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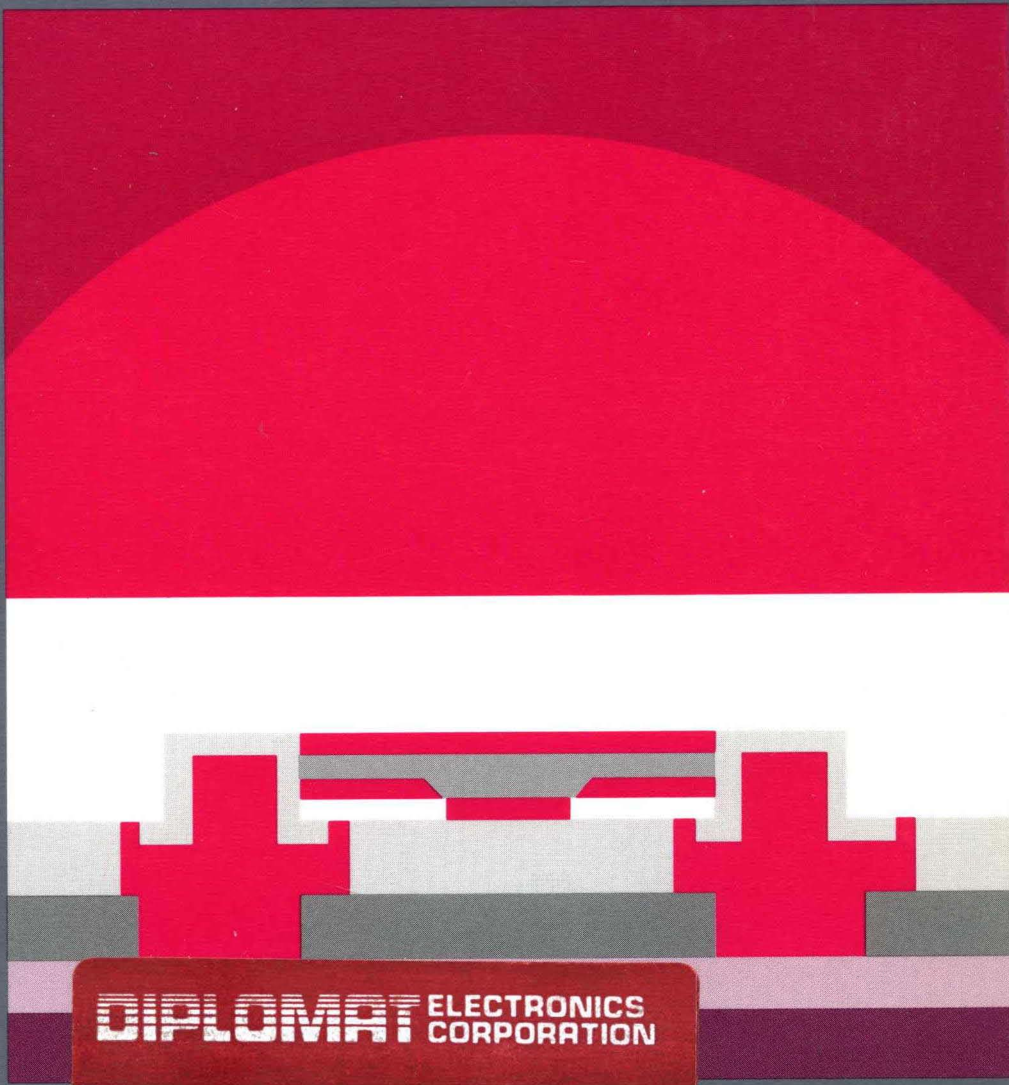
OPTOELECTRONIC DEVICES DATA BOOK



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INTRODUCTION

Optoelectronic semiconductor product properties such as reduced size, weight, low power consumption, high collimating efficiency, monochromacy, and high speed direct modulation capability, offer unique potential in a wide variety of commercial applications.

Hitachi Ltd. produces laser diodes (LDs), high power Infra-Red Emitting Diodes (REDs), and Photo Detectors (PDs) which are indispensable to optical application systems in communication, measurement and medical equipment, information terminals and audio, video, and memory disc systems.

This data book contains:

*Selection Guide
*Operational Features and Reliability
*Application Notes
*Data Sheets

Printed in U.S.A.

Published: September 1984

For updated product information, please contact Hitachi through one of the sales offices listed on the last page of this data book.

SAFETY CONSIDERATIONS

The laser light emitted from injection laser diodes is invisible and may be harmful to the human eye. Avoid looking directly into the LD or the collimated beam along its optical axis when the LD is in operation.

The laser diodes must not be operated outside of their maximum ratings. Power supplies (laser energy sources) used with the laser diode must be such that the maximum output power can not be exceeded.

Warning and Certification Label

Aperture Label

Identification Label

INDEX

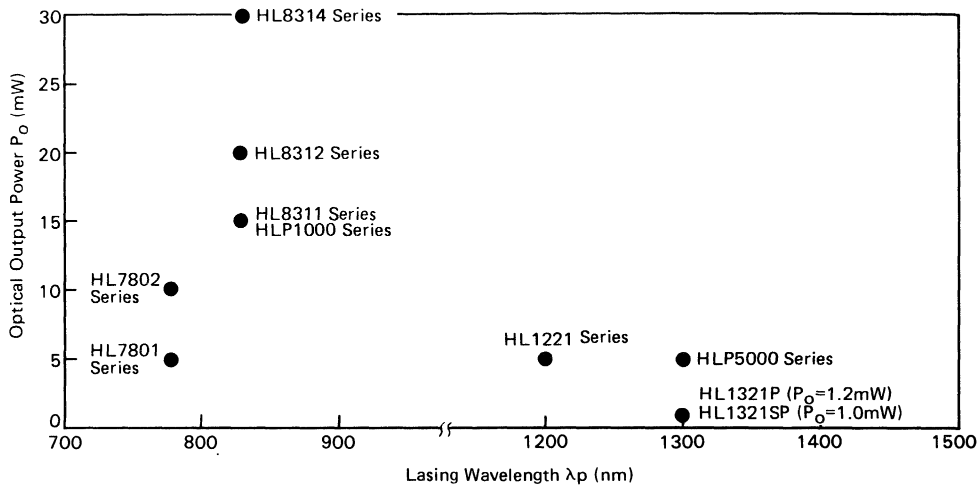
GENERAL INFORMATION

SELECTION GUIDE

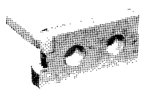
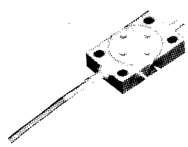
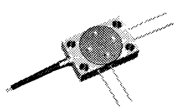
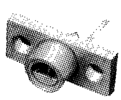
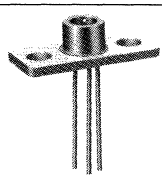
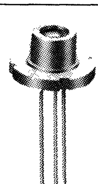
1. PRODUCTS LINE-UP

1.1 Laser Diode (LD) Line-Up and Main Characteristics

- Line-Up



- **Package Variation**

Package		λp: 760 ~ 800nm	800 ~ 850nm	1170 ~ 1230nm	1270 ~ 1330nm	Application
	Products Series	HL7801 Series HL7802 Series	HLP1000 Series HL8311 Series HL8312 Series HL8314 Series	HL1221 Series	HLP5000 Series HL1321 Series	
Open-Air Type	 400 Type (A Type)		HLP1400	HL1221A	HLP5400	○ Experimental Use ○ Capability of Close Access to the Optics
Fiber Pigtail Type	 500 Type (B Type)		HLP1500	HL1221B	HLP5500	○ Intermediate and Long Distance Fiberoptic Transmission
Fiber Pigtail Type	 P Type				HL1321P HL1321SP*	
Hermetic Seal Type	 600 Type (C Type)		HLP1600	HL1221C	HLP5600	○ Optical Beam Transmission ○ Optical Disc Memory ○ Laser Beam Printer ○ Measuring Equipment
Hermetic Seal Type	 E Type	HL7801E HL7802E	HL8311E HL8312E HL8314E			
Hermetic Seal Type	 G Type	HL7801G HL7802G	HL8311G HL8312G			

* Used with a Single Mode Fiber Pigtail.

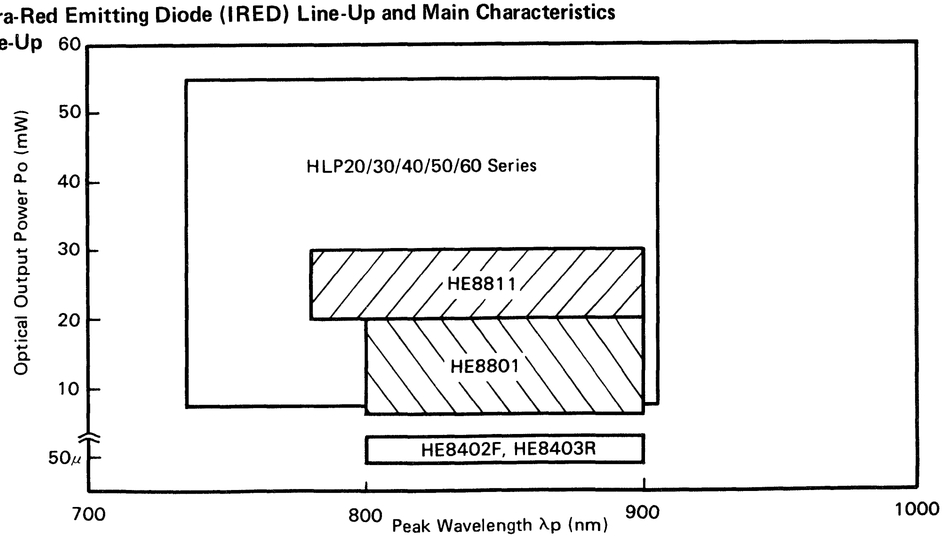
- **Main Characteristics (T_C=25°C)**

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 λp (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	16 x 30	3	53
	HL7801G										53
HL7802 Series	HL7802E †	10	2	-10 ~ +60	-40 ~ +80	760	780	800	11 x 30	10	56
	HL7802G †										56
HLP1000 Series	HLP1400	15	2	0 ~ +60	0 ~ +80	800	830	850	10 x 24	10	58
	HLP1500	6*			-40 ~ +70				–	4	58
	HLP1600	15			-40 ~ +80				10 x 24	10	58
HL8311 Series	HL8311E	15	2	-10 ~ +60	-40 ~ +80	800	830	850	10 x 24	10	62
	HL8311G										62
HL8312 Series	HL8312E	20	2	-10 ~ +50	-40 ~ +80	810	830	850	10 x 24	10	65
	HL8312G										65
HL8314 Series	HL8314E †	30	2	0 ~ +50	-40 ~ +80	810	830	850	10 x 24	20	68
HL1221 Series	HL1221A †	5	2	0 ~ +50	0 ~ +60	1170	1200	1230	30 x 40	3	69
	HL1221B †	1.2*			-40 ~ +60				–	0.5	69
	HL1221C †	5			-40 ~ +60				30 x 40	3	69
HLP5000 Series	HLP5400	5	2	0 ~ +50	0 ~ +60	1270	1300	1330	30 x 40	3	73
	HLP5500	1.2*			-40 ~ +60				–	0.5	73
	HLP5600	5			-40 ~ +60				30 x 40	3	73
HL1321 Series	HL1321P †	1.2*	2	0 ~ +50	-40 ~ +60	1270	1300	1330	–	0.5	77
	HL1321SP †**	1.0*								1.0	80

† Preliminary Specifications
* At the Fiber End
** Used with a Single Mode Fiber Pigtail

1.2 Infra-Red Emitting Diode (IRED) Line-Up and Main Characteristics

- **Line-Up**



- **Package Variation**

Outline		HLP Series	HE Series	Application
Open-Air Type	 R Type	HLP20R/30R/40R/50R/60R (λp = 735 ~ 905nm)	HE8403R (λp = 800 ~ 900nm)	○ Experimental Use (Capability of closs access to the optics)
Hermetic Seal Type	 RG Type	HLP20RG/30RG/40RG/50RG/60RG (λp = 735 ~ 905nm)		○ Auto Focus Camera ○ Optical Beam Transmission ○ Measuring Equipment
	 SG Type		HE8811 (λp = 780 ~ 900nm) HE8801 (λp = 800 ~ 900nm)	
	 F Type		HE8402F (λp = 800 ~ 900 nm)	○ Fiberoptic Transmission

