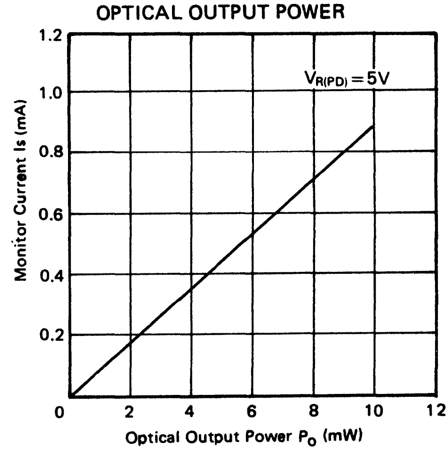
TYPICAL FAR FIELD PATTERN



TYPICAL LASING SPECTRUM



TYPICAL MONITOR CURRENT – OPTICAL OUTPUT POWER



HLP1400, HLP1500, HLP1600

GaAlAs LD

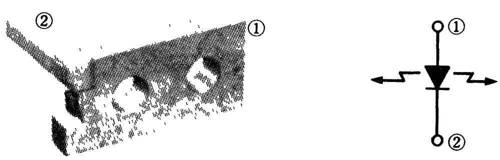
■APPLICATIONS

- Fiberoptic communication.
- Space communication.
- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipment.

■FEATURES

- Lasing between 800 and 850 nm.
- Continuous and pulsed wave operation up to 15mW at room temperature.
- Stable fundamental transverse mode.
- Single longitudinal mode.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- High reliability.

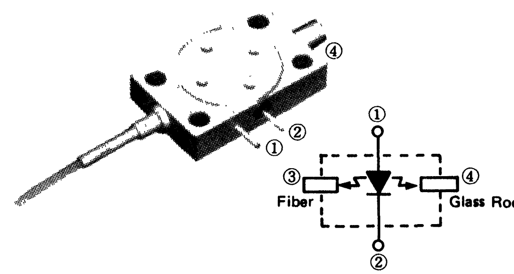
■PACKAGES



The laser chip is mounted on an uncapped stem.
This package is convenient for experimental use.

Caution: Since the chip is exposed to the air, this type is not recommended for commercial application.

HLP1400

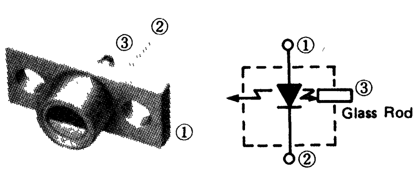


A monitor output guide is provided for external monitoring.

[Standard Fiber]

Numerical Aperture	: 0.2
Core Diameter	: 50 μm
Outer Diameter	: 125 μm
Jacket Diameter	: 900 μm
Refractive Index	: GI
Pigtail Length	: 500 mm min.

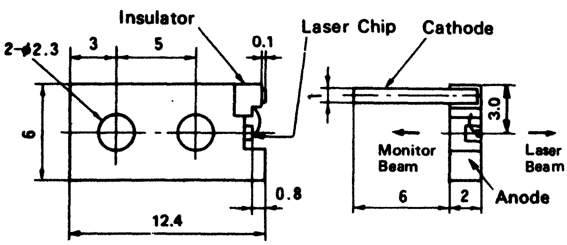
HLP1500



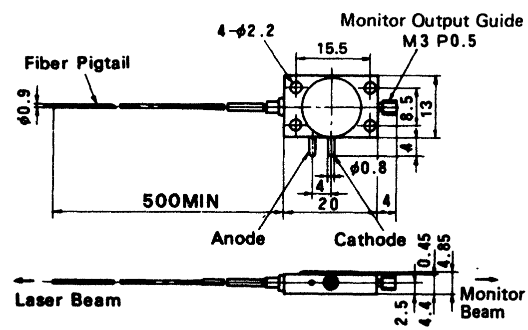
This is general-purpose package with AR-coated glass window.
A monitor output guide is provided for external monitoring.

HLP1600

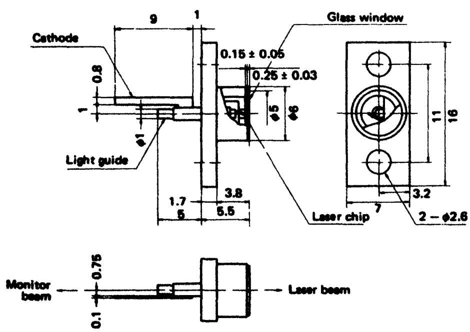
■ PACKAGE DIMENSIONAL OUTLINES (Dimensions in mm)



HLP1400



HLP1500



HLP1600

■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

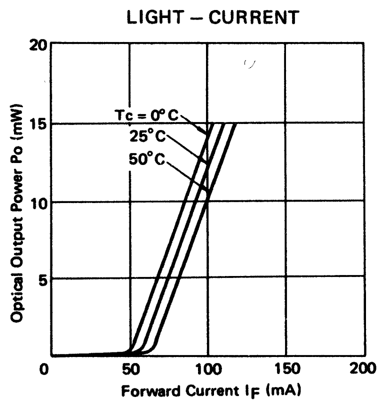
Item	Symbol	HLP1400	HLP1500	HLP1600	Unit
Optical Output Power	P_O	15	6*	15	mW
Reverse Voltage	V_R	2			V
Operating Temperature	T_{opr}	0 ~ +60			°C
Storage Temperature	T_{stg}	0 ~ +80	-40 ~ +70	-40 ~ +80	°C

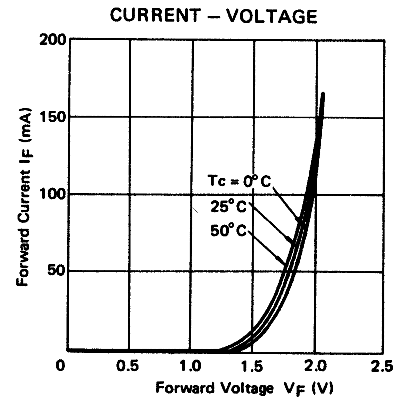
* At the fiber end.

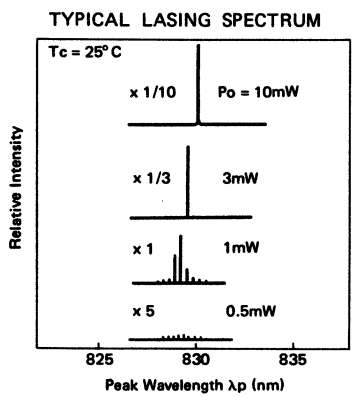
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

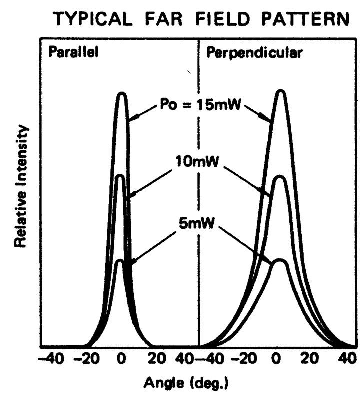
Item	Symbol	Test Condition	HLP1400			HLP1500			HLP1600			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		-	60	90	-	60	90	-	60	90	mA
Optical Output Power	P_O	Kink free	15	-	-	6*	-	-	15	-	-	mW
		$I_F = I_{th} + 25mA$	4	5	-	2*	3*	-	4	5	-	
Monitor Power	P_m		2	-	-	0.5	-	-	0.2	-	-	
Peak Wavelength	λp	P_O = 10mW	800	830	850	-	-	-	800	830	850	nm
		P_O = 4mW*	-	-	-	800	830	850	-	-	-	
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 10mW	-	10	-	-	-	-	-	10	-	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$		-	25	-	-	-	-	-	25	-	
Rise and Fall Time	t_r, t_f		-	-	0.5	-	-	0.5	-	-	0.5	ns

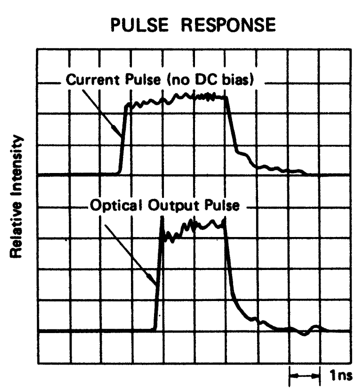
* At the fiber end.

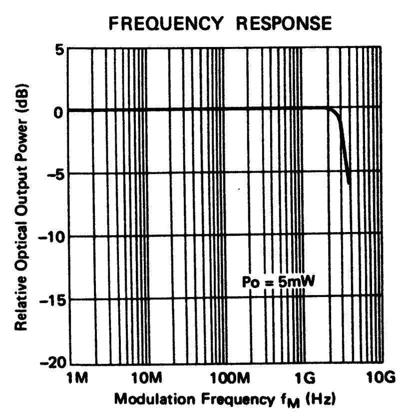

LIGHT – CURRENT
Optical Output Power Po (mW)
Forward Current IF (mA)
Tc = 0°C
25°C
50°C
0
5
10
15
20
50
100
150
200


CURRENT – VOLTAGE
Forward Current IF (mA)
Forward Voltage VF (V)
Tc = 0°C
25°C
50°C
0
50
100
150
200
0.5
1.0
1.5
2.0
2.5

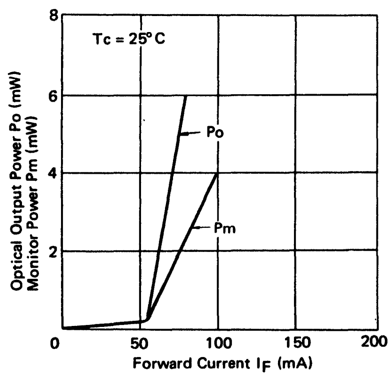

TYPICAL LASING SPECTRUM
Tc = 25°C
x 1/10
Po = 10mW
x 1/3
3mW
x 1
1mW
x 5
0.5mW
Relative Intensity
825
830
835
Peak Wavelength λp (nm)


TYPICAL FAR FIELD PATTERN
Parallel
Perpendicular
Po = 15mW
10mW
5mW
Relative Intensity
-40 -20 0 20 40 -40 -20 0 20 40
Angle (deg.)

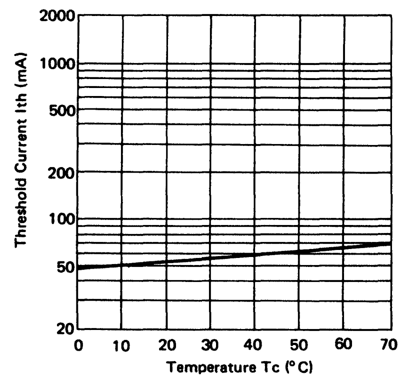

PULSE RESPONSE
Current Pulse (no DC bias)
Optical Output Pulse
Relative Intensity
1ns


FREQUENCY RESPONSE
Relative Optical Output Power (dB)
Po = 5mW
5
0
-5
-10
-15
-20
1M
10M
100M
1G
10G
Modulation Frequency fM (Hz)

LIGHT – CURRENT (HLP1500)



THRESHOLD CURRENT – TEMPERATURE



HL8311E, HL8311G

GaAlAs LD

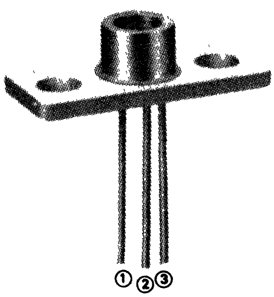
■ **APPLICATIONS**

- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipment.

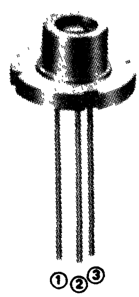
■ **FEATURES**

- Lasing between 800 and 850nm.
- Photodetector built in for monitoring.
- Continuous and pulsed wave operation up to 15mW at room temperature.
- Stable fundamental transverse mode.
- Single longitudinal mode.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- High reliability.

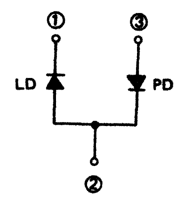
■ **PACKAGES**



HL8311E

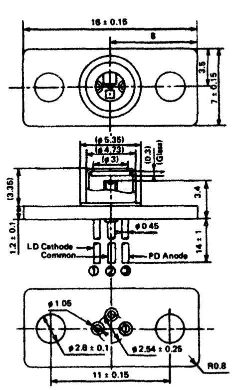


HL8311G

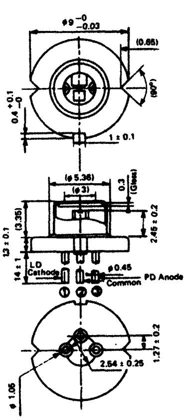


The photodetector built in for power monitoring simplifies an automatic power control circuit.

■ **PACKAGE DIMENSIONAL OUTLINES (Dimensions in mm)**



HL8311E



HL8311G

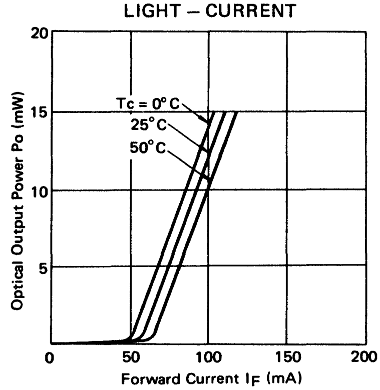
■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

Item	Symbol	HL8311E, HL8311G	Unit
Optical Output Power	P_O	15	mW
Laser Diode Reverse Voltage	$V_{R(LD)}$	2	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	30	V
Operating Temperature	T_{opr}	−10 ~ +60	°C
Storage Temperature	T_{stg}	−40 ~ +80	°C

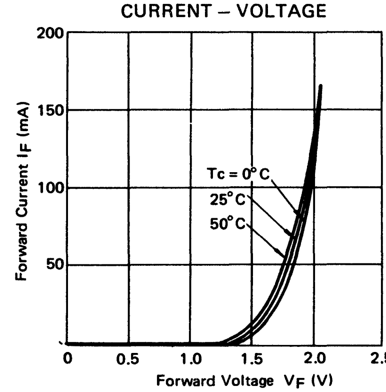
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

Item	Symbol	Test Condition	HL8311E, HL8311G			Unit
			min	typ	max	
Threshold Current	I_{th}		–	60	90	mA
Optical Output Power	P_O	Kink free	15	–	–	mW
Slope Efficiency	η		0.16	0.28	–	mW/mA
Peak Wavelength	λp		800	830	850	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 10mW	–	10	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 10mW	–	27	–	deg.
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 10mW	0.2	–	–	mA
Rise and Fall Time	t_r, t_f		–	–	0.5	ns