- **Main Characteristics (T_C=25°C)**

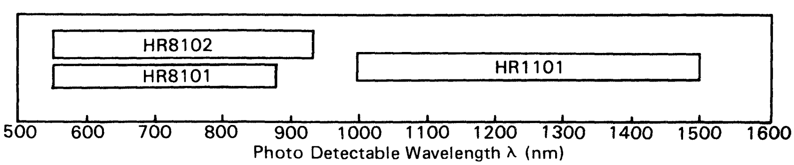
	Part No.	Absolute Maximum Ratings: Reverse Voltage V_R (V)	Power Dissipation P_d (mW)	Operating Temperature T_{opr} (°C)	Storage Temperature T_{stg} (°C)	Optical and Electrical Characteristics: Optical Output Power P_o (mW)	Peak * Wavelength λp (nm)				Spectral Width $\Delta\lambda$ (nm)	Test Condition I_F (mA)	Capacitance C_i (pF)	Test Condition	Reference Page
						min	A	B	C	D	typ		typ		
HLP Series	HLP20R					15	○								
	HLP30R					25	○	○	○	○				V_R=0	
	HLP40R	3	600	-20~+40	-40~+60	35	○	○	○	○	30	200	30	f=1MHz	
	HLP50R					45		○	○	○					
	HLP60R					55		○	○	○					
	HLP20RG					7	○								85
	HLP30RG					12	○	○	○	○				V_R=0	
	HLP40RG	3	600	-20~+60	-40~+80	17	○	○	○	○	30	200	30	f=1MHz	
	HLP50RG					22		○	○	○					
	HLP60RG					27		○	○	○					
HE Series	HE8801	3	400	-20~+60	-40~+90	6	800 ~ 900				30	150	10		88
	HE8811	3	400	-20~+60	-40~+90	20	780 ~ 900				50	150	10	V_R=0	90
	HE8402F	3	350	-20~+60	-40~+90	40μ**	800 ~ 900				50	100	10	f=1MHz	92
	HE8403R	3	350	-20~+40	-40~+60	50μ**	800 ~ 900				50	100	10		94

* HLP Series are grouped with peak wavelength as follows. ** Fiber Output Power

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

1.3 Photo Detector (PD) Line-Up and Main Characteristics

- **Line-Up**



- **Package Variation**

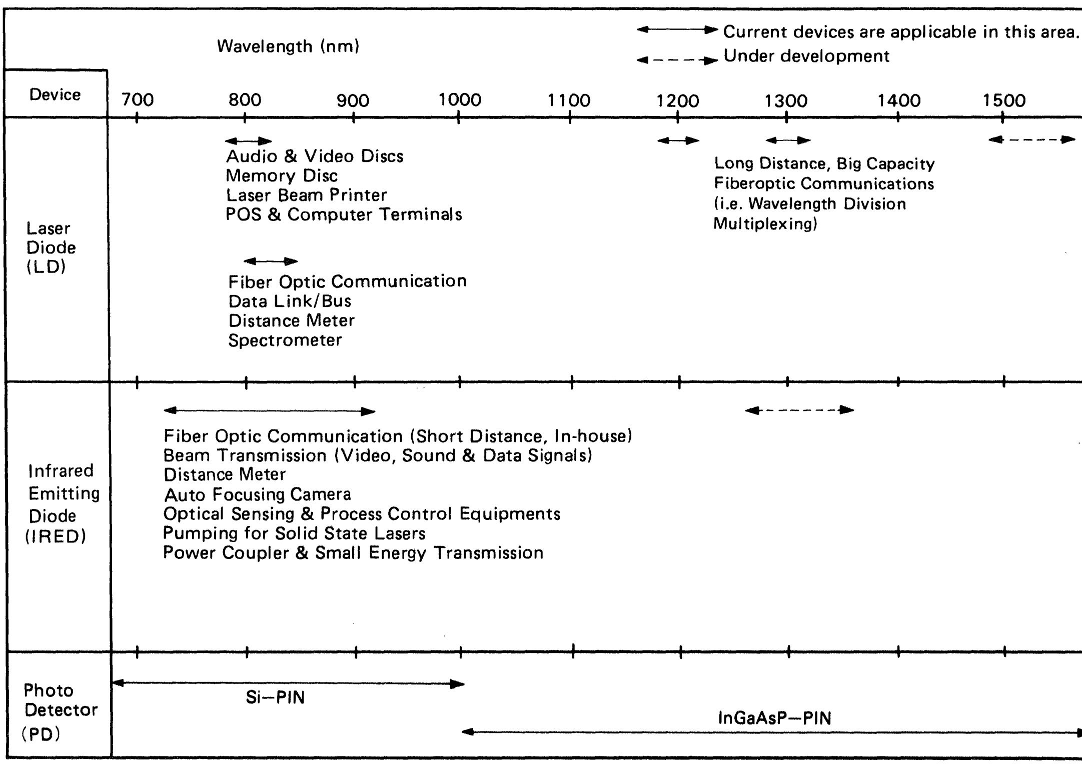
Part No.	HR8101	HR8102	HR1101
Hermetic Seal Type			

- **Main Characteristics (T_C=25°C)**

Part No.	Absolute Maximum Ratings: Reverse Voltage V_R (V)	Operating Temperature T_{opr} (°C)	Storage Temperature T_{stg} (°C)	Optical and Electrical Characteristics: Dark Current I_D (nA) typ	Capacitance C_j (pF) typ	Test Condition	Sensitivity S (mA/mW) min	Test Condition	Reference Page
HR8101*	60	-40 ~ +80	-45 ~ +100	2	10	V_R=10V, f=1MHz	0.4	V_R=10V, λp=830nm	99
HR8102*	100	-40 ~ +80	-45 ~ +100	0.5	1.5	V_R=5V, f=1MHz	0.4	V_R=5V, λp=830nm	101
HR1101*	20	-40 ~ +80	-45 ~ +100	7	2	V_R=10V, f=1MHz	0.55	V_R=10V, λp=1300nm	103

* Preliminary Specifications

1.4 Application Map of Opto Devices



2. SYMBOL AND DEFINITION

2.1 Absolute Maximum Ratings

Absolute maximum ratings are values which should not be exceeded under any condition, and are defined at case temperature (T_c) of 25°C, unless otherwise specified.

Table 1 Absolute Maximum Ratings

Item	Applied Device			Definition
	LD	IRED	PD	
Optical Output Power (P_o)	○			Maximum tolerable output power under continuous operation. The value with no kink phenomenon in light-current characteristics (Fig. 1).
Forward Current (I_F)		○	○	Maximum tolerable current under continuous operation.
Reverse Voltage (V_R)	○	○	○	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)		○		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})	○	○	○	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})	○	○	○	Ambient temperature range in which a device can be stored. It differes with package types even if the same chip is built in.

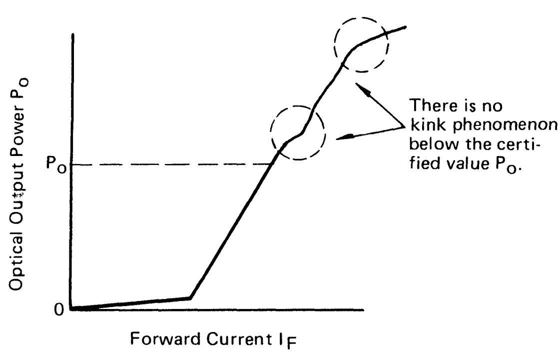


Figure 1 Light — Current Characteristics

2.2 Optical and Electrical Characteristics

This manual describes optimum and typical values for optical and electrical characteristics in electrical circuit and optic applications. 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)

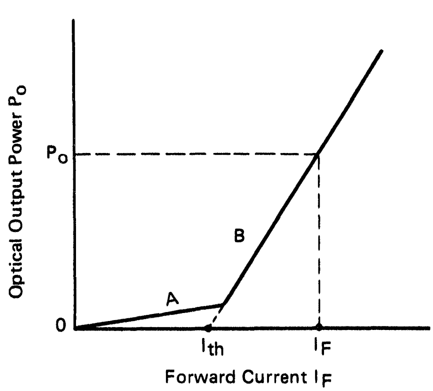


Figure 2 Light – Current Characteristics

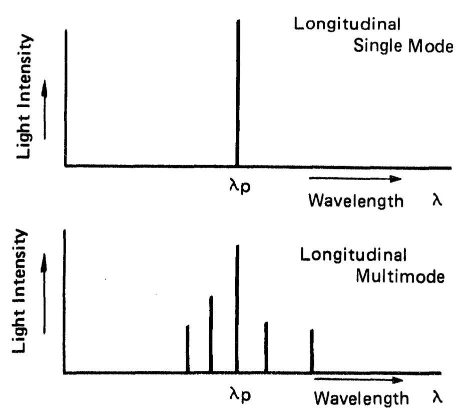


Figure 3 Lasing Spectrum

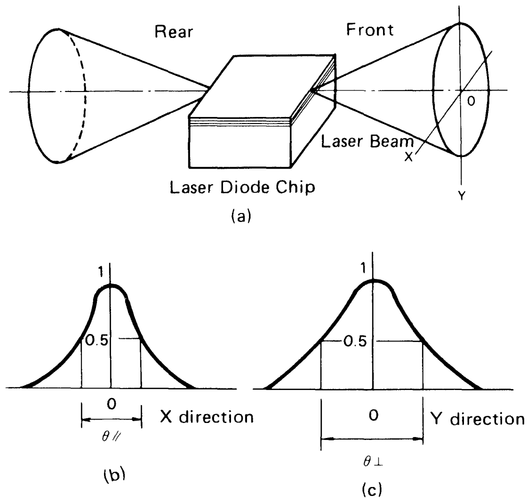


Figure 4 Beam Divergence

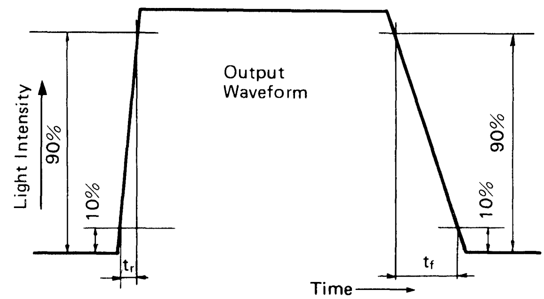


Figure 5 Definition of Rise & Fall Time

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)

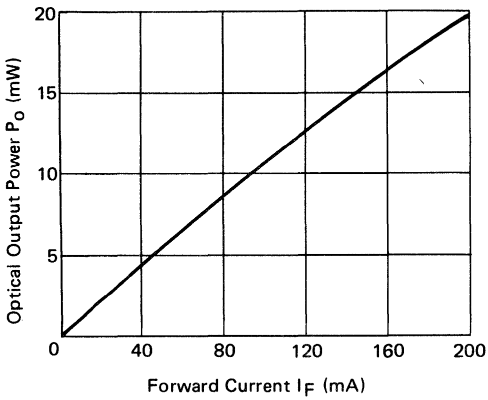


Figure 6 Light – Current Characteristics

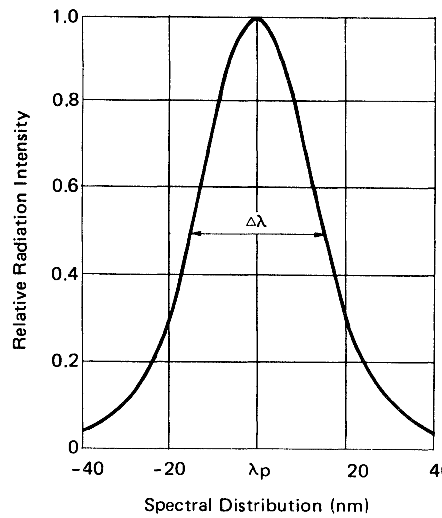


Figure 7 Spectrum Characteristics (HLP30RG)

Table 4 Optical and Electrical Characteristics of PD

Item	Definition
Dark Current (I_D)	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 must be taken during device measurement and in system design to maintain device performance and reliability.

3.1 Absolute Maximum Ratings

Under any condition, never exceed the absolute maximum ratings specified in the individual data sheets. Note the following points:

(1) Avoid device damage caused by current spikes generated at ON-OFF switching or when adjusting power supply output voltage. HLP3000 and HLP5000 are especially vulnerable; their low threshold current I_{th} and high slope efficiency η can easily cause excessive current density. Before operating a device, check the transient phenomenon of a power supply, and do not allow it to exceed the maximum ratings.

(2) Do not exceed the maximum optical output power rating, which can reduce reliability due to mirror facet damage. Operation under 2/3 of maximum optical output power is recommended.

(3) The maximum ratings are specified at an operating temperature of 25°C. Operation at higher temperature lowers the tolerable maximum optical output power and allowable power dissipation. Application design with sufficient margin based on maximum ratings is recommended.

(4) Never apply reverse voltage V_R over the maximum rating.

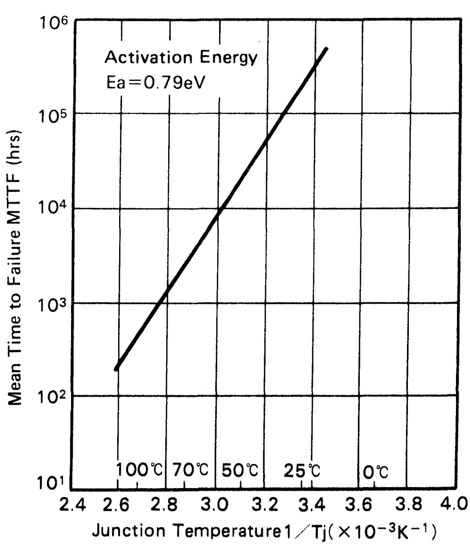


Figure 8 Mean Time to Failure and Junction Temperature of LD

3.2 Derating

LD and IRED reliability largely depends on the junction temperature during operation as shown in Fig. 8 and 9. High temperature deteriorates a device expontentially. Lower the junction temperature by derating and heat sinking. Reliability also depends on optical output power in operation. Use a device at the derated condition.