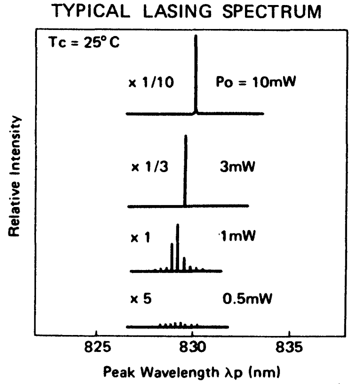
LIGHT — CURRENT



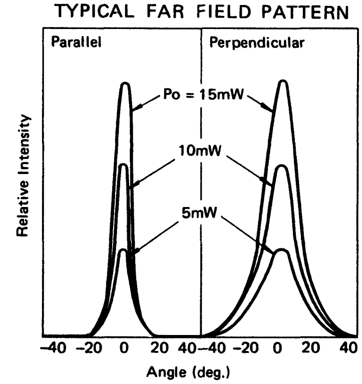
CURRENT — VOLTAGE



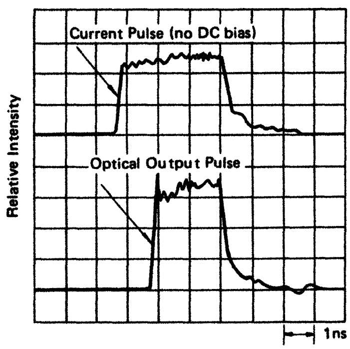
TYPICAL LASING SPECTRUM



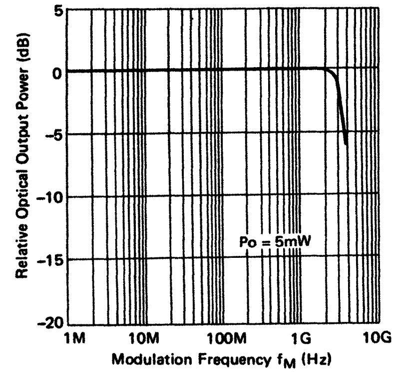
TYPICAL FAR FIELD PATTERN



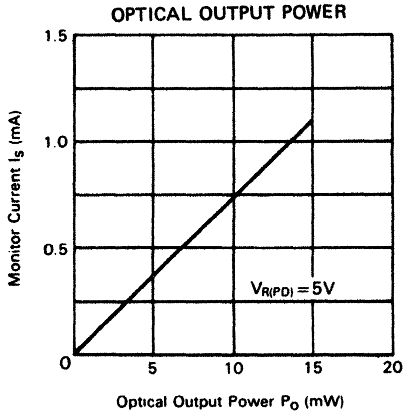
PULSE RESPONSE



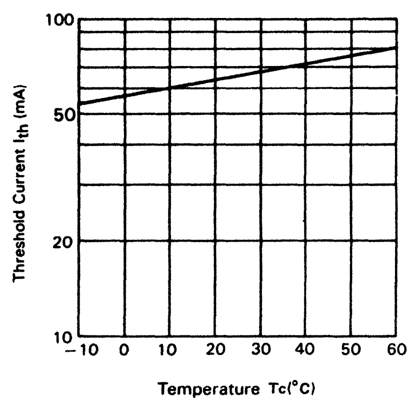
FREQUENCY RESPONSE



MONITOR CURRENT – OPTICAL OUTPUT POWER



THRESHOLD CURRENT – TEMPERATURE



HL8312E

GaAlAs LD

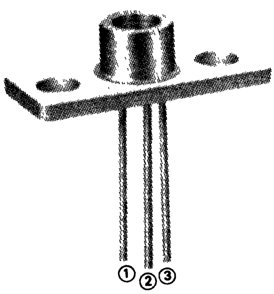
■ **APPLICATIONS**

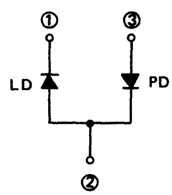
- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipment.

■ **FEATURES**

- Lasing between 810 and 850nm.
- Photodetector built in for monitoring.
- Continuous and pulsed wave operation up to 20mW at room temperature.
- Stable fundamental transverse mode.
- Single longitudinal mode.
- Fast pulse response: t_r and t_f are less than 0.5 ns.
- High reliability.

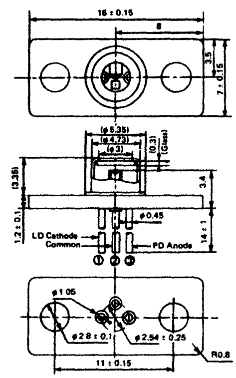
■ **PACKAGE**





The photodetector built in for power monitoring simplifies and automatic power control circuit.

■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



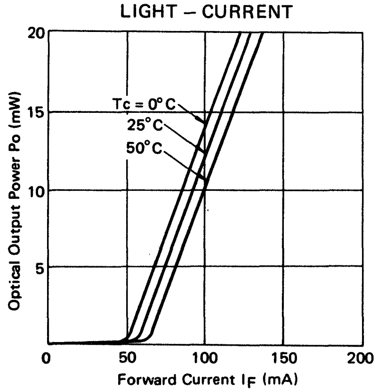
■ **ABSOLUTE MAXIMUM RATINGS (Tc=25°C)**

Item	Symbol	HL8312E	Unit
Optical Output Power	P_O	20	mW
Laser Diode Reverse Voltage	$V_{R(LD)}$	2	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	30	V
Operating Temperature	T_{opr}	-10 ~ +50	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

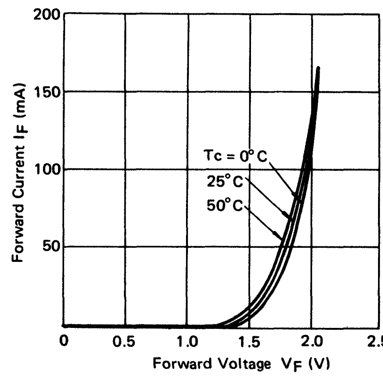
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

Item	Symbol	Test Condition	HL8312E			Unit
			min	typ	max	
Threshold Current	I_{th}		–	60	90	mA
Optical Output Power	P_O	Kink free	20	–	–	mW
Slope Efficiency	η		0.16	0.28	–	mW/mA
Peak Wavelength	λp	P_O = 10mW	810	830	850	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 10mW	–	10	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 10mW	–	27	–	deg.
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 10mW	0.2	–	–	mA
Rise and Fall Time	t_r, t_f		–	–	0.5	ns

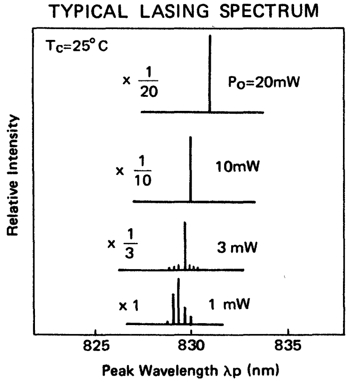
LIGHT – CURRENT



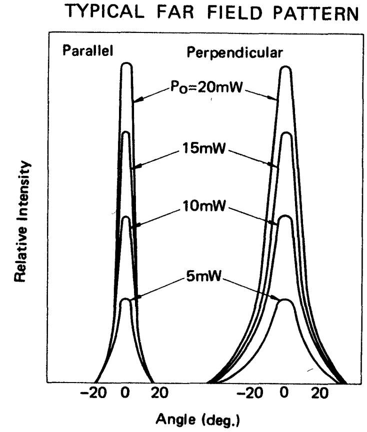
CURRENT – VOLTAGE



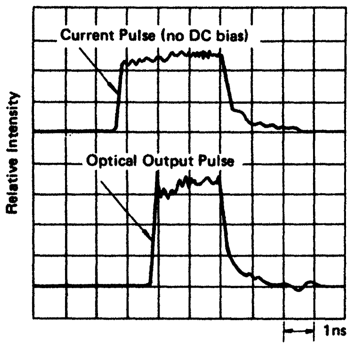
TYPICAL LASING SPECTRUM



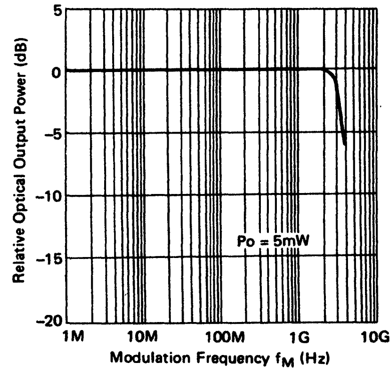
TYPICAL FAR FIELD PATTERN



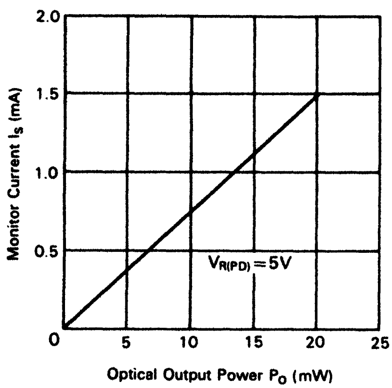
PULSE RESPONSE



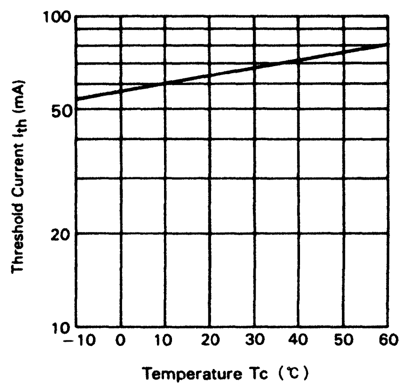
FREQUENCY RESPONSE



MONITOR CURRENT — OPTICAL OUTPUT POWER



THRESHOLD CURRENT — TEMPERATURE



HL8314E

GaAlAs LD

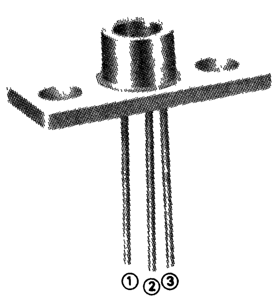
■ **APPLICATIONS**

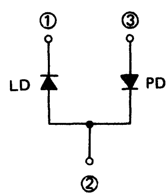
- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipment.

■ **FEATURES**

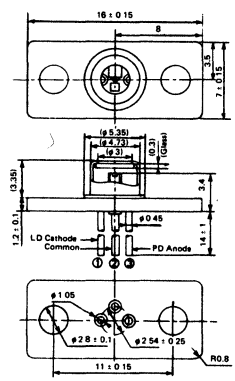
- Lasing between 810 and 850nm.
- Photodetector built in for monitoring.

■ **PACKAGE**





■ **PACKAGE DIMENSIONAL OUTLINE**
(Dimensions in mm)



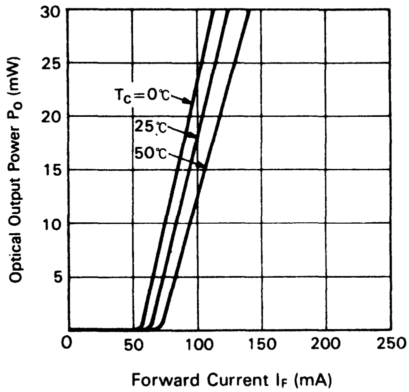
■ **ABSOLUTE MAXIMUM RATINGS (T_c=25°C)**

Item	Symbol	HL8314E	Unit
Optical Output Power	P_o	30	mW
Laser Diode Reverse Voltage	$V_{R(LD)}$	2	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	30	V
Operating Temperature	T_{opr}	-10 ~ +50	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

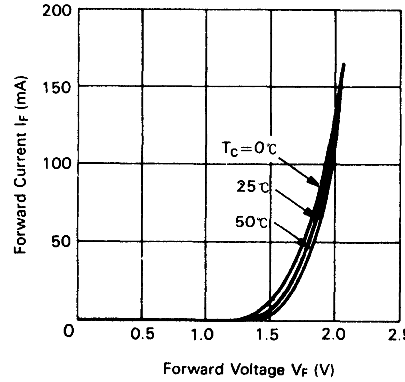
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (T_c=25°C)**

Item	Symbol	Test Condition	HL8314E			Unit
			min	typ	max	
Optical Output Power	P_o	Kink free	30	–	–	mW
Slope Efficiency	η		0.3	0.5	–	mW/mA
Threshold Current	I_{th}		–	70	90	mA
Peak Wavelength	λp	P_o = 30mW	810	830	850	nm
Beam Divergence Parallel to the Junction	$\theta_{/\!/}$	P_o = 30mW	–	10	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_o = 30mW	–	27	–	deg.
Monitor Current	Is	$V_{R(PD)}$ = 5V, P_o = 3mW	20	–	–	μA

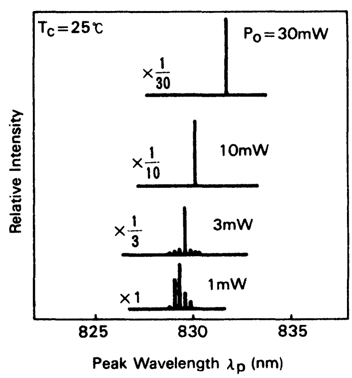
LIGHT—CURRENT



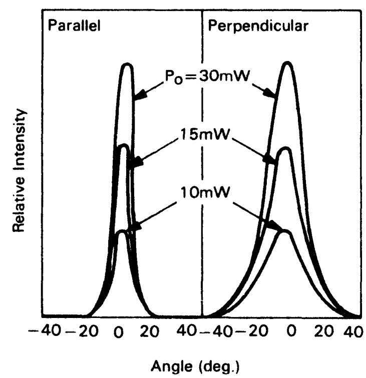
CURRENT—VOLTAGE



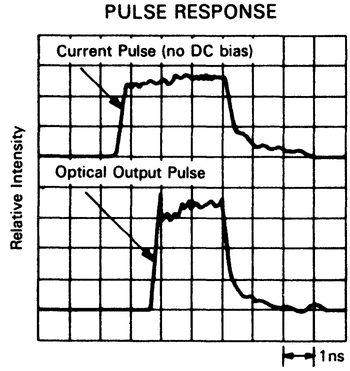
TYPICAL LASING SPECTRUM



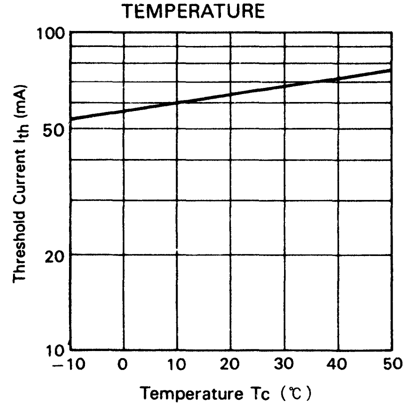
TYPICAL FAR FIELD PATTERN



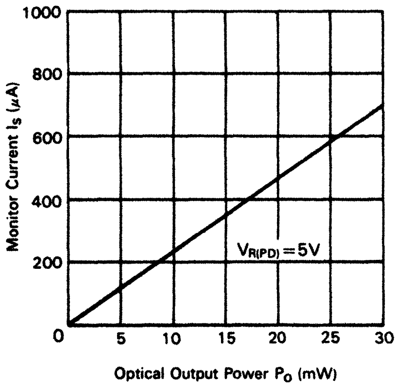
PULSE RESPONSE



THRESHOLD CURRENT-TEMPERATURE



MONITOR CURRENT—OPTICAL OUTPUT POWER



HITACHI

HL1221A,HL1221B,HL1221C

InGaAsP LD

■ APPLICATIONS
- Fiberoptic communication.
- Light source for any other optical equipment.

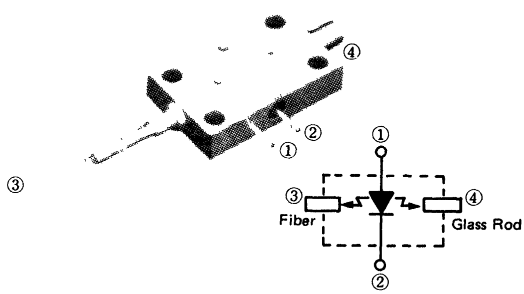
■ FEATURES
- Lasing between 1170 and 1230nm.
- Continuous and pulsed wave operation up to 5mW at room temperature.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- High reliability.

■ PACKAGES

The laser chip is mounted on an uncapped stem.
This package is convenient for experimental use.

Caution: Since the chip is exposed to the air, this type is not recommended for commercial application.

HL1221A

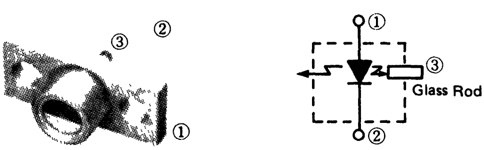


A monitor output guide is provided for external monitoring.

[Standard Fiber]

Numerical Aperture	: 0.2
Core Diameter	: 50 μm
Outer Diameter	: 125 μm
Jacket Diameter	: 900 μm
Refractive Index	: GI
Pigtail Length	: 500mm min.

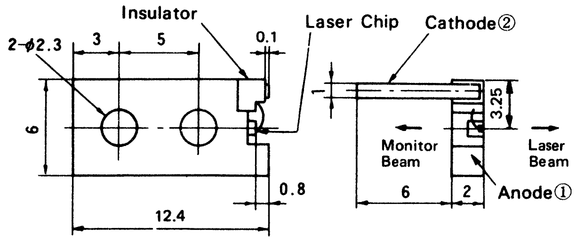
HL1221B



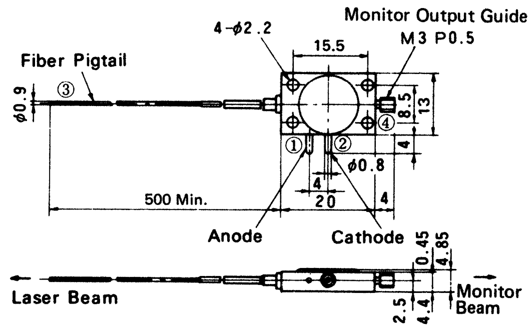
This is general-purpose package with AR-coated glass window.
A monitor output guide is provided for external monitoring.

HL1221C

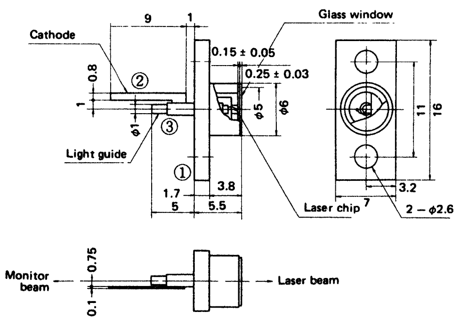
■ PACKAGE DIMENSIONAL OUTLINES (Dimensions in mm)



HL1221A



HL1221B



HL1221C

■ **ABSOLUTE MAXIMUM RATINGS (Tc=25°C)**

Item	Symbol	HL1221A	HL1221B	HL1221C	Unit
Optical Output Power	P_O	5	1.2*	5	mW
Reverse Voltage	V_R	2			V
Operating Temperature	T_{opr}	0 ~ +50			°C
Storage Temperature	T_{stg}	0 ~ +60	-40 ~ +60		°C

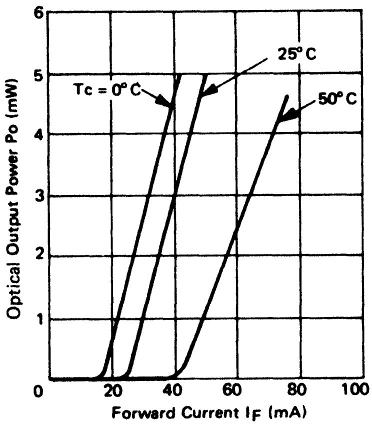
* At the fiber end.

■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)**

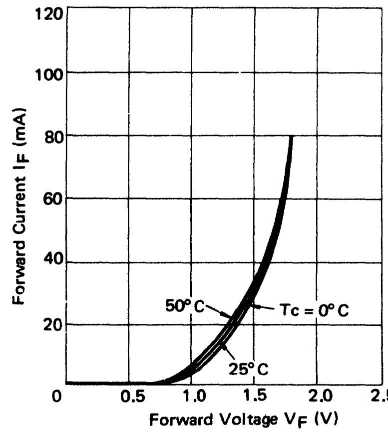
Item	Symbol	Test Condition	HL1221A			HL1221B			HL1221C			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		-	30	80	-	30	80	-	30	80	mA
Optical Output Power	P_O	Kink free	5	-	-	1.2*	-	-	5	-	-	mW
		$I_F = I_{th} + 20mA$	1.5	3.0	-	0.4*	0.7*	-	1.5	3.0	-	mW
Monitor Power	P_m	$I_F = I_{th} + 20mA$	1	-	-	0.05	-	-	0.5	-	-	mW
Lasing Wavelength	λp	P_O = 3mW	1170	1200	1230	-	-	-	1170	1200	1230	nm
		P_O = 0.5mW*	-	-	-	1170	1200	1230	-	-	-	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 3mW	-	30	-	-	-	-	-	30	-	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 3mW	-	40	-	-	-	-	-	40	-	deg.
Rise and Fall Time	t_r, t_f		-	-	0.5	-	-	0.5	-	-	0.5	ns

* At the fiber end.

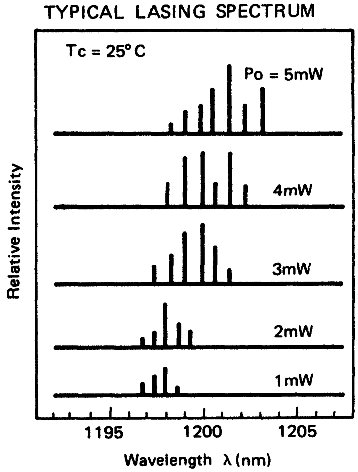
LIGHT – CURRENT



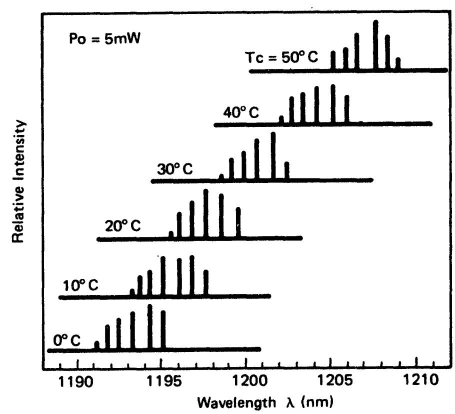
CURRENT – VOLTAGE



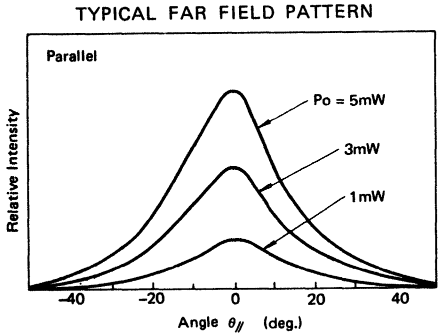
TYPICAL LASING SPECTRUM



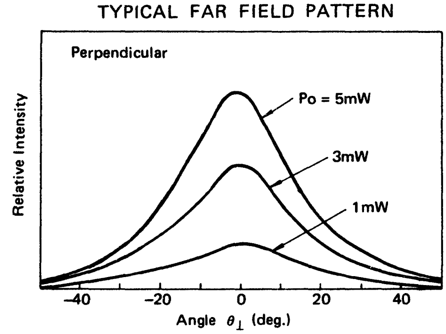
SPECTRUM – TEMPERATURE

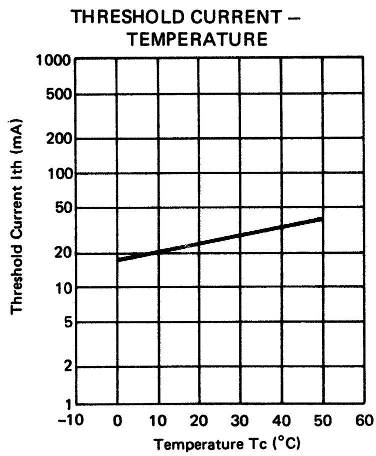


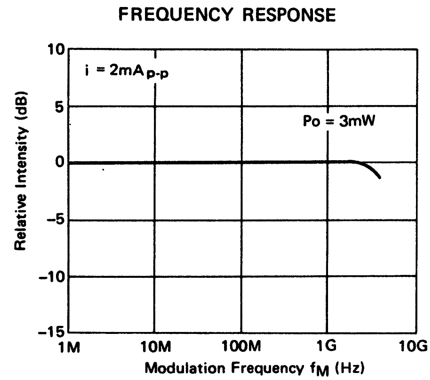
TYPICAL FAR FIELD PATTERN

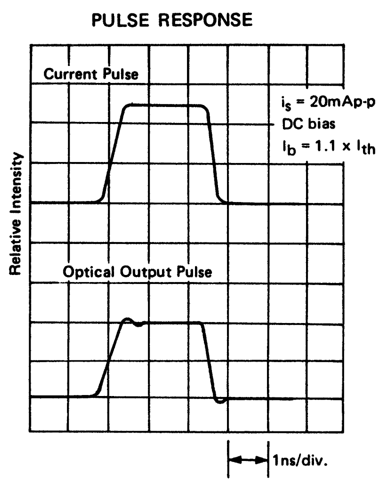


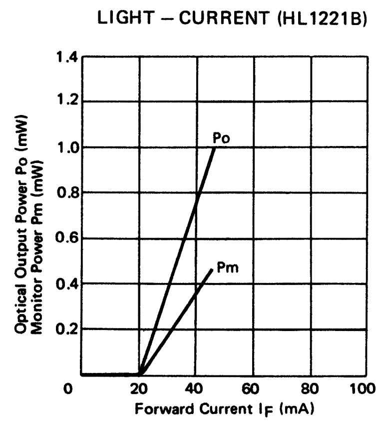
TYPICAL FAR FIELD PATTERN

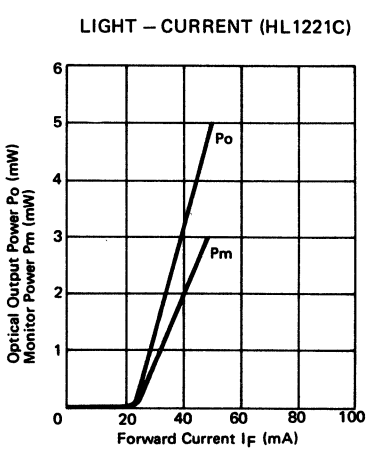



THRESHOLD CURRENT – TEMPERATURE
Threshold Current Ith (mA)
1000
500
200
100
50
20
10
5
2
1
–10
0
10
20
30
40
50
60
Temperature Tc (°C)


FREQUENCY RESPONSE
Relative Intensity (dB)
i = 2mAp-p
Po = 3mW
10
5
0
–5
–10
–15
1M
10M
100M
1G
10G
Modulation Frequency fM (Hz)


PULSE RESPONSE
Relative Intensity
Current Pulse
is = 20mAp-p
DC bias
Ib = 1.1 x Ith
Optical Output Pulse
1ns/div.


LIGHT – CURRENT (HL1221B)
Optical Output Power Po (mW)
Monitor Power Pm (mW)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Po
Pm
20
40
60
80
100
Forward Current IF (mA)


LIGHT – CURRENT (HL1221C)
Optical Output Power Po (mW)
Monitor Power Pm (mW)
6
5
4
3
2
1
0
Po
Pm
20
40
60
80
100
Forward Current IF (mA)

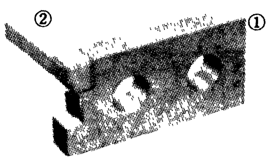
HLP5400,HLP5500,HLP5600

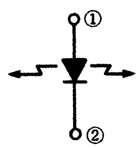
InGaAsP LD

■ **APPLICATIONS**
- Fiberoptic communication.
- Light source for any other optical equipment.

■ **FEATURES**
- Lasing between 1270 and 1330nm.
- Continuous and pulsed wave operation up to 5mW at room temperature.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- High reliability.

■ **PACKAGES**

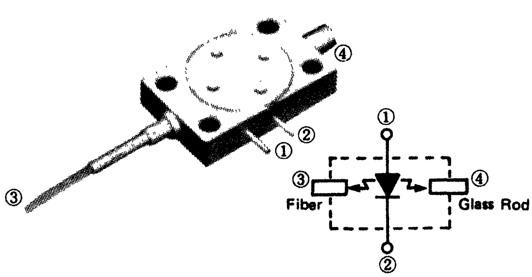




The laser chip is mounted on an uncapped stem.
This package is convenient for experimental use.

Caution: Since the chip is exposed to the air, this type is not recommended for commercial application.

HLP5400

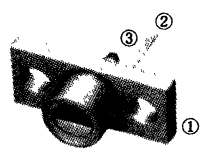


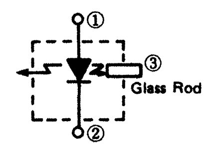
A monitor output guide is provided for external monitoring.

[Standard Fiber]

Numerical Aperture	: 0.2
Core Diameter	: 50 μm
Outer Diameter	: 125 μm
Jacket Diameter	: 900 μm
Refractive Index	: GI
Pigtail Length	: 500mm min.

HLP5500

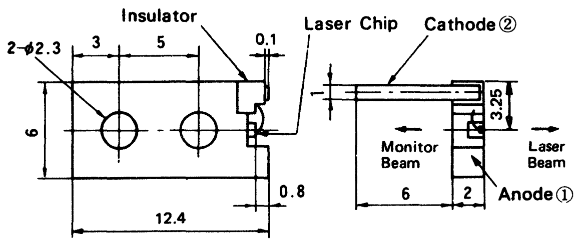




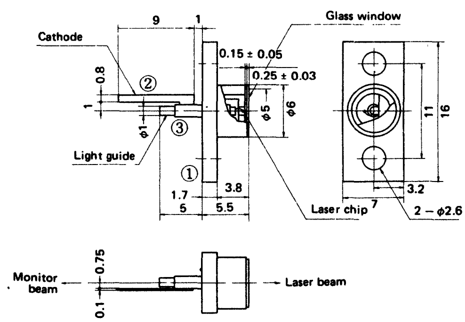
This is general-purpose package with AR-coated glass window.
A monitor output guide is provided for external monitoring.