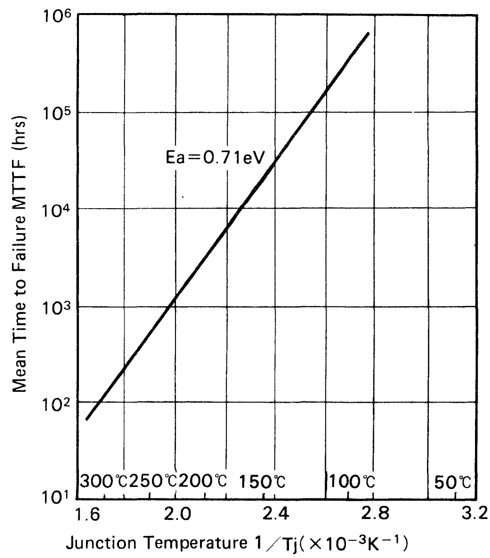


Figure 9 Mean Time to Failure and Junction Temperature of IRED

3.3 Surge Energy

Avoid device degradation caused by electrostatic discharge or electric spikes. Devices should be handled with suitable static electricity preventive measures as follows:

(1) Prevent static electricity damage by using a grounding system for the operator handling devices. Use of a high resistance (500 kΩ~MΩ) is recommended.

(2) Ground soldering irons to prevent voltage leaks during soldering operations.

(3) Choose a suitable carrier material which will not become charged with static electricity caused by rubbing during transportation. Use electroconductive materials or aluminum foil.

3.4 Storage

(1) Devices should be stored at 5 ~ 30° C, with a relative humidity below 40%. Lower temperature and humidity values are optimum where devices are exposed to the air. Avoid condensation caused by sharp temperature drops. Hitachi recommends storing devices in an atmosphere of dry nitrogen (40° C dew point).
(2) Store devices in a dust- and gas-free environment.
(3) Use a storage container which will not become charged with static electricity.

3.5 Safety

Laser beams from a device are harmful, but invisible. Do not look directly into the tip of an optical fiber. Monitor the output guide and the beam through lenses. When aligning the laser beam direction and external optics, observe the laser with an ITV camera such as silicon-visicon to detect infrared rays.

3.6 Handling 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 submounted on a heat sink, and mirror facets are exposed to the air. Special care is required because of this structure:

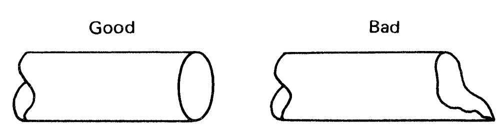
(1) Never touch the bonding wire on the upper part of a device.
(2) Prevent mechanical contact which will peel the chip from the heat sink or deteriorate device properties such as beam divergence, far field pattern, and reliability.
(3) Handle devices in a clean atmosphere to keep mirror facets free from dust or becoming scratched, to prevent degradation of optical output power and far field pattern.
(4) Handle devices by the copper heat sink. Do not drop devices, and prevent other mechanical shock.
(5) Do not process or deform a heat sink.
(6) Use an adequate thermal radiator for mounting devices. The temperature of an LD chip rises greatly, due to high current density, unless adequate heat sinking is provided. This precaution prevents lower optical output power and device deterioration. Note the following precautions in using a thermal radiator:
   (i) Never use silicone grease, which can creep up and adhere to mirror facets, resulting in decreased optical output.
   (ii) Use a copper or aluminum plate thermal radiator larger than $30x40x2mm^3$.
   (iii) Polish the thermal radiator surface to achieve thermal conductivity with the device heat sink, and finish the surface to keep bump, twist or bend below 0.05mm.
   (iv) Chamfer all screw holes. The diameters of chamfered holes should be smaller than that of the screw cap.
   (v) When mounting a device to a radiator, prevent the device from being turned by screwing down, and prevent the chip from contacting the thermal radiator.
(7) Soldering:
   Note the following preventive measures when soldering the electrode ribbon of a device to the circuit:
   (i) Do not exceed a heat sink temperature of 80° C. Finish the soldering process within 30 seconds, using a low melting point solder.
   (ii) Use a fine-tipped, commercially available soldering iron, or a common soldering iron with copper coil around the tip, and ground the tip of the iron. A battery operation type is recommended.
   (iii) Do not allow solder to flow into the pad of the bonding wire.
   (iv) Do not allow scattered flux to adhere to mirror facets.
   (v) Do not wash out flux after soldering, because it contaminates mirror facets.
(8) Hermetic seal.
   Hermetically seal a device to extend its life. As noted previously, the 400 type is not recommended for commercial applications.

3.6.2 500 Type (B Type)

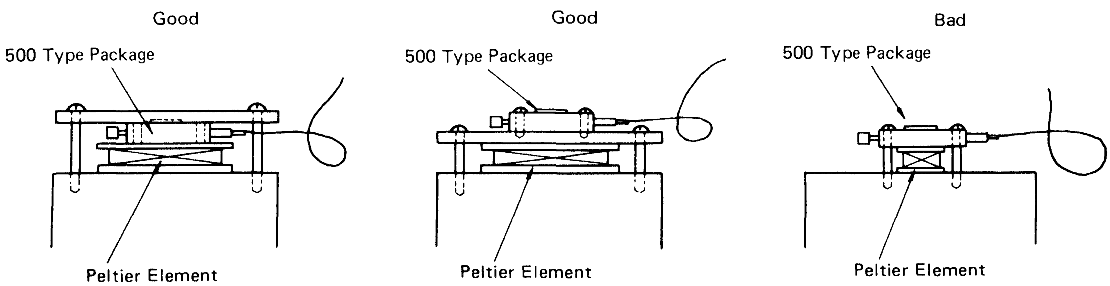
The 500 type package is designed for fiberoptic communications, and is provided with an optical output fiber and a monitor output guide (glass rod).

The LD chip is mounted on a heat sink, with fiber and chip aligned before it is hermetically sealed. Take the following precautions in handling this device type:

(1) Excessive force to an optical fiber disconnects the fiber, or causes partial deforming. Do not pull or twist the fiber, or bend it within a 30mm radius.
(2) Excessive stress between the package and the optical fiber should be avoided to prevent a fiber from breaking or falling out and reducing optical output. Lift both package and optical fiber simultaneously to prevent bending the fiber bottom.
(3) Avoid damaging or contaminating a monitor output guide. Do not apply excessive stress on the monitor guide screw when attaching an external monitor PD, which breaks the monitor glass. Torque should be 1 ~ 2kg·cm.
(4) Preserve hermeticity by avoiding bending or pulling stress to pins.
(5) Do not process or deform a package.
(6) Processing the optical fiber:
   To prevent loss of optical output or coupling efficiency, follow the instructions given below in processing the fiber tip.
   (i) Remove an appropriate length of nylon jacket from the fiber tip with a proper stripper.
   (ii) Remove the fiber coating remedy from the peeled fiber with acetone.
   (iii) Scratch the cutting point of the fiber with a diamond cutter.
   (iv) Hold the fiber tip with tweezers, bend and snap, so that the tip surface is flat as shown below.



(7) Mounting devices on a thermal radiator:
   (i) When mounting a device on a radiator, screw torque should be 1 ~ 2kg·cm. Less torque may result in excessive thermal resistance, and excessive torque may damage the diode.
   (ii) Use a 2mm diameter screw, and secure with spring washers and lock paint applied to tapping holes or to nuts.
   (iii) When mounting a peltier element between a laser package and a thermal radiator, avoid deforming stress applied to the package which can reduce device reliability.
   (iv) Follow instructions described in section 3.6.1 (6).



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

(1) Do not directly touch the surface of a window glass. Contamination and mars on the surface result in lower optical output and distorted far field pattern. Contamination can usually be wiped away using ethanol and a cotton swab.

(2) Do not cut the cap roughly, which can crack the window glass and deteriorate package hermeticity.

(3) Bending the bottom of the lead wire will also crack the glass area and deteriorate hermeticity.

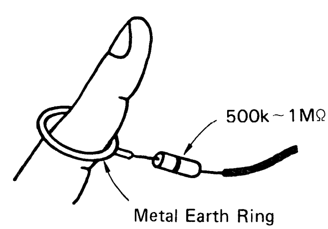
(4) Never cut, process, or deform a package.

(5) Mounting devices on a thermal radiator:
Laser diodes must be mounted on a thermal radiator to achieve adequate heat sinking with minimum mechanical stress applied to packages. Further details regarding thermal radiators, are given in section 3.6.1 (6).
  (i) When screw mounting a device on a radiator, the torque should be 2.0±0.5 kg·cm. Less torque can result in excessive thermal resistance; more torque may damage the diode.
  (ii) Use 2 or 2.5mm diameter screws, spring washers, and apply lock paint.
  (iii) Do not solder a package to a thermal radiator which may create excessive temperature applied to the inside package assembly, or reduce hermeticity.
  (iv) When mounting a device to a thermal radiator, avoid touching or hitting the cap to prevent contamination or cracking of the window glass.
  (v) Do not use heat sink grease which may contaminate the window glass.

3.7 Handling Instructions

(1) Prevent electrostatic damage by taking the following precautions in handling devices and designing application circuits:
  (i) Set the electric potential of working surfaces the same as the power supply ground.
  (ii) Ground the operator by using a metallic ring with a resistance of 500 kΩ~1MΩ, connected to the same potential as the power supply ground.
  (iii) Do not operate high frequency equipment near a device, which can generate a surge. The lead wire of the drive circuit may pick up surge electricity and destroy the induction electric field in the device.

(2) Operating laser diodes:
  (i) Mount devices on a thermal radiator. Radiator size is dependent upon operating time and output power. When conditions are not set, use a 50x50x2mm³ copper or aluminum radiator.
  (ii) Hitachi recommends a drive circuit with an APC (Automatic Power Control) function. However, a simple constant current source is recommended for basic performance measurement, because adjustment of a complex circuit can cause device damage.



  (iii) Before connecting an LD with power applied as shown in Fig. 10, set the output level at minimum. Before disconnecting an LD from the power supply, set the output voltage at minimum, and turn off the main switch.

Light-current characteristics and far field pattern descriptions accompany diode devices.

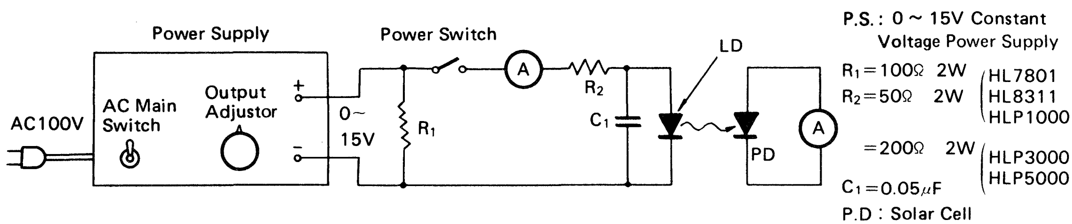


Figure 10 Simple Drive Circuit

(3) Experimental LD drive circuit:
The optical output power of an LD is influenced by ambient temperature fluctuation. An APC (Automatic Power Control) function is generally recommended in the drive circuit to achieve stable operation. The function of monitoring the beam and feeding it back to the drive current is recommended to achieve constant optical output power against temperature change. Fig. 11 shows an example of experimental APC circuits. A_1 provides constant voltage. A_2 converts photo voltaic current of PD to voltage. By adjusting R_1, optical output power of the LD is controlled to obtain the desired value through a differential amplifier (A_3). The integral circuits of C_1 and R_2 are slow starting to prevent surge input from the power supply. Terminal T applied at 1V provides a standby function of switching off the drive circuit to minimize idling current when the LD is not in operation. Fig. 12 shows that optical power output stability is achieved while diode case temperature varies significantly.