HLP5600

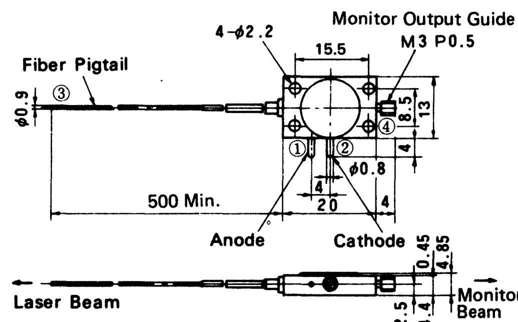
■ PACKAGE DIMENSIONAL OUTLINES (Dimensions in mm)



HLP5400



HLP5600



HLP5500

■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

Item	Symbol	HLP5400	HLP5500	HLP5600	Unit
Optical Output Power	P_O	5	1.2*	5	mW
Reverse Voltage	V_R	2			V
Operating Temperature	T_{opr}	0 ~ +50			°C
Storage Temperature	T_{stg}	0 ~ +60	-40 ~ +60		°C

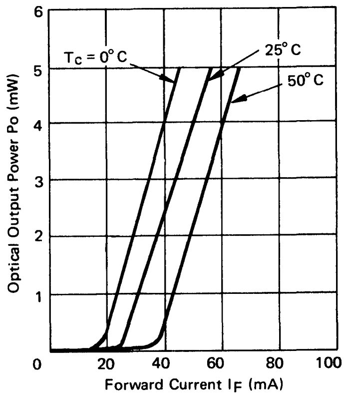
* At the fiber end.

■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

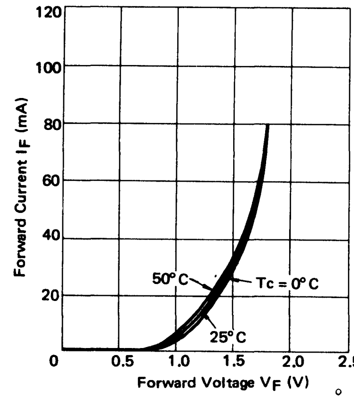
Item	Symbol	Test Condition	HLP5400			HLP5500			HLP5600			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		-	30	80	-	30	80	-	30	80	mA
Optical Output Power	P_O	Kink free	5	-	-	1.2*	-	-	5	-	-	mW
		$I_F = I_{th} + 20mA$	1.5	3.0	-	0.4*	0.7*	-	1.5	3.0	-	mW
Monitor Power	P_m	$I_F = I_{th} + 20mA$	1	-	-	0.05	-	-	0.5	-	-	mW
Lasing Wavelength	λp	P_O = 3mW	1270	1300	1330	-	-	-	1270	1300	1330	nm
		P_O = 0.5mW*	-	-	-	1270	1300	1330	-	-	-	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 3mW	-	30	-	-	-	-	-	30	-	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 3mW	-	40	-	-	-	-	-	40	-	deg.
Rise and Fall Time	t_r, t_f		-	-	0.5	-	-	0.5	-	-	0.5	ns

* At the diber end.

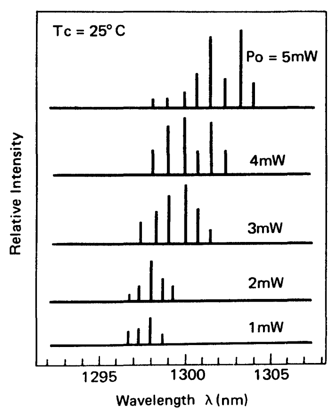
LIGHT – CURRENT



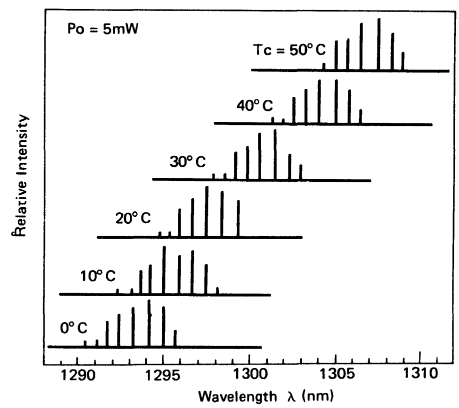
CURRENT – VOLTAGE



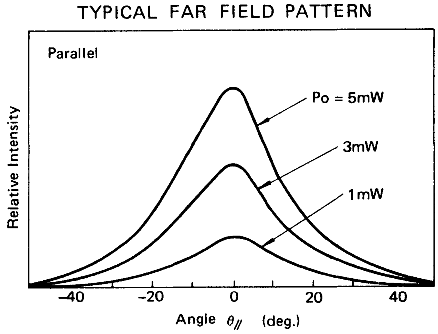
TYPICAL LASING SPECTRUM



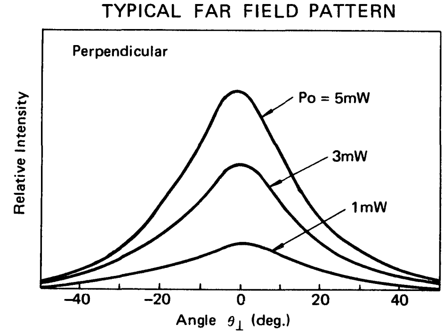
SPECTRUM – TEMPERATURE



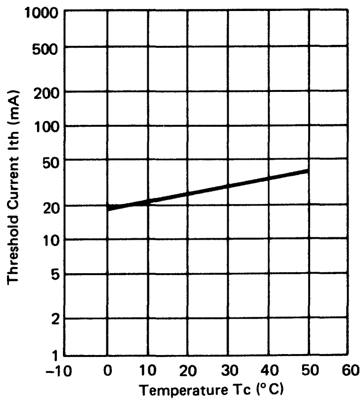
TYPICAL FAR FIELD PATTERN



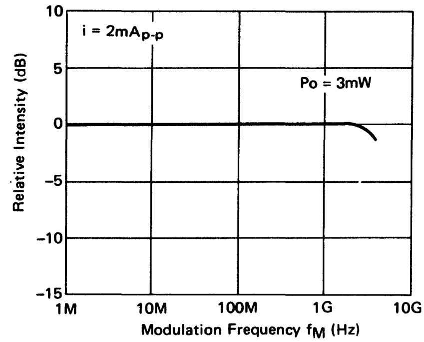
TYPICAL FAR FIELD PATTERN



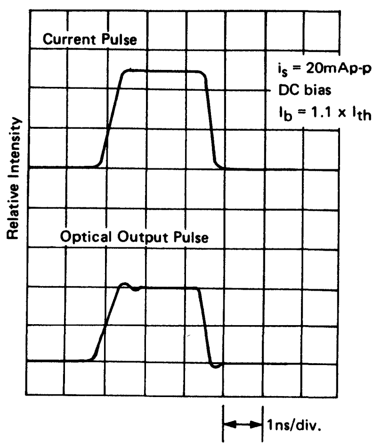
THRESHOLD CURRENT – TEMPERATURE



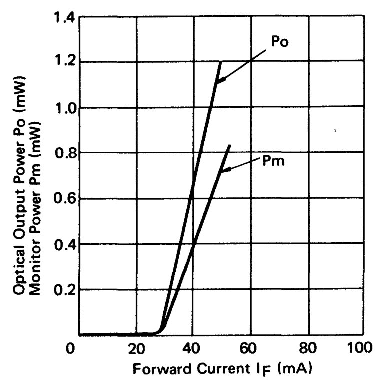
FREQUENCY RESPONSE



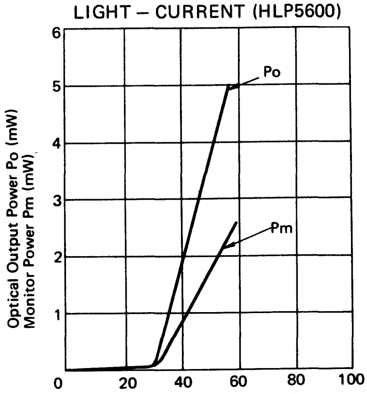
PULSE RESPONSE



LIGHT – CURRENT (HLP5500)



LIGHT – CURRENT (HLP5600)



HL1321P

InGaAsP LD

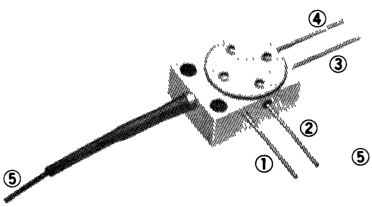
■APPLICATION

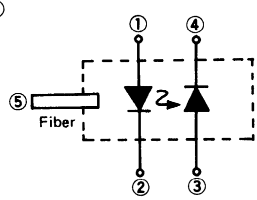
- Fiberoptic communication.

■FEATURES

- Lasing between 1270 and 1330nm.
- Continuous and pulsed wave operation up to 1.2 mW at room temperature.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- Photodetector built in for monitoring.
- Hermetic seal for high reliability.

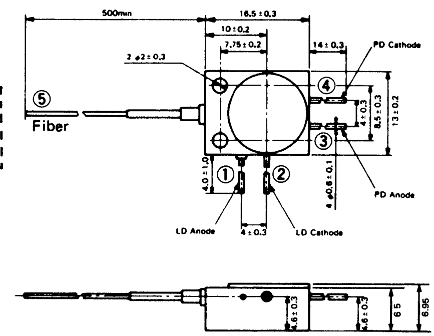
■PACKAGE





[Standard Fiber]
Numerical Aperture : 0.2
Core Diameter : 50 μm
Outer Diameter : 125 μm
Jacket Diameter : 900 μm
Refractive Index : GI
Pigtail Length : 500 mm min.

■PACKAGE DIMENSIONAL OUTLINE
(Dimensions in mm)



■ ABSOLUTE MAXIMUM RATINGS (T_c=25°C)

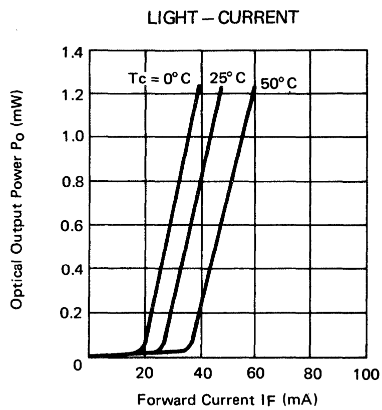
Item	Symbol	HL1321P	Unit
Optical Output Power	P_O	1.2*	mW
Photo Diode Forward Current	$I_{F(PD)}$	1.0	mA
Laser Diode Reverse Voltage	$V_{R(LD)}$	2.0	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	20	V
Operating Temperature	T_{opr}	0 ~ +50	°C
Storage Temperature	T_{stg}	-40 ~ +60	°C

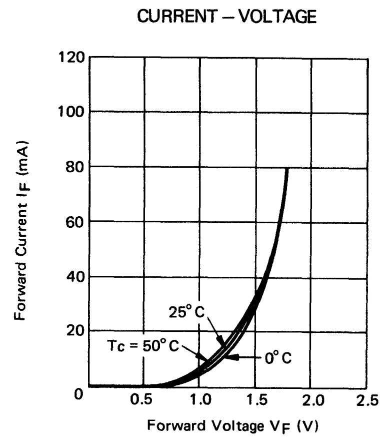
* At the fiber end.

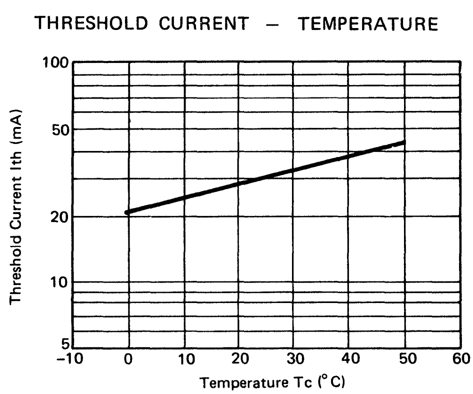
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (T_c=25°C)

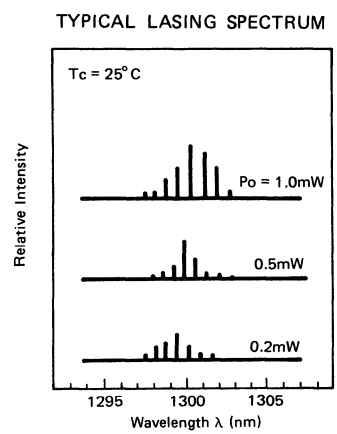
Item	Symbol	Test Condition	HL1321P			Unit
			min	typ	max	
Threshold Current	I_{th}		–	30	50	mA
Optical Output Power	P_O	Kink free	1.2*	–	–	mW
		$I_F = I_{th}$ + 20mA	0.7*	–	–	
Lasing Wavelength	λp	P_O = 0.5mW *	1270	1300	1330	nm
Dark Current	I_{DARK}	$V_{R(PD)}$ = 5V	–	–	150	nA
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 1.0mW*	70	–	–	μA
Capacitance (PD)	C_j	$V_{R(PD)}$ = 5V, f = 1MHz	–	3.0	4.0	pF
Sensitive Saturation Voltage	$V_{R(S)}$		–	–	2	V

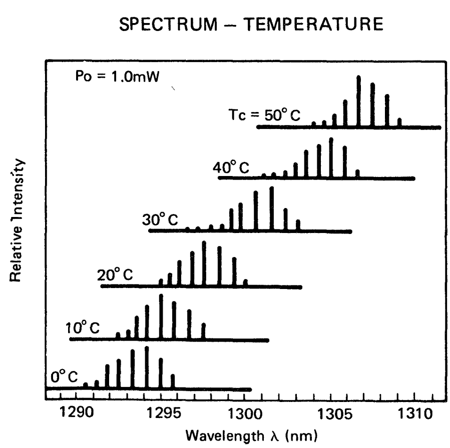
* At the fiber end.