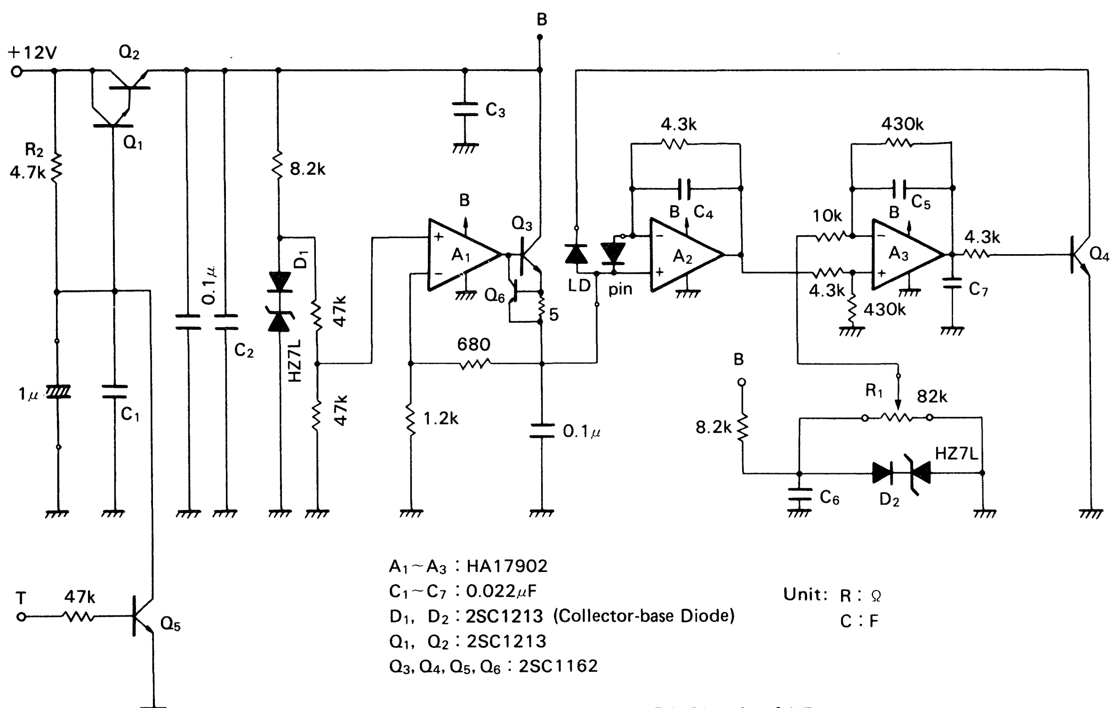


Figure 11 Experimental APC Circuit of LD

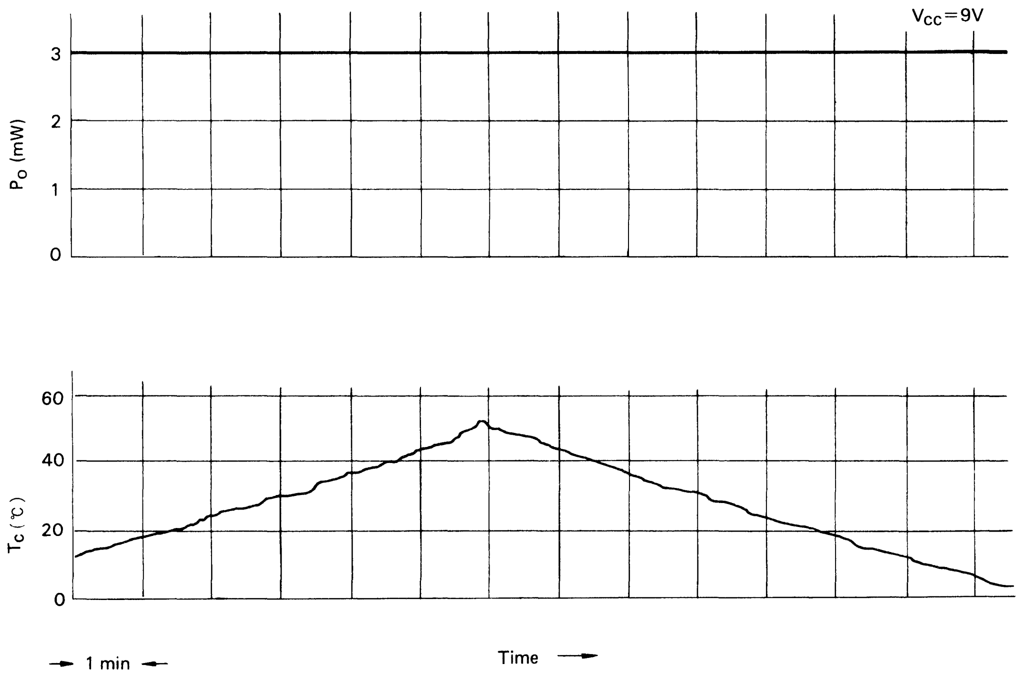


Figure 12 Temperature Characteristics of LD with APC Circuit (HL7801E)

3.8 IRED Package Handling Instructions

3.8.1 T Type and R Type (Open-air Types)

An IRED chip is exposed to the air for convenience of coupling to the fiber or external optics. The following particular precautions must be taken for these packages:

(1) Never touch the extremely thin, bare gold bonding wire.

(2) Never apply mechanical stress to an IRED chip, which peels the chip from a diode base, and deteriorates properties and reliability. Do not contaminate the chip surface to deteriorate 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 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 deteriorate due to 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, although a $20x30x20mm^3$ plate of copper or aluminum is usually recommended.

(ii) Polish the thermal radiator surface to achieve adequate thermal conductivity with the device heat sink. Finish the radiator surface to keep bump, twist or bend below 0.05mm.

(iii) Use of silicone grease is absolutely prohibited as described in section 3.6.1 (6) for 400 type LD heat sink.

(5) Soldering:

(i) Use a low melting point solder (below 200° C).

(ii) Soldering operation should be performed in 10 seconds, below 260 °C.

(iii) Scattered flux should not be allowed to adhere to the chip surface.

(6) Hermetically seal a device to extend its life.

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

Moisture protection provided in the hermetically sealed packaging of these types permits more latitude in handling devices. However, precautions must be taken as follows:

(1) Maintain a clean glass surface to achieve uniform optical output.

(2) Do not process or deform packaging. Avoid nipping the cap, or forcibly bending the bottom of a lead wire which cracks the glass area, and deteriorates hermeticity.

(3) Mount devices on a thermal radiator to achieve higher reliability. Do not apply silicone grease to the contact area of the thermal radiator in heat sinking. The material creeps up to adhere to the window glass as temperature increases, resulting in degradation of optical properties and output power. Consult section 3.8.1(4) for further details.

(4) Soldering:
   (i) The soldering point must be 1.5mm or more distance from the bottom of the lead wires.
   (ii) Use a low melting point solder (below 200° C).
   (iii) Complete soldering operation in 10 seconds, below 260° C.

3.8.3 F Type (Hermetically Sealed)

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

Both fiber rod and 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. Use the following precautions in handling these devices:

(1) Never touch the tip of the fiber rod, which contaminates the tip and reduces optical output power.
(2) Do not apply mechanical stress to the bottom of a ceramic ferrule and a lead wire, which deteriorates hermeticity and optical coupling efficiency.
(3) Mount devices on a thermal radiator to extend device life. Refer to section 3.8.1(4).
(4) Follow the instructions described in section 3.8.1(5) for soldering operations.

OPERATIONAL FEATURES AND RELIABILITY

1. LD AND IRED OPERATION PRINCIPLES

1.1 Emitting Principles

Each electron of atoms and molecules holds a specific descrete 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 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 processes of electron transition, as shown in Fig. 14:

(a) Resonant Absorption: An electron transits from the stable low energy level E_1 to the higher energy level E_2 with absorbing light.

(b) Spontaneous Emission: An electron transits from the high energy level E_2 to the more stable and lower energy level E_1. At the same time, the energy balance of $|E_2—E_1|$ is emitted light. Since each electron in level E_2 transits independently, light is emitted randomly, or out of phase. Such light is referred to as incoherent light—a typical characteristic of spontaneous emission, or IRED light. The phenomenon occurs at random, and is independent of phase or direction of each light.

Under thermal equilibrium, the probability is higher that electrons will exist in the lower level E_1, than in the higher energy level E_2. Therefore, electron transition to higher energy level ($E_1 \rightarrow E_2$), by absorbing light is more probable than light emission as shown in Fig. 14(a). In order to emit light, electrons must exist in E_2 with high probability, which is referred to as inversed population. Forward driving current creates this condition in IRED—referred to as current injection.

(c) Stimulated Emission: The electrons in the higher energy level E_2 are forcibly transferred to the lower energy level E_1 by incident light. The light generated is 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. Light due to stimulated emission is referred to as coherent light.

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

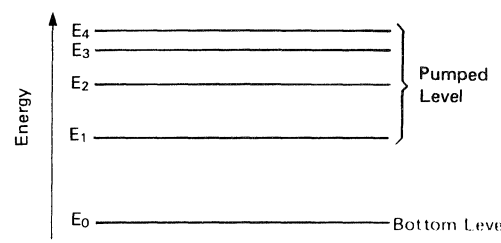
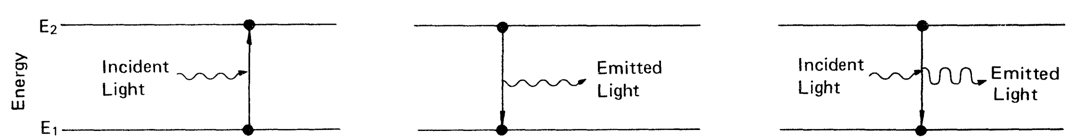


Figure 13 Energy Level



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

Figure 14 Transition Process

Figure 15 shows a Fabry-Pérot resonator—the most fundamental optical resonator. Basic LD structure is also indicated, showing both surfaces of the chip with reflection mirrors by cleaving.

Light heading toward the reflection mirror for incident spontaneous emission light is amplified by stimulated emission, and returns to initial position after reflection. This process accompanies the 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 LD, and at the condition where gain and loss are balanced, initial light intensity becomes equal to that returned. This condition is referred to as threshold. The laser oscillates above the threshold when there is sufficient gain increase.

Injection pumping basically takes place at the p-n junction in a semiconductor laser diode. Semiconductor crystals can obtain a higher gain than gas lasers, due to the higher density of atoms available in a cavity (e.g., HeNe). Therefore, lasers can oscillate with a short resonant cavity of 300 μm and low reflectivity of 30%.

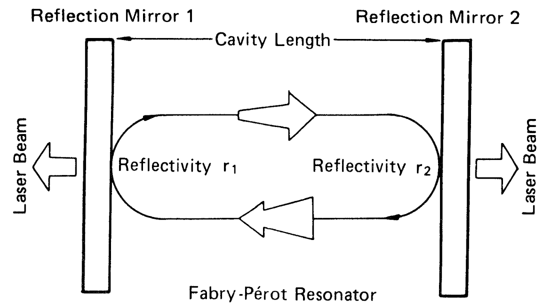


Figure 15 Fabry-Pérot Resonator Fundamental Structure

1.2 Structure of GaA1As LD

The p-type active layer is processed first, in which stimulated emission enforces optical amplification as shown in Fig. 16(a). The p-n junction is made to inject minority carriers (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 the p-n junction (hetero isolation junction), the injected carriers are confined within the p-type active layer. This carrier confinement facilitates population inversion, and light emission intensity increases.

The active layer of GaA1As laser diodes is made of GaAs or Gal-yAlyAs (see Fig. 17). The thickness of the layer is 0.05 ~ 0.2 μm. P-type Gal-xAlxAs and n-type Gal-xAlxAs (x > y) sandwich the active layer (x and y here are the mixture ratio of aluminum).

When x is 0.3, the band gap of the sandwich layers is 1.8eV and there is a balance of 0.4eV against 1.4eV of GaAs. When forward bias is applied, the hetero barrier confines carriers within the 0.05 ~ 0.3 μm active layer, carrier population is inverted, and gain increases. The refractive index of GaAs is a percentage higher than Gal-xAlxAs, which confines the generated light within the GaAs active layer. Light penetrating into AlxAs layer is not absorbed, because of its wide band gap; therefore, the laser oscillates effectively (see Fig. 16). The thinner GaAs layer can use a lower threshold current density for laser oscillation—as low as 1 ~ 2 kA/cm² to realize continuous oscillation (CW) stabilized at room temperature.

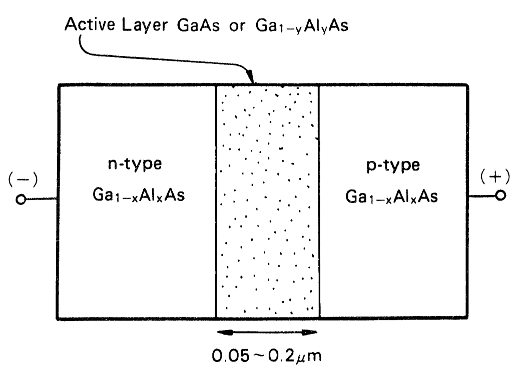


Figure 17 GaAlAs DH Structure LD

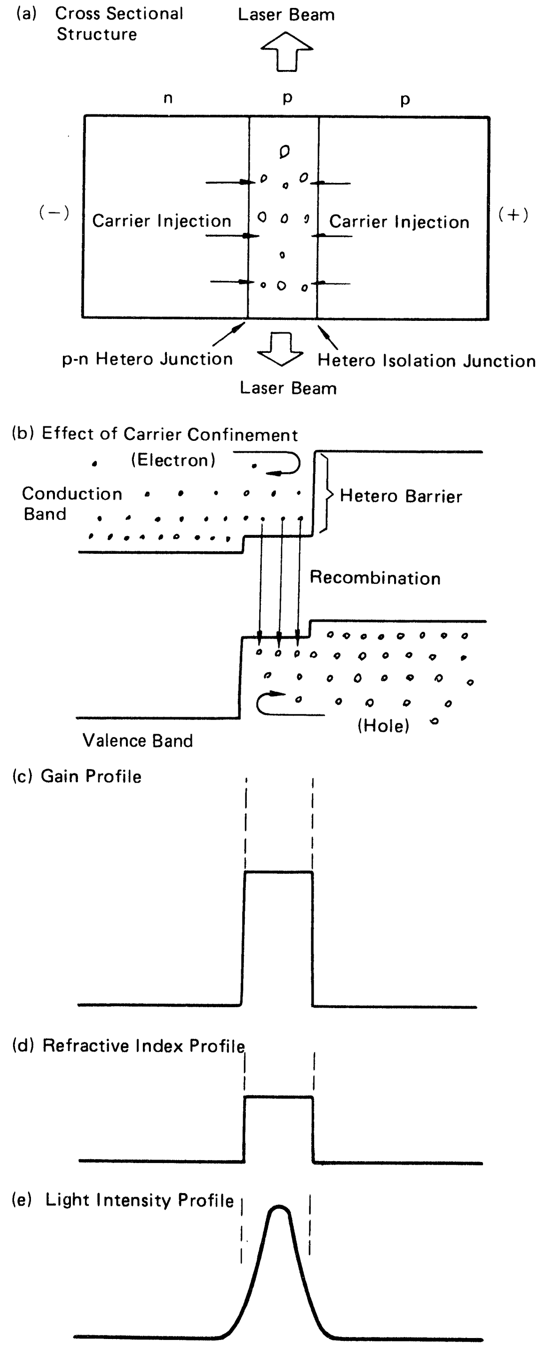


Figure 16 Operation Principle of Double Hetero Junction LD

1.2.1 Lasing Mode

Under laser oscillation, a light standing wave forms, with wavefront parallel to the 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 the cavity length (z direction). Transverse mode expresses the condition of the perpendicular axis to the cavity length direction. The transverse mode is divided into perpendicular transverse mode which is perpendicular to the active layer, and parallel transverse mode which is parallel to the layer.

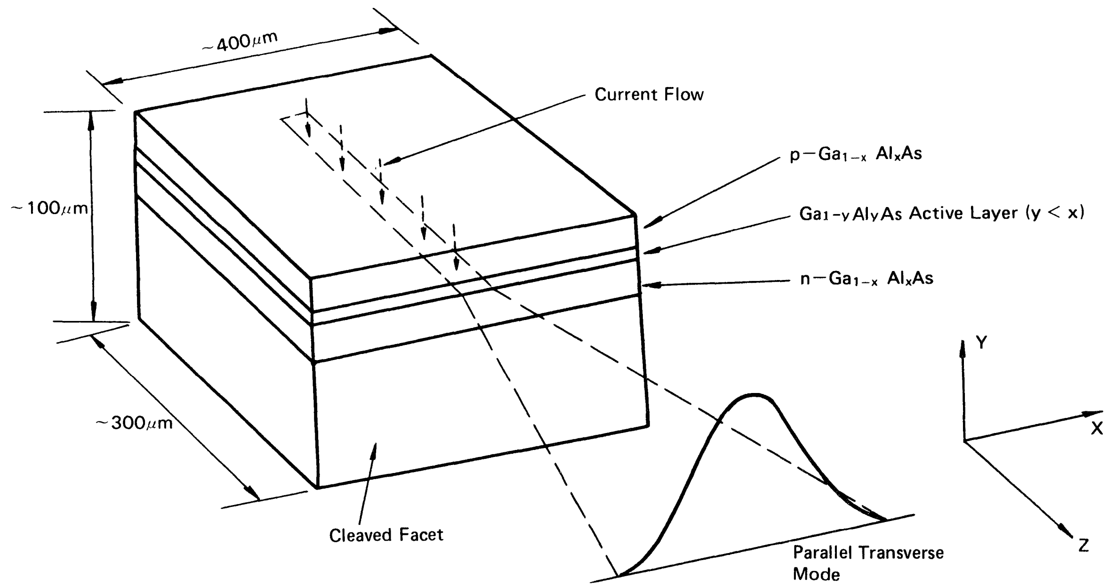


Figure 18 Lasing Mode

(1) Longitudinal Mode

Fig. 19 shows that a standing wave of the half wavelength multiplied by an integer q forms in the direction of the 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:

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

The half wavelength is expressed as:

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

As described previously, the half wavelength multiplied by an integer q equals the cavity length L:

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

In semiconductor laser diodes, when λ is 850nm, n is 3.5, and L is 300 μm, q is approximately 2500. This q is referred to 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 wavelength, cavity resonance can occur at multiple wavelengths. The particular wavelength area where the cavity gain is at maximum is then chosen to have a stable standing wave.

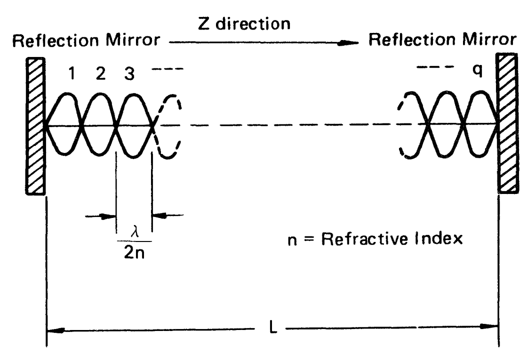


Figure 19 Longitudinal Mode

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

(2) Perpendicular Transverse Mode

In a GaAlAs laser diode, the active layer is sandwiched by hetero junction (Fig. 20). Light is confined within the active layer because of the slightly higher refractive index than that of the sandwiched layer. The amount of light confined depends upon the thickness of the active layer. A thicker layer confines more light. However, thinner layers cause this light to penetrate into the sandwiched layers.

The width of laser beam divergence depends upon the thickness of the active layer; e.g., an active layer of 0.3 ~ 0.4μm, creates the narrowest width. At this width, the radiation angle of the laser beam emitted from the cleaved facet is widest, as shown in Fig. 21. Generally, the radiation angle of a laser beam from the device is extremely wide because the laser beam profile width in the device is equal to or less than the lasing wavelength. This characteristic is in contrast with characteristics of conventional gas lasers, or solid state lasers.

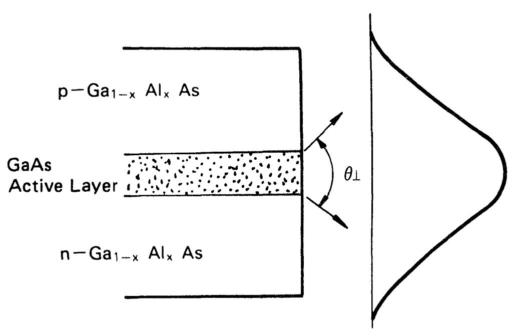


Figure 20 Perpendicular Transverse Mode

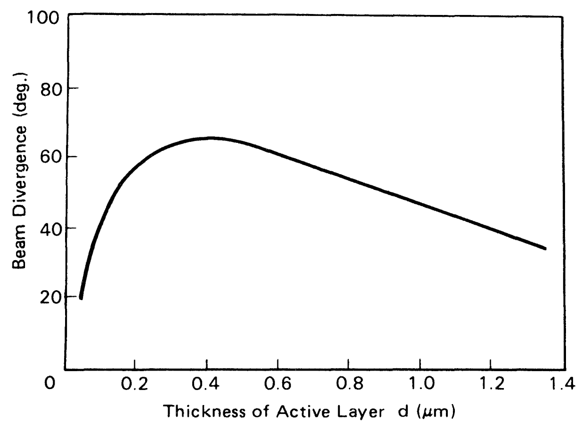


Figure 21 Thickness of Active Layer – Beam Divergence

(3) Parallel Transverse Mode

A waveguide must be formed to guide the light in the active layer in parallel to the junction. When the current injection is limited to a sufficiently narrow region with a full cavity length, laser oscillation occurs in the region as shown in Fig. 18. Fig. 22 indicates the basic stripe structure which can limit current pass only.

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

Fig. 23(a) describes a CSP (Channel Substrated Planar) laser. Outside the channel fabricated in the base, the light penetrating from the active layer reaches the base and suppresses lasing due to absorption loss.

Fig. 23(b) describes a BH (Buried Heterostructure) laser. In both perpendicular and parallel directions, the double-heterostructure is made.

Structural waveguides stabilize the single fundamental tranverse mode. All Hitachi LDs have a stable single transverse mode.

HLP1000, HLP3000, HL7801 and HL8311 series employ the same material—GaAlAs, as described above. HLP5000 series employ InGaAsP in an active layer, and InP in sandwiching layers. Fundamental lasing principles and mode are identical.

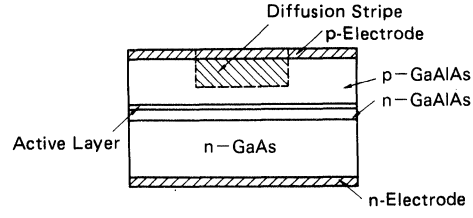


Figure 22 Basic Stripe LD

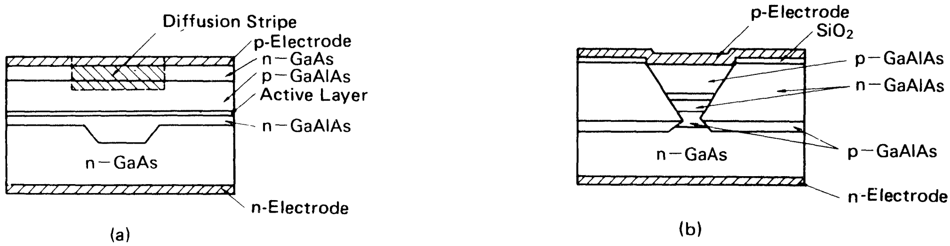


Figure 23 Various Stripe Laser Built-in Waveguide

1.3 IRED Structure

High efficiency of current-light conversion is achieved using GaAs crystals—a direct transition type material. Hitachi shapes the chip surface hemispherically to optimize emitted light.

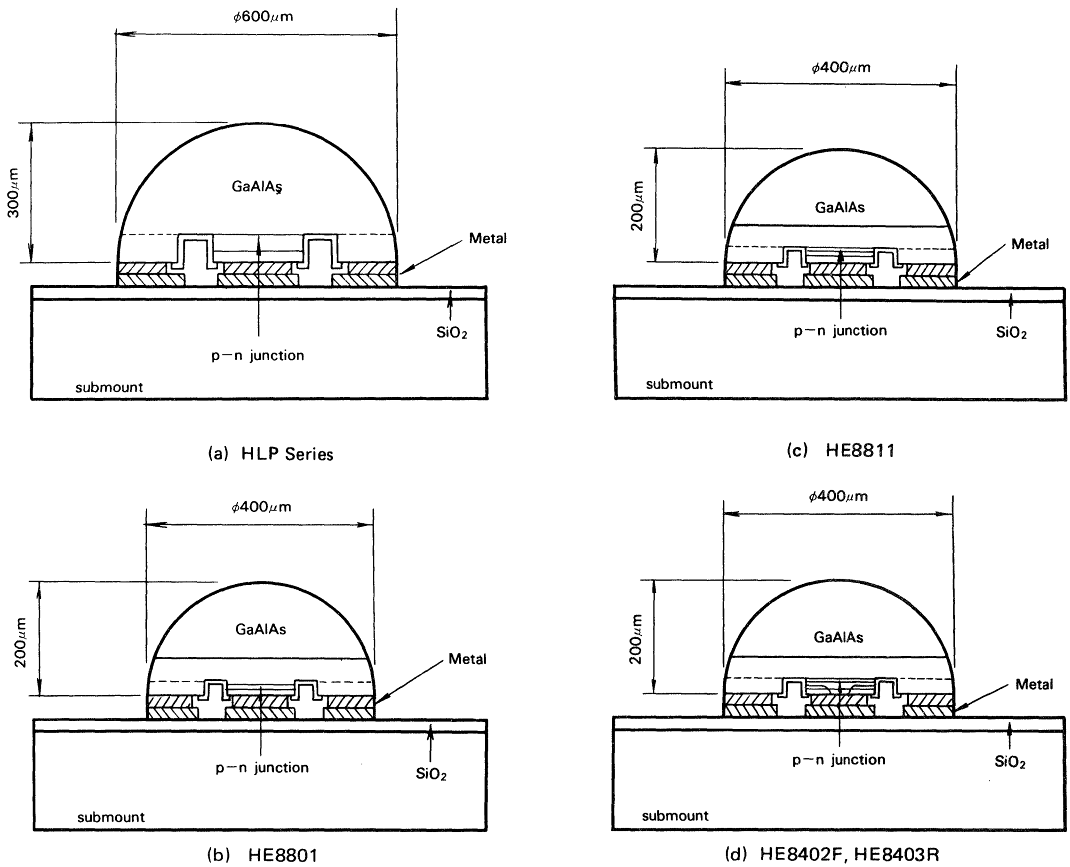


Figure 24 IRED Structure

1.3.1 Heterostructure

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

Hitachi IREDs are divided into two structures: SH (Single Hetero) structure with one hetero junction, and DH (Double Hetero) structure with two hetero junctions as shown in Fig. 25(b). Table 5 shows the structure of each type number.