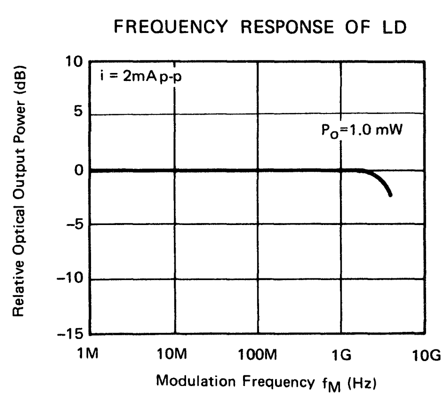

LIGHT – CURRENT
Optical Output Power Po (mW)
Tc = 0°C
25°C
50°C
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
20
40
60
80
100
Forward Current IF (mA)


CURRENT – VOLTAGE
Forward Current IF (mA)
120
100
80
60
40
20
0
25°C
Tc = 50°C
0°C
0.5
1.0
1.5
2.0
2.5
Forward Voltage VF (V)

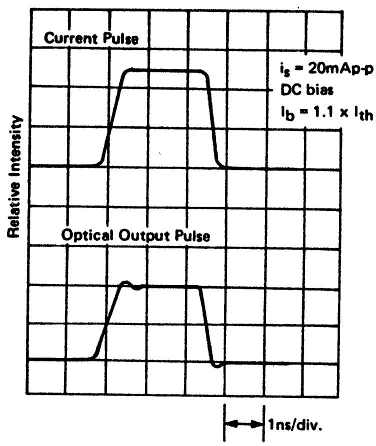

THRESHOLD CURRENT – TEMPERATURE
Threshold Current Ith (mA)
100
50
20
10
5
−10
0
10
20
30
40
50
60
Temperature Tc (°C)


TYPICAL LASING SPECTRUM
Relative Intensity
Tc = 25°C
Po = 1.0mW
0.5mW
0.2mW
1295
1300
1305
Wavelength λ (nm)

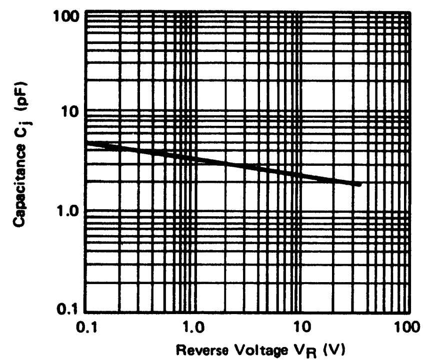

SPECTRUM – TEMPERATURE
Relative Intensity
Po = 1.0mW
Tc = 50°C
40°C
30°C
20°C
10°C
0°C
1290
1295
1300
1305
1310
Wavelength λ (nm)


FREQUENCY RESPONSE OF LD
Relative Optical Output Power (dB)
i = 2mA p-p
Po=1.0 mW
10
5
0
−5
−10
−15
1M
10M
100M
1G
10G
Modulation Frequency fM (Hz)

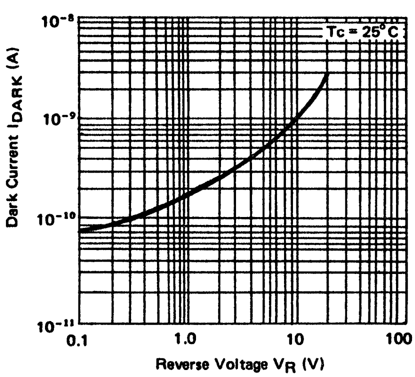
PULSE RESPONSE



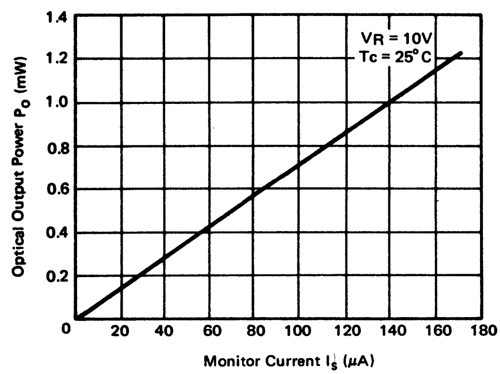
CAPACITANCE – REVERSE VOLTAGE OF PD



DARK CURRENT – REVERSE VOLTAGE OF PD



OPTICAL OUTPUT POWER – MONITOR CURRENT



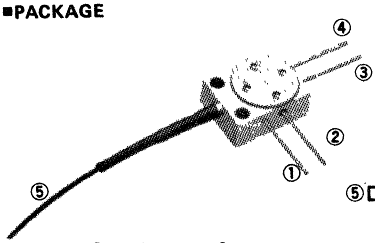
HL1321SP

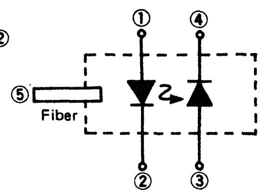
InGaAsP LD

■APPLICATION
- Fiberoptic communication.

■FEATURES
- Lasing between 1270 and 1330nm.
- Continuous and pulsed wave operation up to 1.0 mW at room temperature.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- Photodetector built in for monitoring.
- Single mode fiber coupled.
- Hermetic seal for high reliability.

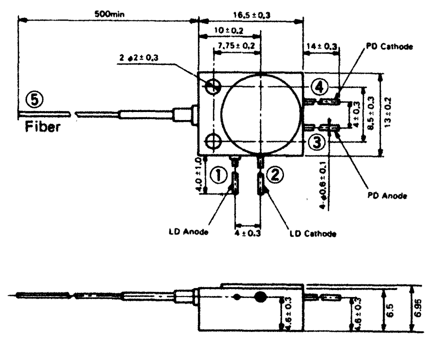
■PACKAGE





[Standard Fiber]
Spot Size; ≃ 5 μm
Core Diameter; ≃ 10 μm
Outer Diameter; ≃ 125 μm
$\lambda c \simeq 1.10 \sim 1.28$ μm
Pigtail Length; 500mm min.

■PACKAGE DIMENSIONAL OUTLINE
(Dimensions in mm)



■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

Item	Symbol	HL1321SP	Unit
Optical Output Power	P_O	1.0*	mW
Photo Diode Forward Current	$I_{F(PD)}$	1.0	mA
Laser Diode Reverse Voltage	$V_{R(LD)}$	2.0	V
Photo Diode Reverse Voltage	$V_{R(PD)}$	20	V
Operating Temperature	T_{opr}	0 ~ +50	°C
Storage Temperature	T_{stg}	−40 ~ +60	°C

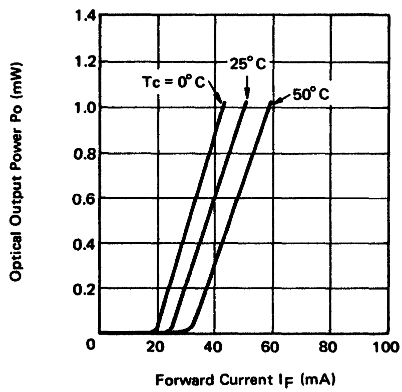
* At the fiber end.

■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

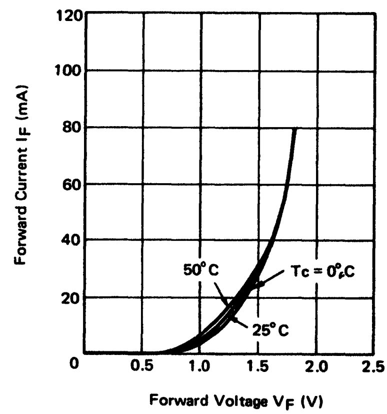
Item	Symbol	Test Condition	HL1321SP			Unit
			min	typ	max	
Threshold Current	I_{th}		–	30	50	mA
Optical Output Power	P_O	Kink free	1.0*	–	–	mW
		$I_F = I_{th} + 20mA$	0.6*	–	–	
Lasing Wavelength	λp	P_O = 1.0mW*	1270	1300	1330	nm
Dark Current	I_{DARK}	$V_{R(PD)}$ = 5V	–	–	150	nA
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 1.0mW*	140	–	–	μA
Capacitance (PD)	C_j	$V_{R(PD)}$ = 5V, f = 1 MHz	–	3.0	4.0	pF
Sensitive Saturation Voltage	$V_{R(S)}$		–	–	2	V

* At the fiber end.

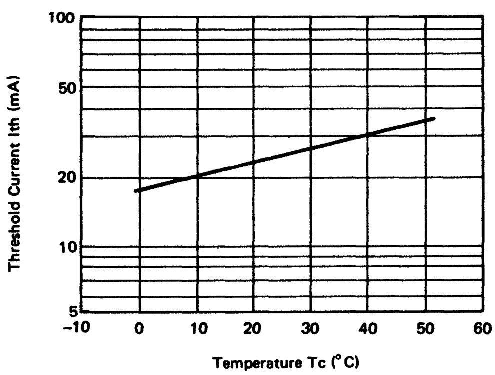
LIGHT – CURRENT



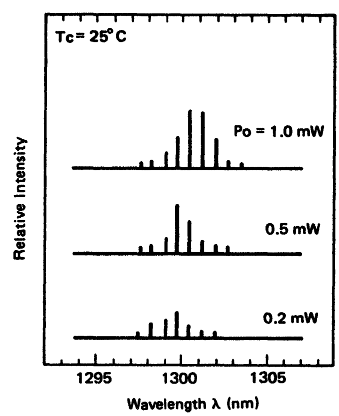
CURRENT – VOLTAGE



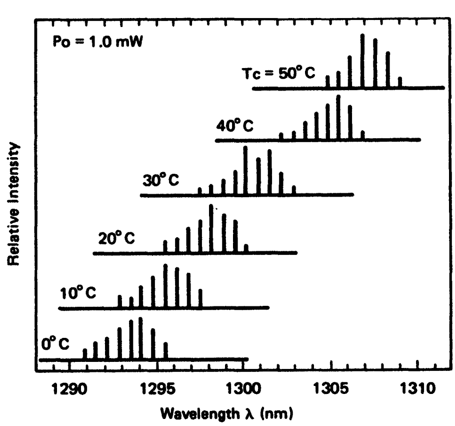
THRESHOLD CURRENT – TEMPERATURE



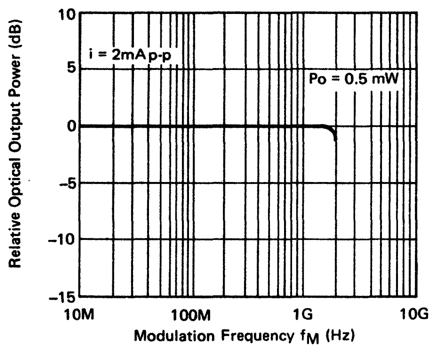
TYPICAL LASING SPECTRUM



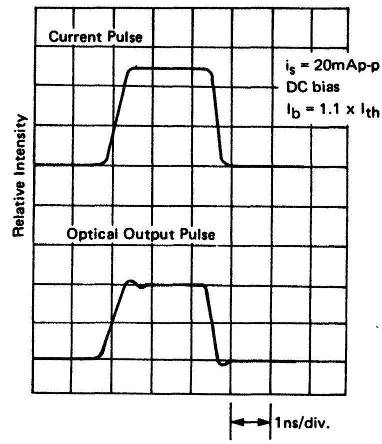
SPECTRUM – TEMPERATURE



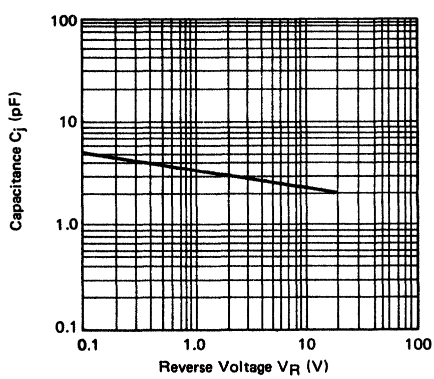
FREQUENCY RESPONSE OF LD



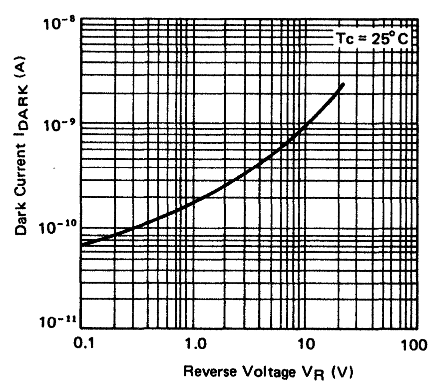
PULSE RESPONSE



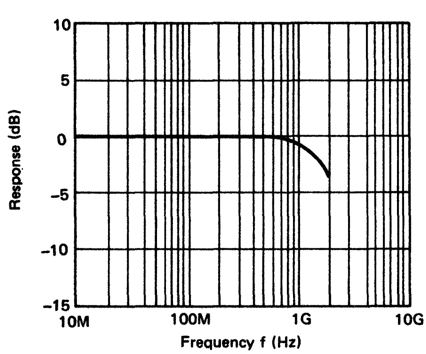
CAPACITANCE –
REVERSE VOLTAGE OF PD



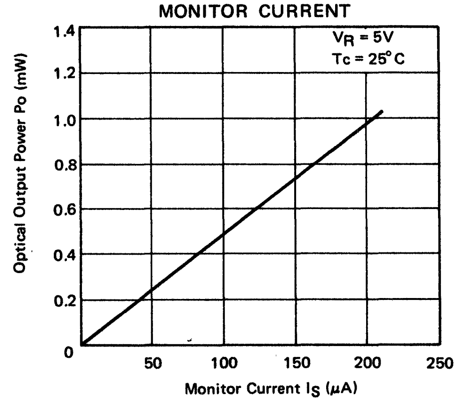
DARK CURRENT –
REVERSE VOLTAGE OF PD



FREQUENCY RESPONSE OF PD



OPTICAL OUTPUT POWER –
MONITOR CURRENT



INFRARED EMITTING DIODES

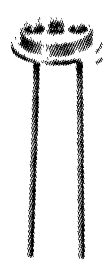
HLP20, HLP30, HLP40, HLP50, HLP60

GaAlAs IRED

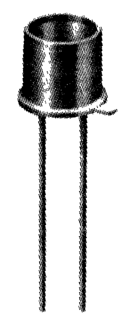
■ **APPLICATION**
- Infrared emitting source.

■ **FEATURES**
- High output power, high efficiency.
- High speed response: t_r and t_f are 20ns.
- Wide selection of wavelength from 735 to 905nm.
- Narrow spectral width.
- Long service life.

■ **PACKAGES**

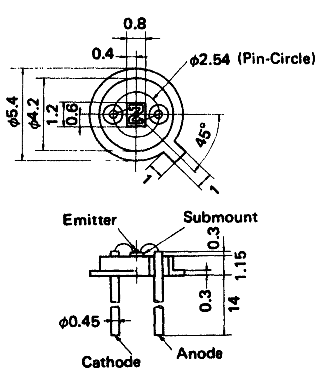


(R-Type)

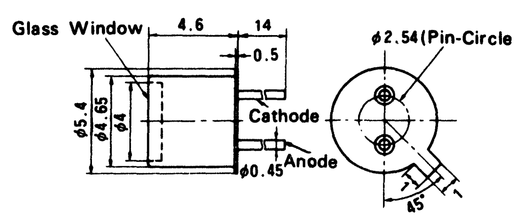


(RG-Type)

■ **PACKAGE DIMENSIONAL OUTLINES** (Dimensions in mm)



(R-Type)



(RG-Type)

■ ABSOLUTE MAXIMUM RATINGS (Tc = 25°C)

Item	Symbol	R-Type	RG-Type	Unit
Forward Current	I_F	250		mA
		230*		mA
Reverse Voltage	V_R	3		V
Power Dissipation	P_d	600		mW
Operating Temperature	T_{opr}	-20 ~ +40**	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +60**	-40 ~ +80	°C

* Value for devices with λp from 735nm to 785nm.
** Value under non-condensed condition.

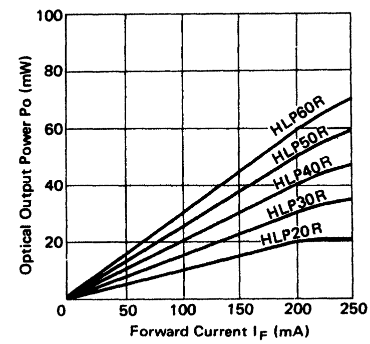
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)

Item		Symbol	Test Condition	min	typ	max	Unit
Output Power		P_O	I_F = 200mA	(cf. Note)**			mW
Wavelength Accuracy		λ_p					nm
Spectral Width		$\Delta\lambda$		–	30	60	nm
Beam Divergence	R-Type	θ_H		–	180	–	deg.
	RG-Type			–	120	–	deg.
Forward Voltage		V_F		–	1.7	2.3	V
				–	2.0*	2.6*	V
Reverse Current		I_R	V_R = 3V	–	–	30	μA
Capacitance		C_j	V_R = 0V, f = 1MHz	–	30	–	pF
Rise and Fall Time		t_r, t_f	I_F = 50mA	–	12	–	ns
				–	20*	–	ns

* Value for devices with λ_p from 735nm to 785nm.
** HLP Series are classified by λ_p and P_O as follows.

Grade	λp(nm)			Package	P_O(mW)									
	min	typ	max		7 (min)	12 (min)	15 (min)	17 (min)	22 (min)	25 (min)	27 (min)	35 (min)	45 (min)	55 (min)
A	735	760	785	R-Type			HLP20R			HLP30R		HLP40R		
				RG-Type	HLP20RG	HLP30RG		HLP40RG						
B	775	800	825	R-Type						HLP30R		HLP40R	HLP50R	HLP60R
				RG-Type		HLP30RG		HLP40RG	HLP50RG		HLP60RG			
C	815	840	865	R-Type						HLP30R		HLP40R	HLP50R	HLP60R
				RG-Type		HLP30RG		HLP40RG	HLP50RG		HLP60RG			
D	855	880	905	R-Type						HLP30R		HLP40R	HLP50R	HLP60R
				RG-Type		HLP30RG		HLP40RG	HLP50RG		HLP60RG			

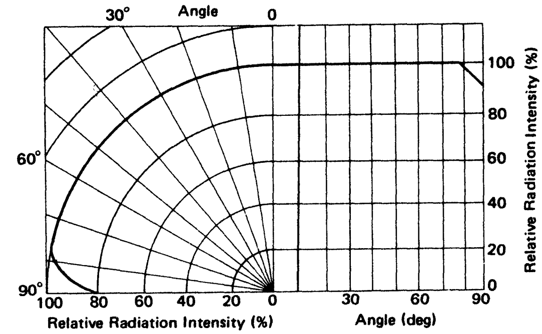
LIGHT – CURRENT



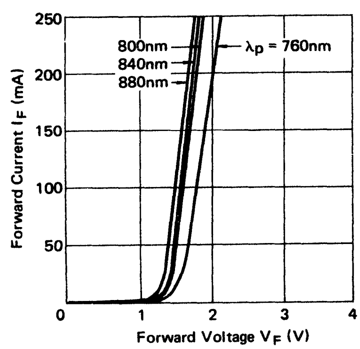
Note) Output Power P_O of RG-Type is half value of R-Type.

RADIATION PATTERN

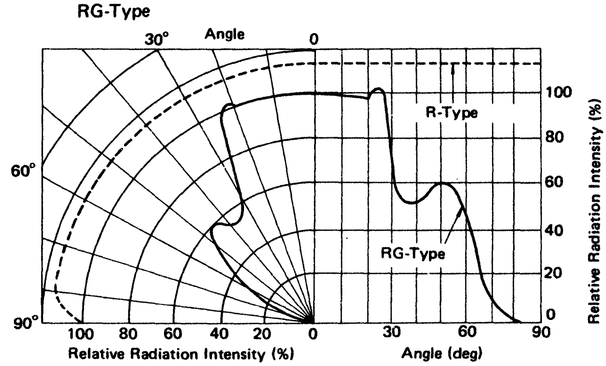
R-Type



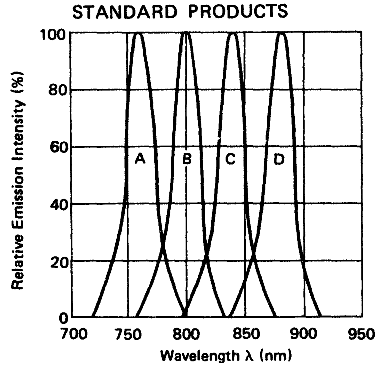
CURRENT – VOLTAGE



RG-Type



EMISSION SPECTRA OF THE STANDARD PRODUCTS



HE8801

GaAlAs IRED

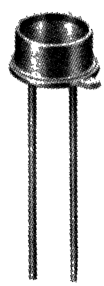
■ **APPLICATION**

- Light source for measuring or any other optical equipment.

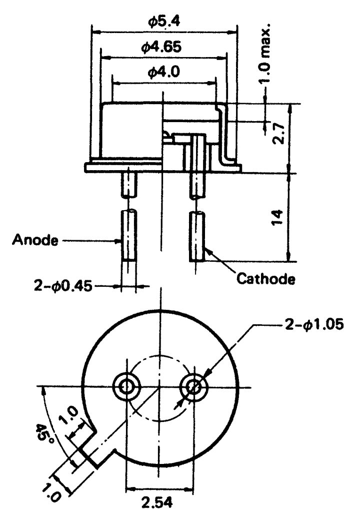
■ **FEATURES**

- High efficiency, high output power.
- Narrow spectral width.
- High speed response: t_r and t_f are 12ns.
- Hermetic seal for long service life.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**

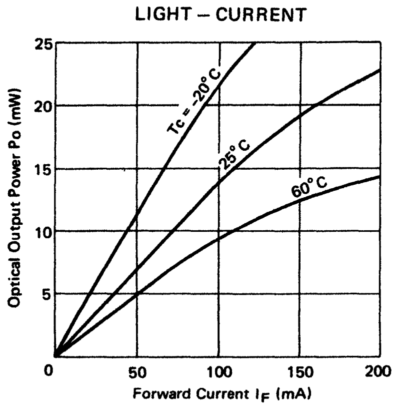


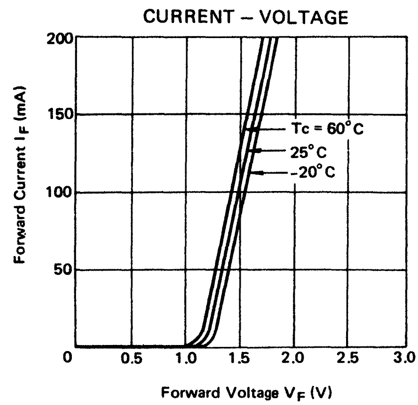
■ **ABSOLUTE MAXIMUM RATINGS (T_c = 25°C)**

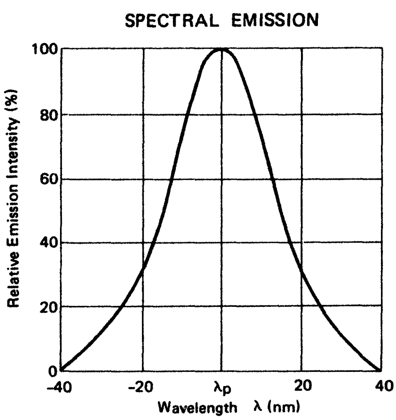
Item	Symbol	HE8801	Unit
Forward Current	I_F	200	mA
Reverse Voltage	V_R	3	V
Power Dissipation	Pd	400	mW
Operating Temperature	T_{opr}	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +90	°C

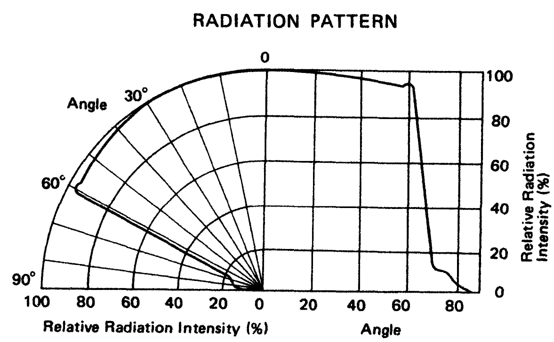
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (T_c = 25°C)**

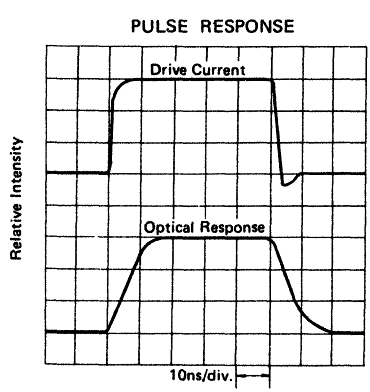
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po	I_F = 150mA	6	20	–	mW
Wavelength Accuracy	λp		800	880	900	nm
Spectral Width	Δλ		–	30	60	nm
Forward Voltage	V_F		–	1.7	2.3	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise and Fall Time	t_r, t_f	I_F = 50 mA	–	12	–	ns


LIGHT – CURRENT
Optical Output Power Po (mW)
Forward Current IF (mA)
Tc = -20°C
25°C
60°C
0
50
100
150
200
5
10
15
20
25


CURRENT – VOLTAGE
Forward Current IF (mA)
Forward Voltage VF (V)
Tc = 60°C
25°C
-20°C
0
0.5
1.0
1.5
2.0
2.5
3.0
50
100
150
200


SPECTRAL EMISSION
Relative Emission Intensity (%)
Wavelength λ (nm)
-40
-20
λp
20
40
0
20
40
60
80
100


RADIATION PATTERN
0
Angle
30°
60°
90°
100
80
60
40
20
0
20
40
60
80
Relative Radiation Intensity (%)
Angle
Relative Radiation Intensity (%)


PULSE RESPONSE
Relative Intensity
Drive Current
Optical Response
10ns/div.

HE8811

GaAlAs IRED

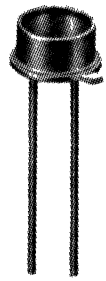
■ **APPLICATION**

- Light source for measuring, optical beam transmission equipment.

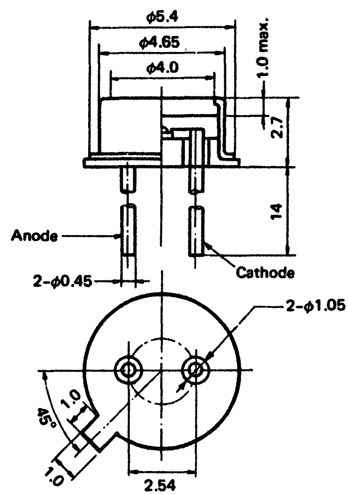
■ **FEATURES**

- High frequency response.
- High power, high efficiency and high brightness.
- No directional radiation pattern.
- Hermetic seal for long service life

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



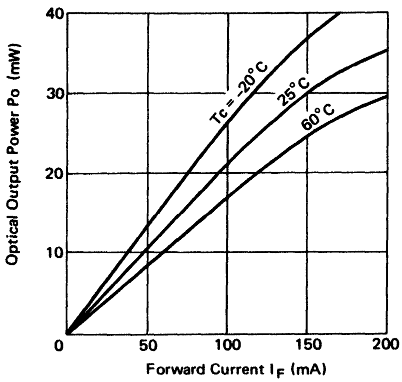
■ **ABSOLUTE MAXIMUM RATINGS ($T_c = 25°C$)**

Item	Symbol	HE8811	Unit
Forward Current	I_F	200	mA
Reverse Voltage	V_R	3	V
Power Dissipation	P_d	400	mW
Operating Temperature	T_{opr}	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +90	°C

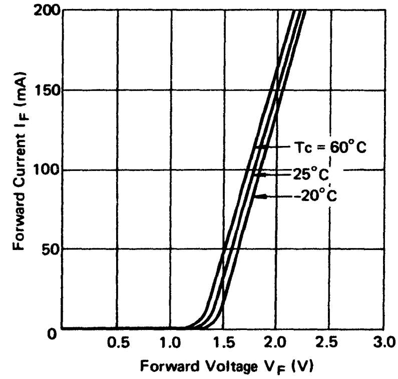
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS ($T_c = 25°C$)**

Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po	I_F = 150mA	20	30	–	mW
Wavelength Accuracy	λp		780	820	900	nm
Spectral Width	Δλ		–	50	–	nm
Forward Voltage	V_F		–	–	2.5	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise Time	t_r	I_F = 50mA	–	5	–	ns
Fall Time	t_f	I_F = 50mA	–	7	–	ns

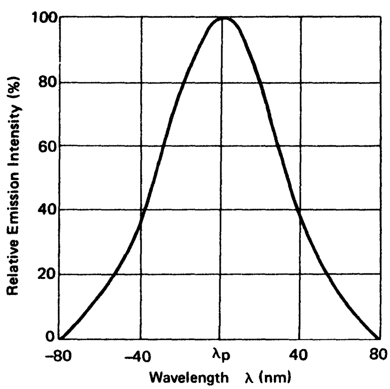
LIGHT – CURRENT



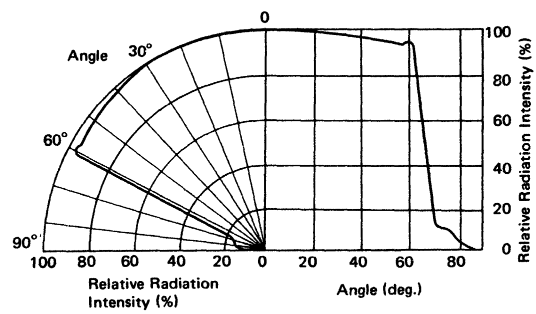
CURRENT – VOLTAGE



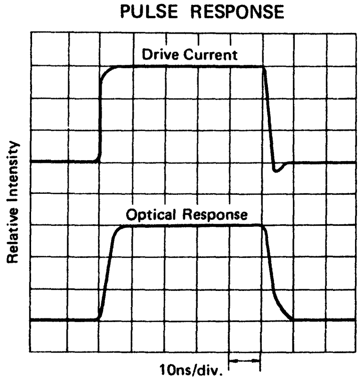
SPECTRAL EMISSION



RADIATION PATTERN



PULSE RESPONSE



HE8402F

GaAlAs IRED

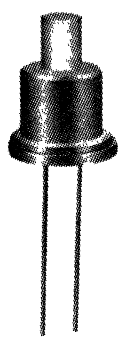
■ **APPLICATION**

- Fiberoptic communication.