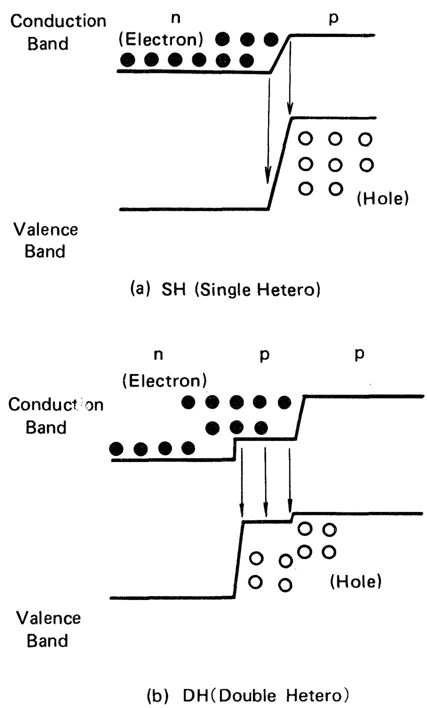


Figure 25 Junction Structure

Table 5 Structure of Hitachi IRED

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

1.3.2 Dome Type Chip

Hitachi IREDs are all dome shaped to maximize light output which is contingent upon factors of air and refraction at the boundary of a GaAlAs chip surface. Since the refractive index of GaAlAs is about 3.4, light output power hitting the crystal surface with an incident angle of more than 17 degrees will be reflected within the chip (Fig. 26). With a dome shaped chip surface, emitted light from the center area of a chip will hit the surface with an incident angle of 90 degrees—minimizing refractive loss (see Fig. 27). Table 6 shows the dome and junction diameters of each part number.

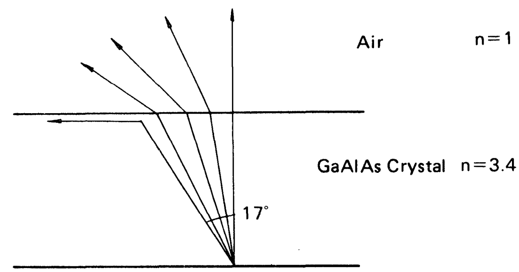


Figure 26 Light Refraction at Boundary Layer

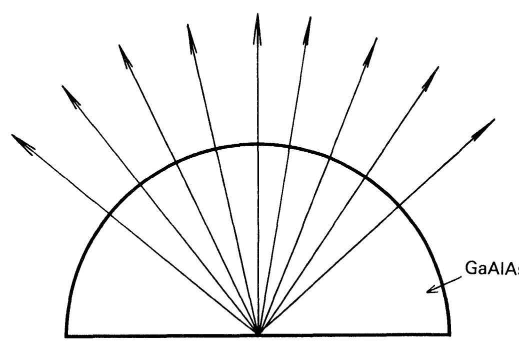


Figure 27 Light Radiation by Hemispherical Shape

Table 6 Dome Diameter and Junction Diameter of Each Part Number

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

2. OPTICAL AND ELECTRICAL CHARACTERISTICS

2.1 Fundamental Characteristics Measurement

2.1.1 Light-current Characteristics

(1) LD Light-current Characteristics

A photo detector of proper response and photo sensitivity is required for measuring LD optical characteristics.

The measurement setup for light-current characteristics under CW operation is shown in Fig. 28. A photo cell of more than 20mm diameter is recommended to provide sufficient photo sensitive area for taking in full light power without a lens.

Suitable distance between a photo cell and an LD chip is 5 ~ 10mm. Since photo voltaic sensitivity differs within devices, each photo cell must be calibrated with a standard cell, and R_2 must be adjusted before using the setup. A device must be mounted on a copper or aluminum heat radiator approximately $30x40x2mm^3$ for CW testing, because heat generated from a chip deteriorates device characteristics.

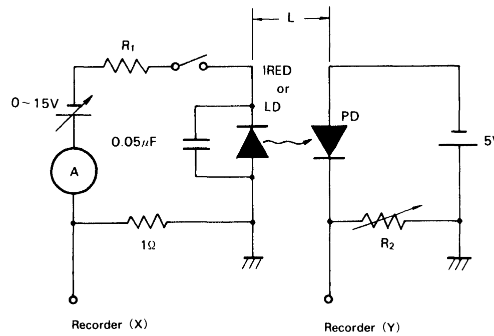
The measurement setup example for light-current characteristics under low frequency up to several 10 kHz with low duty (1%) pulsed operation is shown in Fig. 29, and employs a PIN photo diode as photo detector. Sample measurement of photo voltaic current should be performed when it has stabilized.

The measurement setup for fast-pulse response employs a high-speed PIN photo diode of APD (Avalanche Photo Diode) which can respond up to several GHz (Fig. 30).

Optical output pulse delay time appears against drive current pulse, when DC bias is set below the threshold. Delay time depends on the bias point and temperature as shown in Fig. 31.

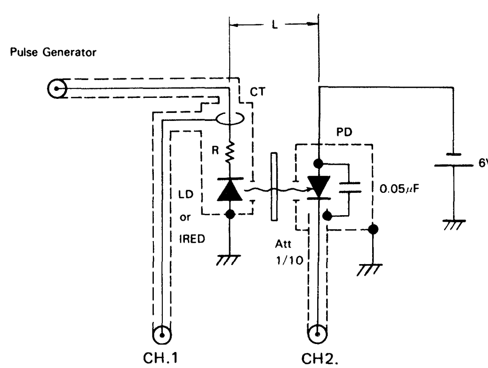
A typical light-current characteristic of HLP1400 is shown in Fig. 32. Average threshold current I_{th} is about 60mA at room temperature, and slope efficiency η is approximately 0.3mW/mA. Although there is some light emission at the bias point below the threshold current, it is not laser light, but spontaneous emission—as in LEDs. Optical output power at the threshold current is less than 0.2mW for HLP1400.

Temperature characteristic T_0, representing temperature dependence of the threshold current, is between 160K and 250K (typically 200K). Slope efficiency tends to become lower as temperature rises (Fig. 33).



D : Large area Si-Solar Cell
R_1 = 10~50Ω for HLP1000, HL7801, HL8311
= 100~300Ω for HLP3000, 5000
R_2 ≃ 20Ω for 10mV output at 1mW optical power
L ≃ 1 cm

Figure 28 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 HLP3000, 5000 and IRED
L ≃ 6mm

Figure 29 Measurement Setup for Light-Current Characteristics under Low Frequency Pulsed Operation

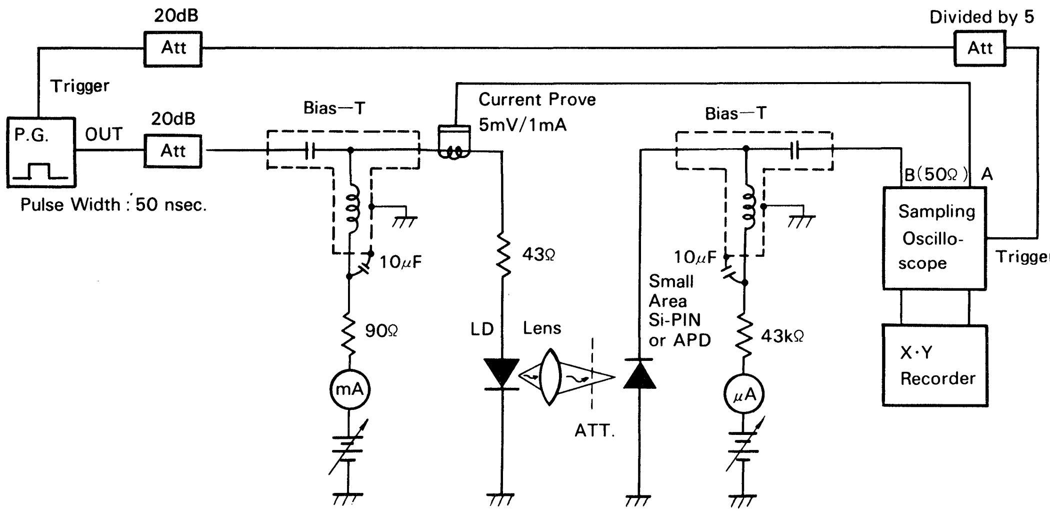


Figure 30 Measurement Setup for Fast Pulse Response

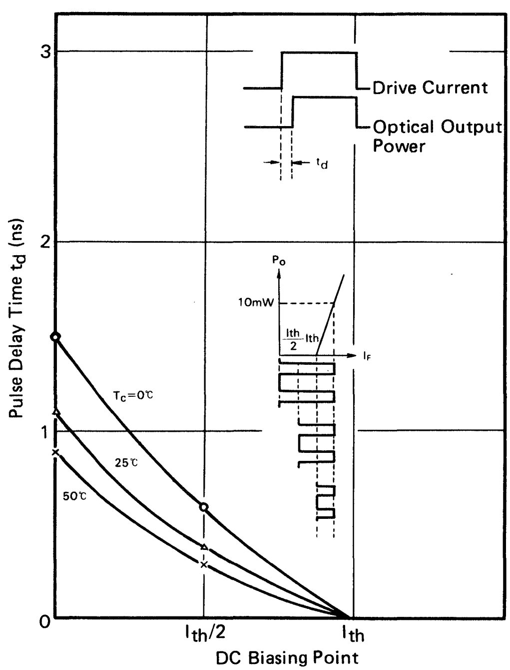


Figure 31 Bias Dependence of Pulse Delay Time (HLP1400)

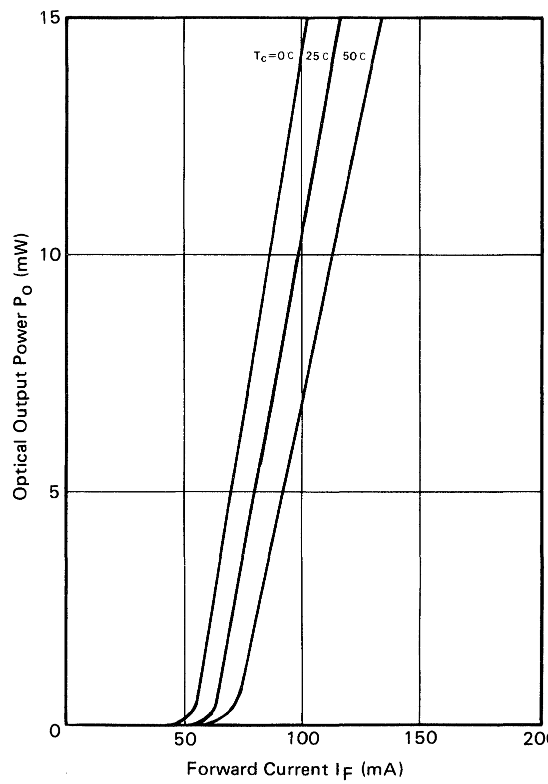


Figure 32 Light-Current Characteristics (HLP1400)

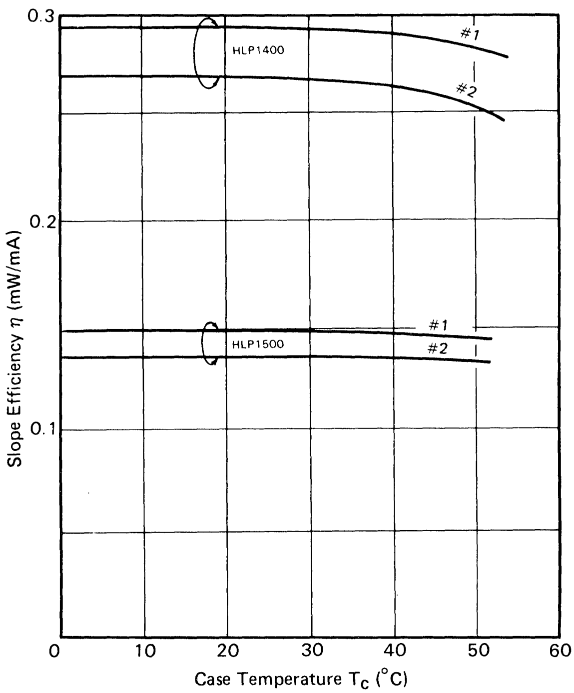


Figure 33 Temperature Dependence of Slope Efficiency

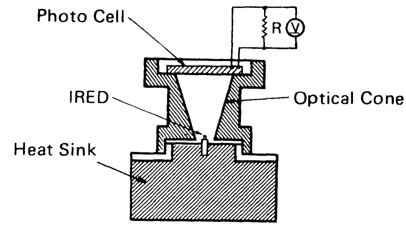


Figure 34 Measurement of Optical Output Power (P_O) under CW Operation

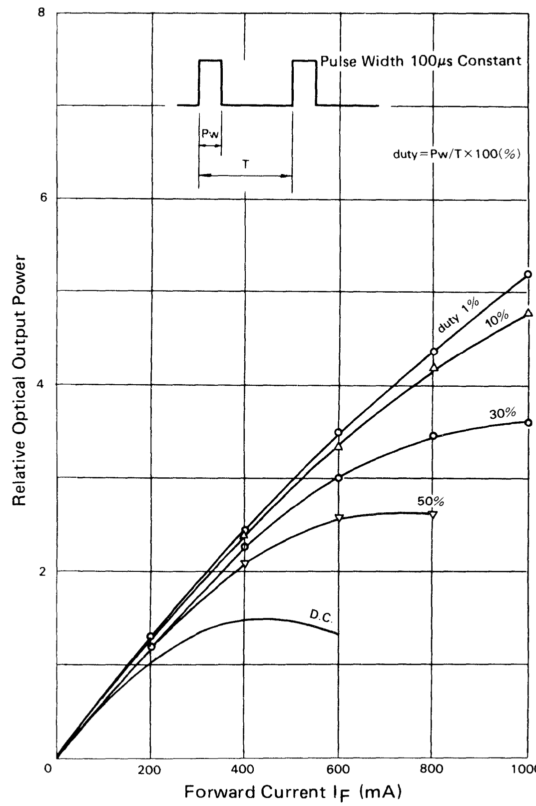


Figure 35 Light-Current Characteristics under Pulsed Operation

(2) IRED Light-current Characteristics

Fig. 28 shows a measurement setup for light-current characteristics used under CW operation. An optical cone described in Fig. 34 is required for leading whole light to a photo cell. Setup calibration 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 that is larger than 30x40x2mm^3 for CW testing, due to heat generated from the chip itself which greatly reduces optical output power.