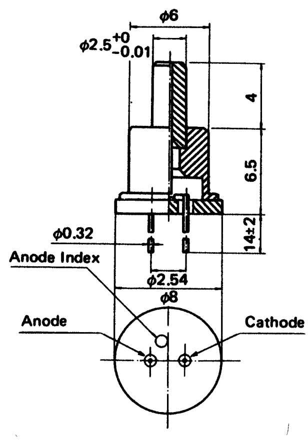
■ **FEATURES**

- Optical fiber rod (core dia. 50μm GI) coupled with 2.5mm dia. ferrule.
- Fiber easy coupled with connecter.
- High frequency response.
- Excellent linearity of light-current characteristics.
- Hermetic seal for long service life.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



■ **ABSOLUTE MAXIMUM RATINGS (Tc = 25°C)**

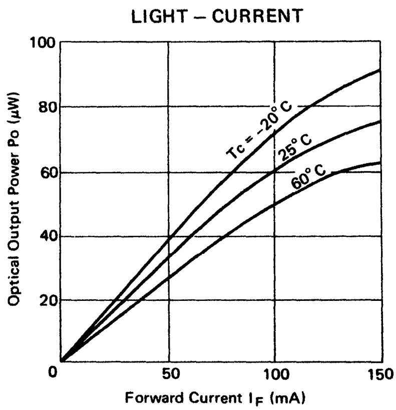
Item	Symbol	HE8402F	Unit
Forward Current	I_F	150	mA
Reverse Voltage	V_R	3	V
Power Dissipation	Pd	350	mW
Operating Temperature	T_{opr}	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +90	°C

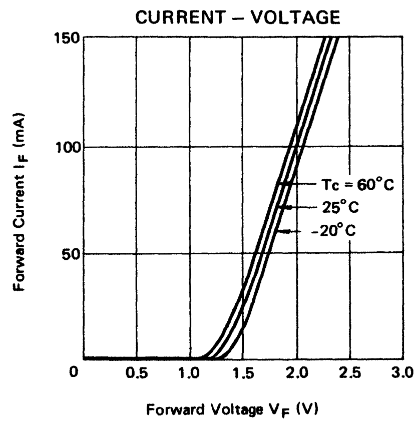
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)**

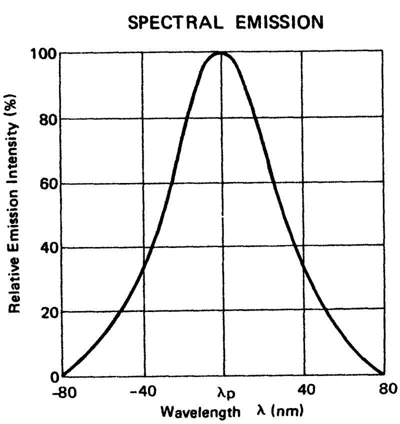
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po*	I_F = 100mA	40	60	–	μW
Wavelength Accuracy	λp		800	840	900	nm
Spectral Width	Δλ		–	50	–	nm
Forward Voltage	V_F		–	–	2.5	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise Time	t_r	I_F = 50mA	–	5	–	ns
Fall Time	t_f	I_F = 50mA	–	7	–	ns

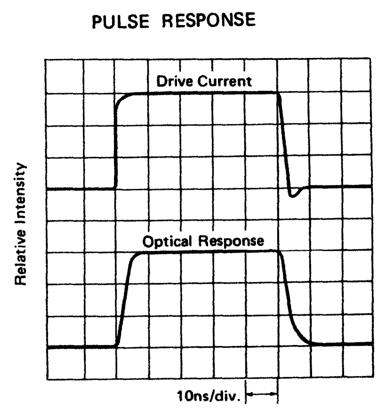
* Fiber Output Power.

HITACHI

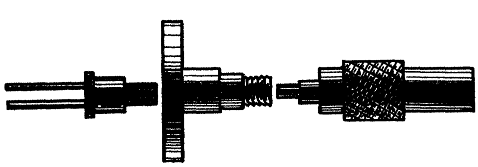


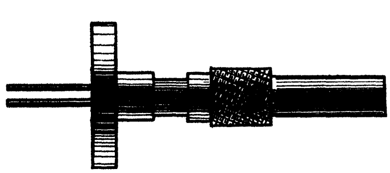






■ EXAMPLE OF ACTUAL USE





HE8403R

GaAlAs IRED

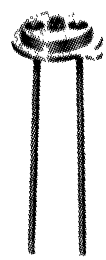
■ **APPLICATION**

- Fiberoptic communication.

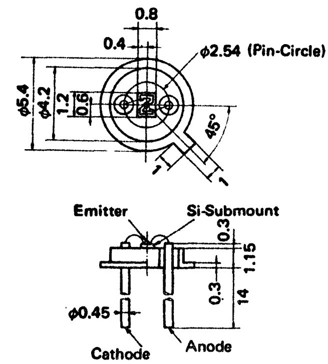
■ **FEATURES**

- Suitable for fiber attachment.
- High efficiency, high brightness.
- High frequency response.
- Excellent linearity of light-current characteristics.
- Long service life.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



■ **ABSOLUTE MAXIMUM RATINGS ($T_c = 25°C$)**

Item	Symbol	HE8403R	Unit
Forward Current	I_F	150	mA
Reverse Voltage	V_R	3	V
Power Dissipation	P_d	350	mW
Operating Temperature	T_{opr}	-20 ~ +40*	°C
Storage Temperature	T_{stg}	-40 ~ +60*	°C

* Conditions under humidity lower than 40%.

■ **PRECAUTION**

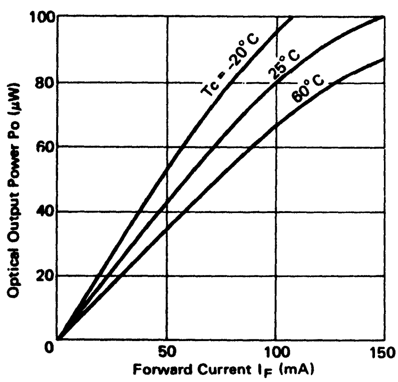
Hermetic seal for the system of this package is recommended, since the chip is exposed to the air.

■ **OPTICAL AND ELECTRICAL CHARACTERISTICS ($T_c = 25°C$)**

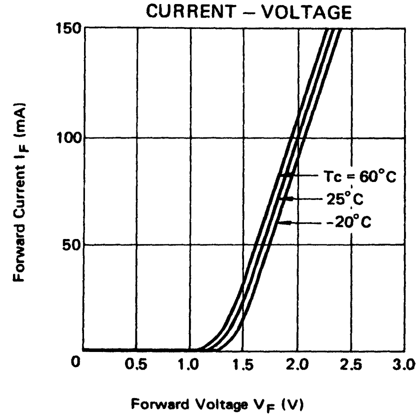
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po *	I_F = 100mA	50	80	–	μW
Wavelength Accuracy	λ_p		800	840	900	nm
Spectral Width	$\Delta\lambda$		–	50	–	nm
Forward Voltage	V_F		–	–	2.5	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise Time	t_r	I_F = 50mA	–	5	–	ns
Fall Time	t_f	I_F = 50mA	–	7	–	ns

* Expected output power from a 50μm dia. GI fiber.

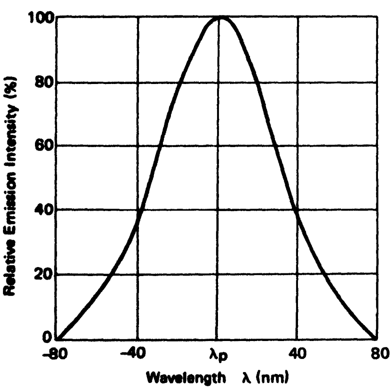
LIGHT – CURRENT



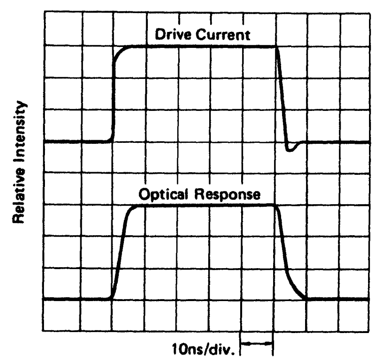
CURRENT – VOLTAGE



SPECTRAL EMISSION



PULSE RESPONSE



HE1301

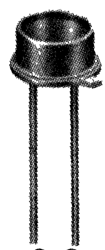
InGaAsP IRED

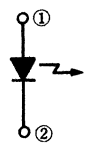
—PRELIMINARY—

■ **APPLICATION**
- Fiberoptic communication.

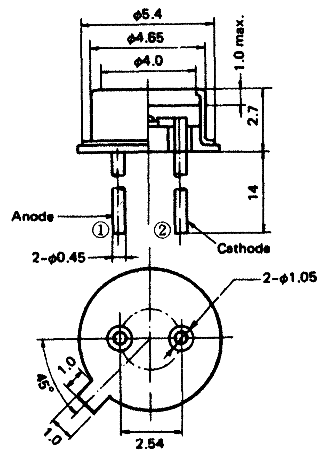
■ **FEATURES**
- Suitable for fiber attachment.
- High efficiency, high brightness.
- High frequency response.

■ **PACKAGE**





■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



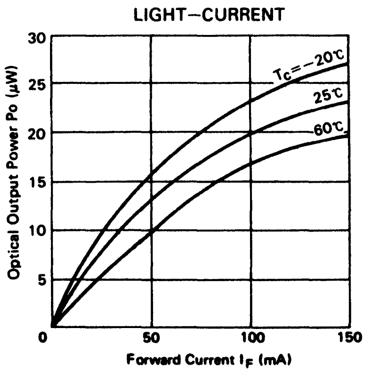
■ **ABSOLUTE MAXIMUM RATINGS ($T_c = 25°C$)**

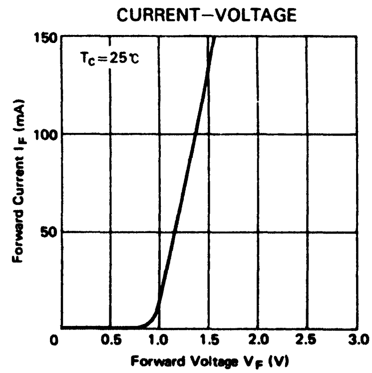
Item	Symbol	HE1301	Unit
Forward Current	I_F	150	mA
Reverse Voltage	V_R	0.3	V
Power Dissipation	P_d	300	mW
Operating Temperature	Topr	-20 ~ +60	°C
Storage Temperature	Tstg	-40 ~ +90	°C

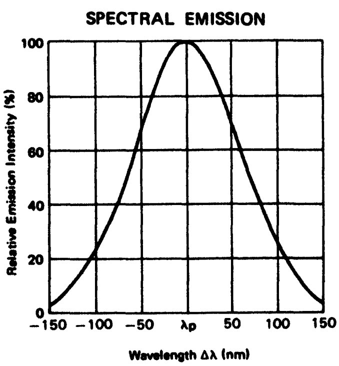
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS ($T_c = 25°C$)**

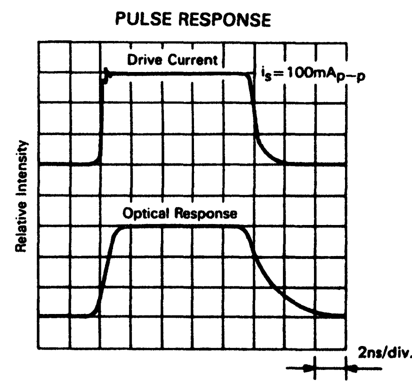
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po*	I_F = 100mA	15	–	–	μW
Wavelength Accuracy	λp		1260	1300	1340	nm
Spectral Width	Δλ		–	140	180	nm
Forward Voltage	V_F		–	1.5	2.0	V
Capacitance	C_j	V_R = 0, f = 1MHz	–	30	–	pF
Rise Time	t_r	I_F = 100mA	–	1.5	–	ns
Fall Time	t_f		–	4.0	–	ns

* Expected output power from GI 50/125 fiber.


LIGHT−CURRENT
Optical Output Power Po (μW)
Forward Current I$_F$ (mA)
Tc=−20℃
25℃
60℃
0
5
10
15
20
25
30
50
100
150


CURRENT−VOLTAGE
Tc=25℃
Forward Current I$_F$ (mA)
Forward Voltage V$_F$ (V)
0
50
100
150
0.5
1.0
1.5
2.0
2.5
3.0


SPECTRAL EMISSION
Relative Emission Intensity (%)
Wavelength Δλ (nm)
0
20
40
60
80
100
−150
−100
−50
λp
50
100
150


PULSE RESPONSE
Drive Current
i$_s$=100mA$_{p-p}$
Optical Response
Relative Intensity
2ns/div.

PHOTODETECTORS

HR8101

SILICON PIN DIODE

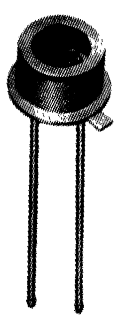
■ **APPLICATION**

• Measuring, communication or any other optical equipment.

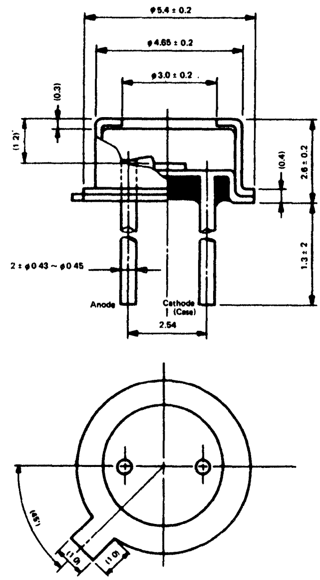
■ **FEATURES**

• Fast response: t_r and t_f are 80ns.
• Hermetic seal for high reliability.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**

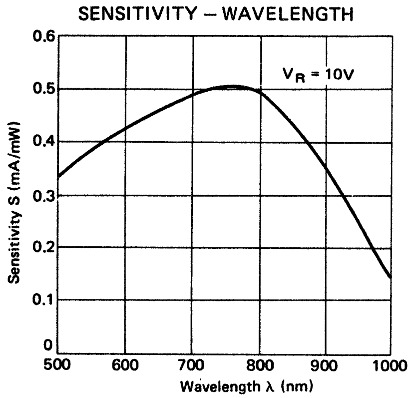


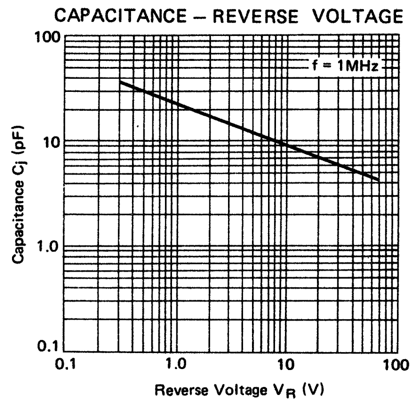
■ **ABSOLUTE MAXIMUM RATINGS (Tc = 25°C)**

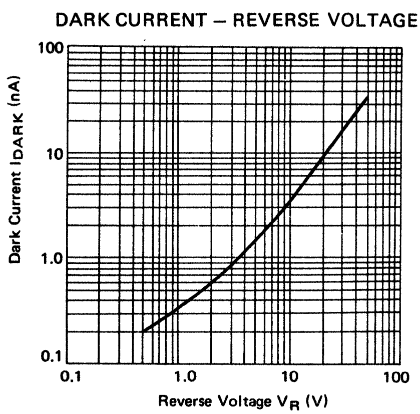
Item	Symbol	HR8101	Unit
Reverse Voltage	V_R	100	V
Forward Current	I_F	100	mA
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	°C

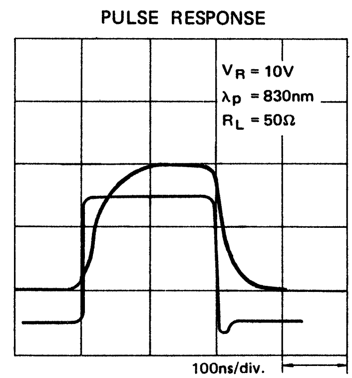
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)**

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_{DARK}	V_R = 10V	–	2	10	nA
Capacitance	C_j	V_R = 10V, f = 1MHz	–	10	15	pF
Sensitivity	S	V_R = 10V, λ_p = 830nm	0.4	–	–	mA/mW
Rise and Fall Time	t_r, t_f	V_R = 10V, λ_p = 830nm, R_L = 50Ω	–	80	–	ns









Upper trace : PD Output
Lower trace : LD* Drive Current
*t_r and t_f of LD are less than 0.5ns.

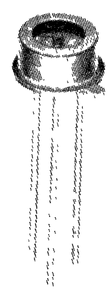
HR8102

SILICON PIN DIODE

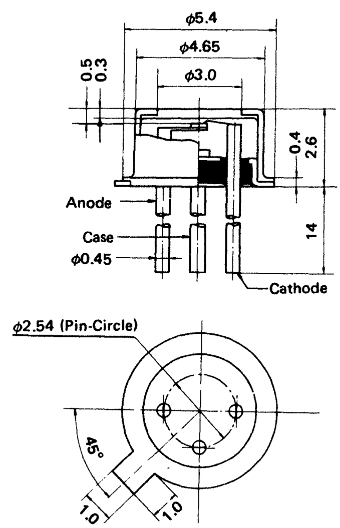
■ **APPLICATION**
- High speed optical communication equipment.

■ **FEATURES**
- High sensitivity to wide wavelength range.
- Fast response: t_r and t_f are 1ns.
- Available operation under reverse voltage as low as 5V.
- Photosensitive area of 300μm dia.
- Hermetic seal for high reliability.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



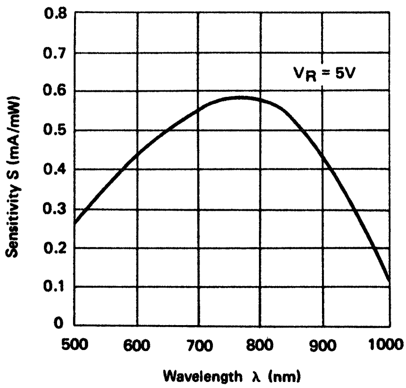
■ **ABSOLUTE MAXIMUM RATINGS (T_c = 25°C)**

Item	Symbol	HR8102	Unit
Forward Current	I_F	100	mA
Reverse Voltage	V_R	100	V
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	°C

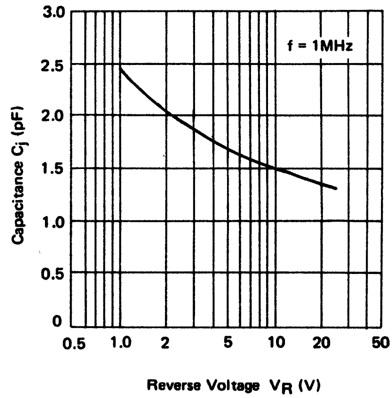
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)**

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_{DARK}	V_R = 10V	–	0.5	3	nA
Capacitance	C_j	V_R = 10V, f = 1MHz	–	1.5	3	pF
Sensitivity	S	V_R = 10V, λp = 830nm	0.4	–	–	mA/mW
Rise and Fall Time	t_r, t_f	V_R = 10V, λp = 830nm, R_L = 50Ω	–	1	–	ns

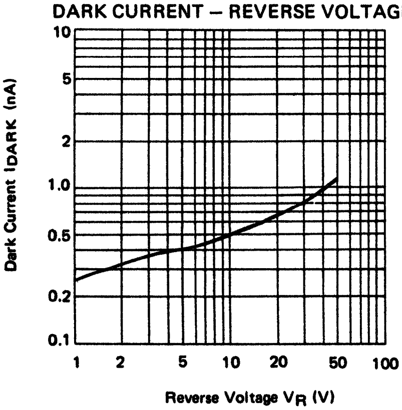
SENSITIVITY – WAVELENGTH



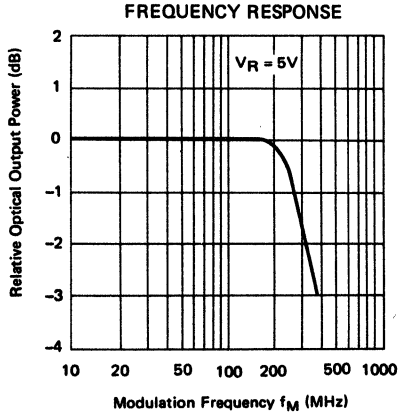
CAPACITANCE – REVERSE VOLTAGE



DARK CURRENT – REVERSE VOLTAGE



FREQUENCY RESPONSE



HR1101

InGaAsP PIN DIODE

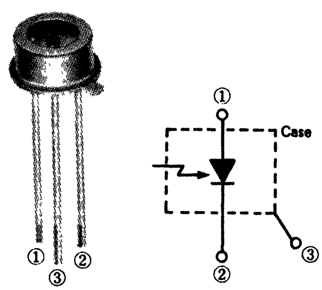
■ **APPLICATION**

- High bit rate fiberoptic communication.

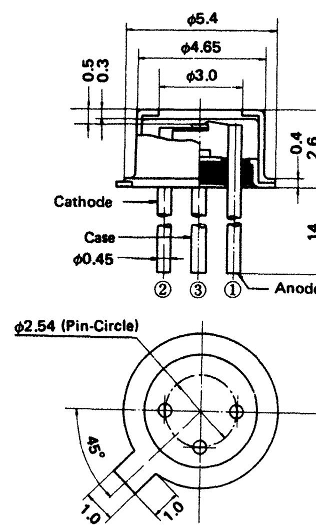
■ **FEATURES**

- Long-wave PIN photodetector 1000 ~ 1500nm
- High frequency response t_r, t_f = 0.5ns typ
- High sensitivity S ≧ 0.45mA/mW
- Low dark current I_{DARK} = 7nA typ., V_R = 10V
- Low capacitance C_j = 2.0pF typ., V_R = 10V, f = 1MHz
- Hermetic seal for high reliability
- Photosensitive area of 100μm dia.

■ **PACKAGE**



■ **PACKAGE DIMENSIONAL OUTLINE** (Dimensions in mm)



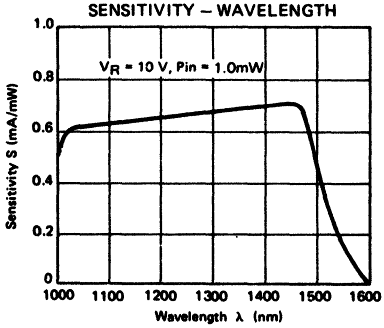
■ **ABSOLUTE MAXIMUM RATINGS** (Tc = 25°C)

Item	Symbol	HR1101	Unit
Reverse Voltage	V_R	20	V
Forward Current	I_F	1	mA
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	

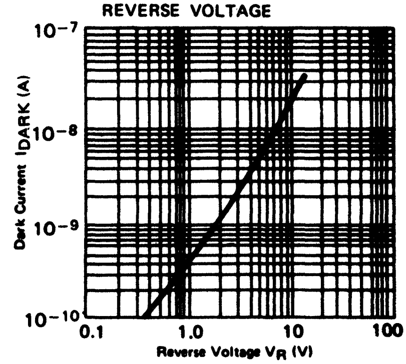
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS** (Tc = 25°C)

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_{DARK}	V_R = 10V	–	7	200	nA
Capacitance	C_j	V_R = 10V, f = 1MHz	–	2.0	3.0	pF
Sensitivity	S	V_R = 10V, λp = 1300nm, Pin = 1.0mW	0.45	0.7	–	mA/mW
Sensitive Saturation Voltage	$V_{R(S)}$		–	–	2	V
Rise and Fall Time	t_r, t_f	V_R = 10V, λp = 1300nm, R_L = 50Ω	–	0.5	–	ns

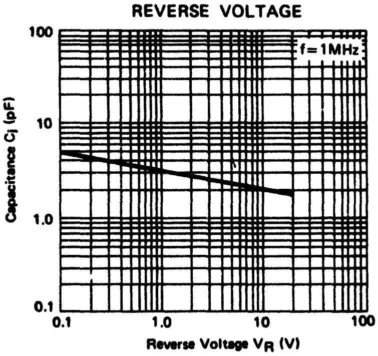
SENSITIVITY – WAVELENGTH



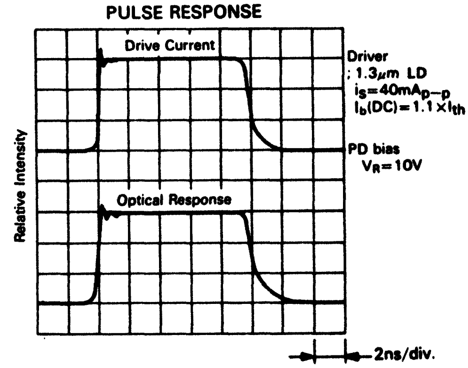
DARK CURRENT – REVERSE VOLTAGE



CAPACITANCE – REVERSE VOLTAGE



PULSE RESPONSE



HR1102

InGaAsP PIN DIODE

—PRELIMINARY—

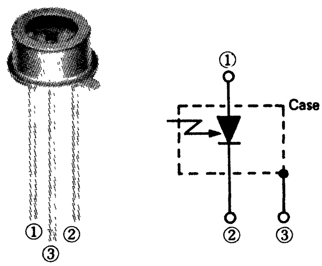
■ APPLICATION

- High bit rate fiberoptic communication.

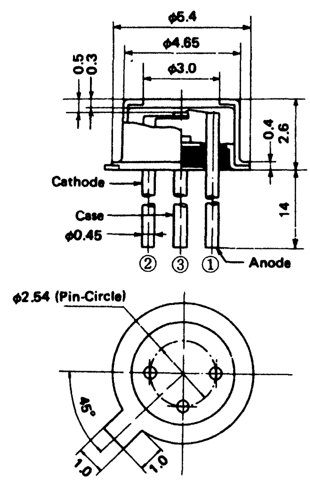
■ FEATURES

- Long-wave PIN photodetector 1000 ~ 1500nm
- High sensitivity S ≧ 0.45mA/mW
- Low dark current I_{DARK} = 20nA typ., V_R = 10V
- Hermetic seal for high reliability
- Photosensitive area of 300μm dia.

■ PACKAGE



■ PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)

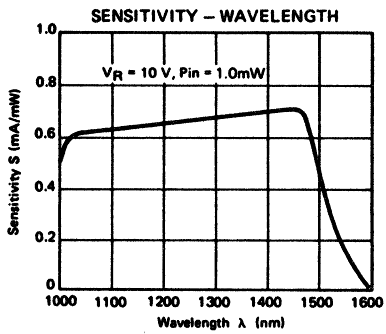


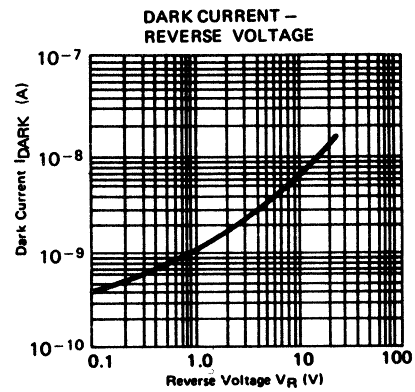
■ ABSOLUTE MAXIMUM RATINGS (Tc = 25°C)

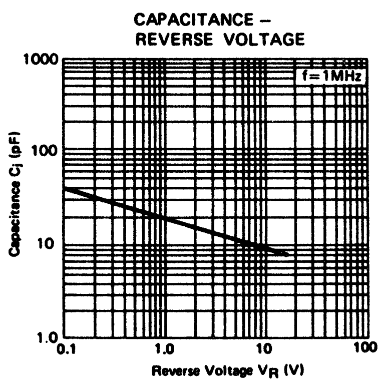
Item	Symbol	HR1102	Unit
Reverse Voltage	VR	15	V
Forward Current	IF	1	mA
Operating Temperature	Topr	-40 ~ +80	°C
Storage Temperature	Tstg	-45 ~ +100	

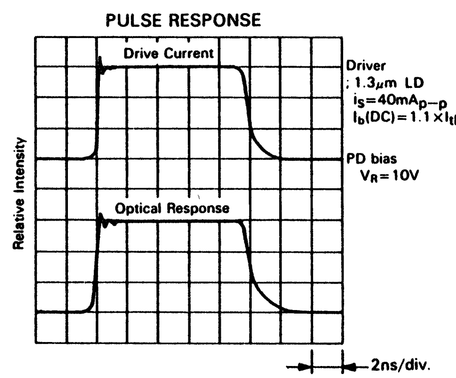
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_{DARK}	VR = 10V	–	20	500	nA
Capacitance	C_j	VR = 10V, f = 1MHz	–	9	15	pF
Sensitivity	S	VR = 10V, λp = 1300nm, Pin = 1.0mW	0.45	0.7	–	mA/mW
Sensitive Saturation Voltage	VR(S)		–	–	2	V
Rise and Fall Time	tr, tf	VR = 10V, λp = 1300nm, RL = 50Ω	–	1.2	–	ns


SENSITIVITY – WAVELENGTH
VR = 10 V, Pin = 1.0mW
Sensitivity S (mA/mW)
1.0
0.8
0.6
0.4
0.2
0
1000
1100
1200
1300
1400
1500
1600
Wavelength λ (nm)


DARK CURRENT – REVERSE VOLTAGE
Dark Current IDARK (A)
10−7
10−8
10−9
10−10
0.1
1.0
10
100
Reverse Voltage VR (V)


CAPACITANCE – REVERSE VOLTAGE
f = 1MHz
Capacitance Cj (pF)
1000
100
10
1.0
0.1
1.0
10
100
Reverse Voltage VR (V)


PULSE RESPONSE
Drive Current
Optical Response
Relative Intensity
Driver
: 1.3μm LD
is=40mAp−p
Ib(DC)=1.1×Ith
PD bias
VR=10V
2ns/div.

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