Fig. 29 measurement setup is also used for light-current characteristics under low frequency up to several 10 kHz with 1% pulsed operation. The light-current characteristics of HLP30RG under various pulsed operation is shown in Fig. 35.

Since junction temperature rise is lower under pulsed operation, due to a lower average current, light-current linearity and peak optical output power are improved compared with DC operation.

Note that peak pulse current should not exceed the destructive level described in section 2.2.4. Confirmation of device degradation under the specified pulse condition is recommended before actual use.

2.1.2 Far Field Pattern (FFP) Measurement

FFP is the light intensity profile measured in two directions as a function of angle: parallel and perpendicular to a device (the active LD layer, and arbitrary for IREDs). The measurement setup for FFP is shown in Fig. 36, which employs the same drive circuit as light-current characteristics measurement under CW operation.

Use a PIN photo diode with a smaller photo sensitive area, or an APD for photo detector. Distance between the detector and the LD is approximately 10cm. Set the emitting point of the LD at the center of the turntable. Use of a potentiometer is effective in translating the rotation angle into voltage.

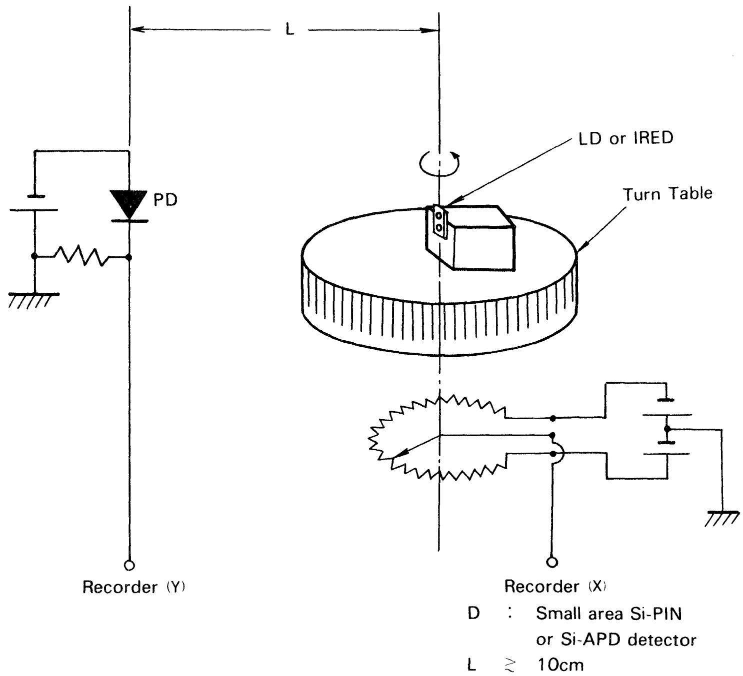


Figure 36 Measurement Setup for Far Field Pattern (FFP)

(1) LD FFP

HLP1000 Series FFP is shown in Fig. 37 for various power output levels. HLP Series lase with stable transverse fundamental mode, with single peak FFP close to the gaussian curve. FFP grows proportionally to optical output power, and has no peak point steering or light distribution width change within the maximum ratings.

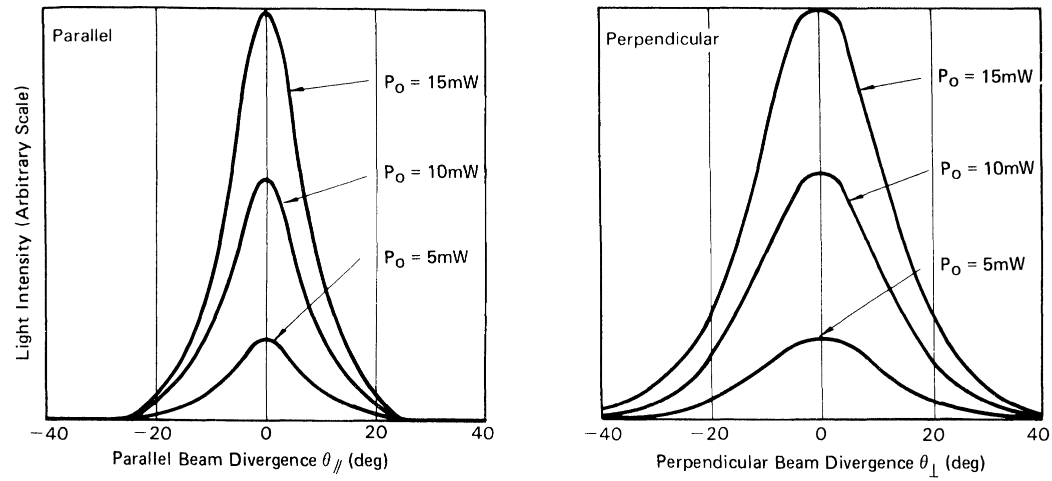


Figure 37 Light Dependence of Far Field Pattern (FFP) (HLP 1000 Series)

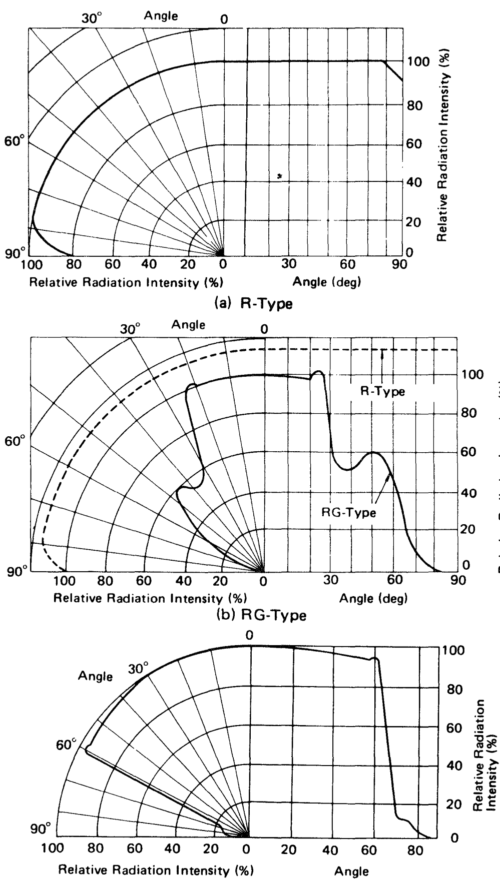


Figure 38 IRED Far Field Pattern (FFP)

(2) IRED FFP

Since Hitachi IRED chip surfaces are hemispherically polished, the FFP of an IRED R type chip exhibits a flat appearance against the angle, as shown in Fig. 38(a). However, the flat area is limited on RG (Modified TO-18) and SG (Modified TO-46) types due to the cap interference shown in Fig. 38(b) and (c).

2.1.3 LD Polarization Ratio Measurement

Measurement setup for polarization ratio is shown in Fig. 39. An objective lens collimates light emitted from the LD to form a parallel beam. Use of an infrared phosphor plate is helpful to detect light. Choose measuring equipment with an appropriate aperture and photo sensitive area to avoid disturbing the parallel beam input. Polarization ratio is calculated with the maximum and minimum values of a power meter while turning a polarization prism.

Polarization phenomenon of an LD is illustrated in Fig. 40. The electric field oscillates in parallel to the active layer, and the magnetic field oscillates perpendicularly.

Polarization ratio is dependent upon optical output power and numerical aperture. The polarization ratio vs. power output of the HL7801 and HLP1400 Series is shown in Fig. 41(a) and 41(b), respectively. The ratio is greater when optical output power is higher, or when NA (numerical aperture) of an objective lens is smaller. For 600 type packages, the polarization ratio is kept high due to its optical isotropic window glass. Fig. 41(c) shows the light dependence of polarization ratio for HLP3400.

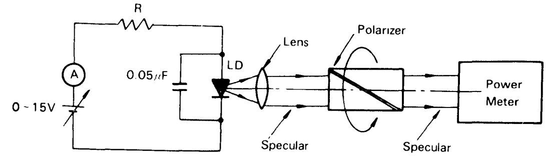


Figure 39 Measurement Setup for Polarization Ratio

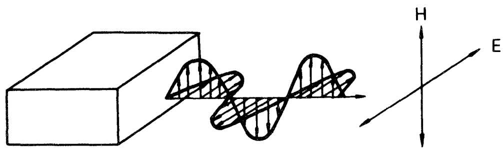
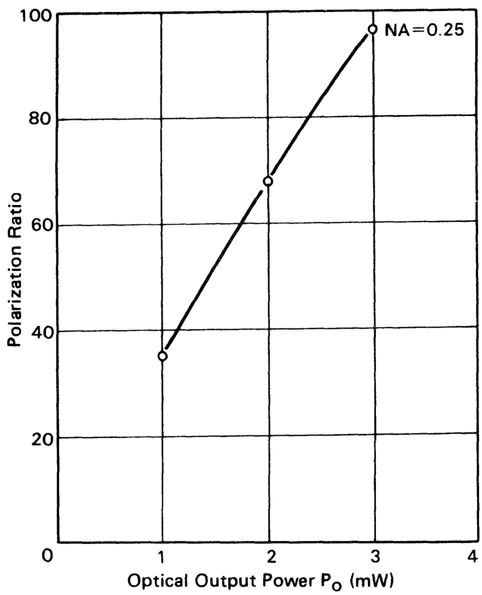
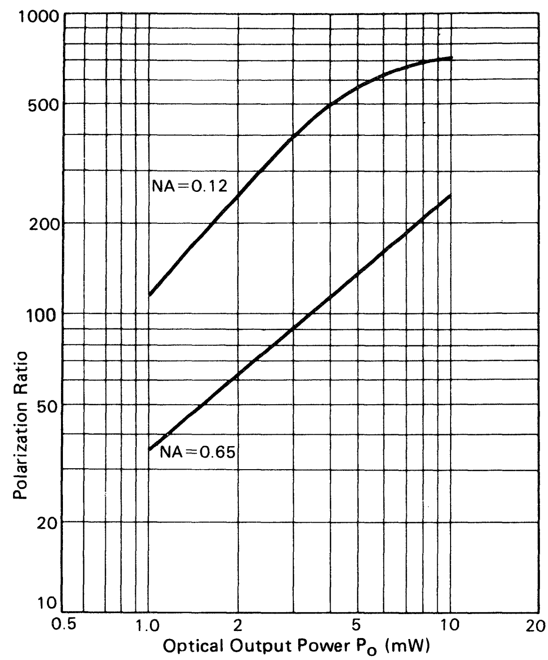


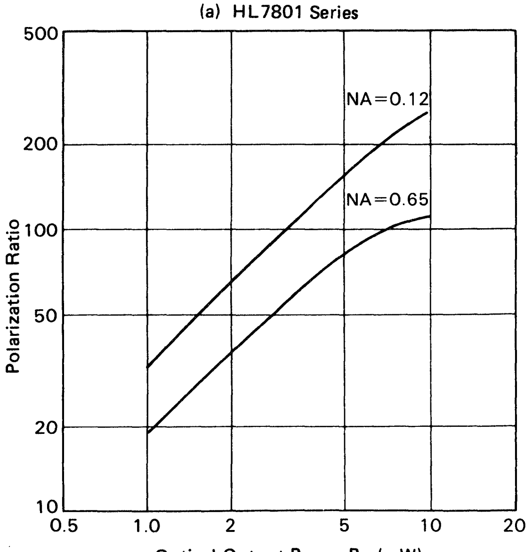
Figure 40 Polarization



(a) HL7801 Series



(b) HLP1400

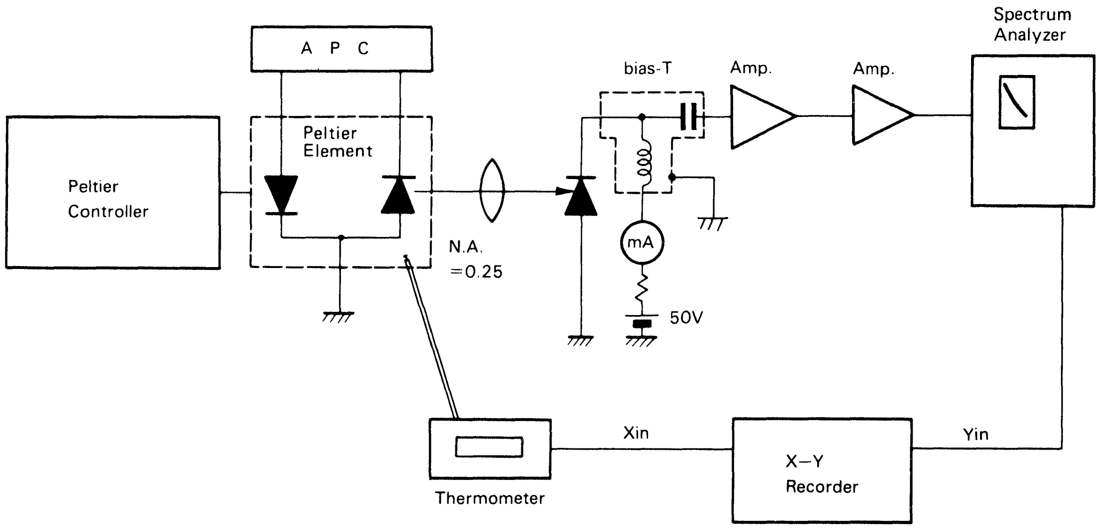


(c) HLP3400

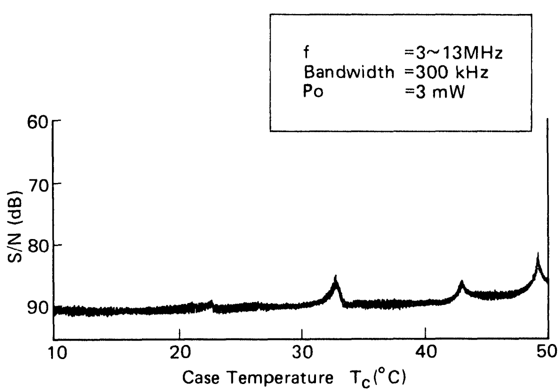
Figure 41 Output Power Dependence of Polarization Ratio

2.1.4 LD Noise Measurement

The measurement setup for LD noise is shown in Fig. 42(2). Set the measurable frequency range according to device application. Fig. 42(b) shows an example of noise characteristics vs. case temperature.



(a) Measurement Setup for Noise



(b) An Example of Noise Measurement

Figure 42 LD Noise

2.1.5 Observation of Radiation Pattern

Observe the radiation pattern with an infrared camera when operating a device under CW and collimating the emitted light to the parallel beam with a lens (Fig. 43). Control the amount of incident light into the infrared TV camera with an optical attenuator (overflow of light into the camera causes halation).

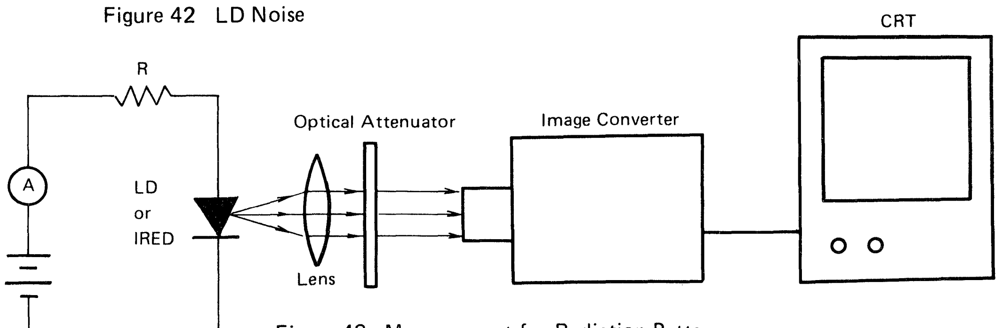


Figure 43 Measurement for Radiation Pattern

2.2 Reference Data

2.2.1 LD Second Harmonic Distortion

The ratio of 200 MHz second harmonic component to 2mWp-p of 100 MHz input signal and optical output power is shown in Fig. 44(a), (b), and (c).

2.2.2 Temperature Dependence of LD Lasing Spectrum

The lasing spectrum hops as the combined result of axis mode number change (0.2 ~ 0.3 nm/° C), and the active layer's refractive index change (≃ 0.05nm/° C) vs. temperature (Fig. 45).

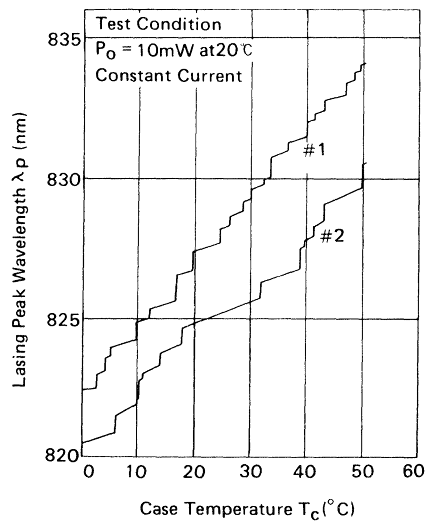


Figure 45 Temperature Dependence of Lasing Spectrum (HLP1400)

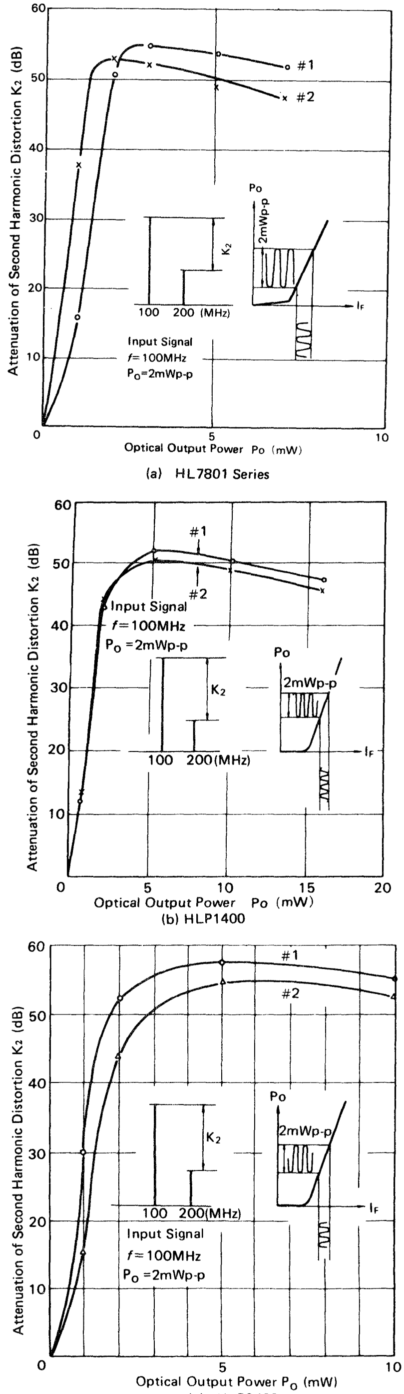


Figure 44 Second Harmonic Distortion of LD

2.2.3 IRED Fiber Coupling Characteristics

Fig. 46 shows launched power vs. fiber dimensions on various IRED with about 5μm gap between a fiber tip and the chip surface.

Fig. 47 shows effective far field pattern for HE8403R as relative intensity vs. horizontal fiber positioning.

Fig. 48 shows coupling stability for HE8402F which fits to the standard connector with a fiber. Reproducibility at multiple coupling trials, and coupling stability at device rotation against a connector, are favorable and within ±0.5dB.

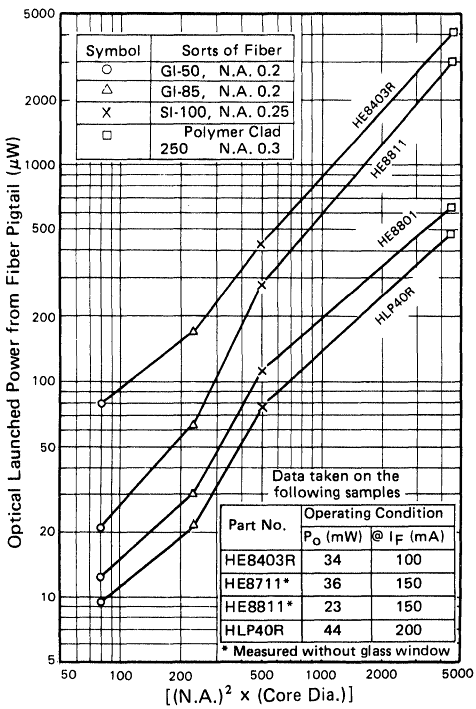


Figure 46 Typical Launched Power Characteristics

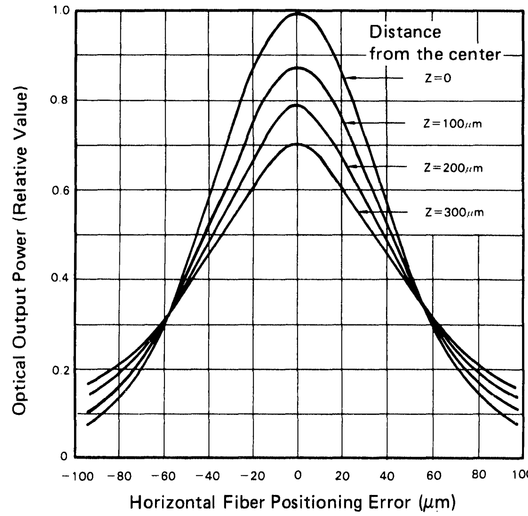


Figure 47 Relative Intensity vs. Horizontal Fiber Positioning

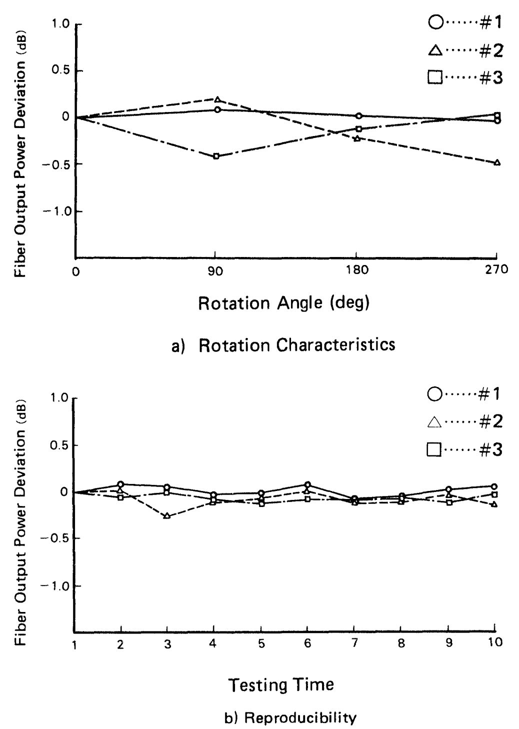
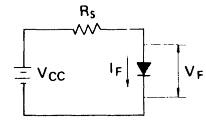


Figure 48 Reproducibility of Fiber Connection

2.2.4 IRED Current Destruction

Absolute maximum ratings should not be exceeded under DC operation. Do not allow excessive current flow, even at switching on, or under pulsed operation. The destruction current value for each product type is shown against pulse width in Fig. 49. Operating current should be below one half of the destruction level, and the value at which the optical output is saturated in the light-current characteristics curve.

Insert series protection resistance R_s to limit excessive current in DC operation. When a constant voltage supply is used, design a drive circuit to use sufficient 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, employ enough series resistance R_s to limit excessive current before a current limit device begins to function.



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)

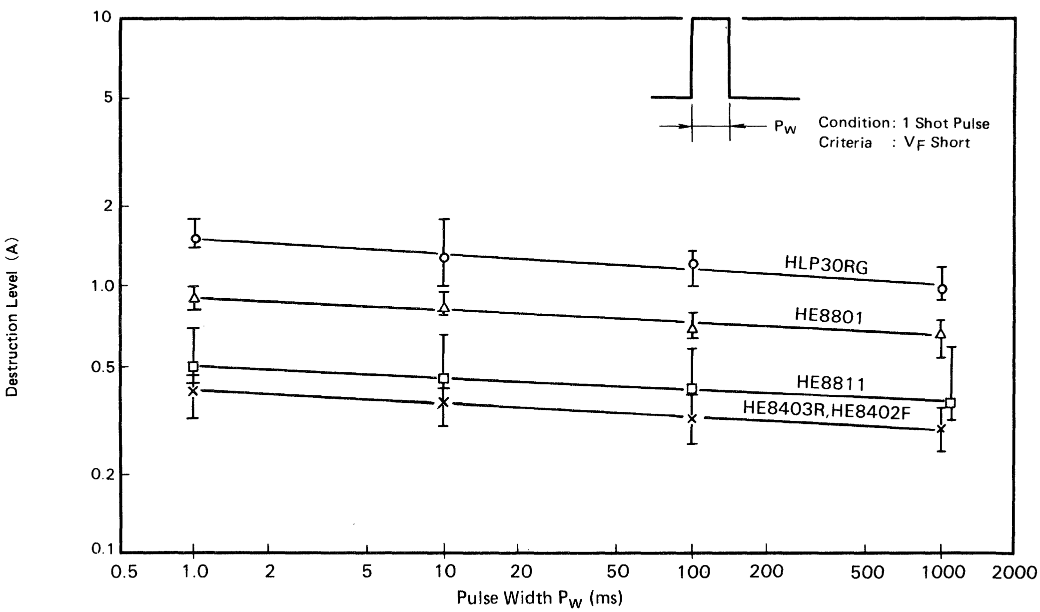


Figure 49 Destruction Level

2.2.5 IRED Thermal Resistance

Optimum heat sink design is required for IRED device life, which is dependent upon junction temperature. 10,000 hours of device life (degraded to one half the initial output power) is expected in operation at T_j=100°C, with an effective thermal radiator (Fig. 50).

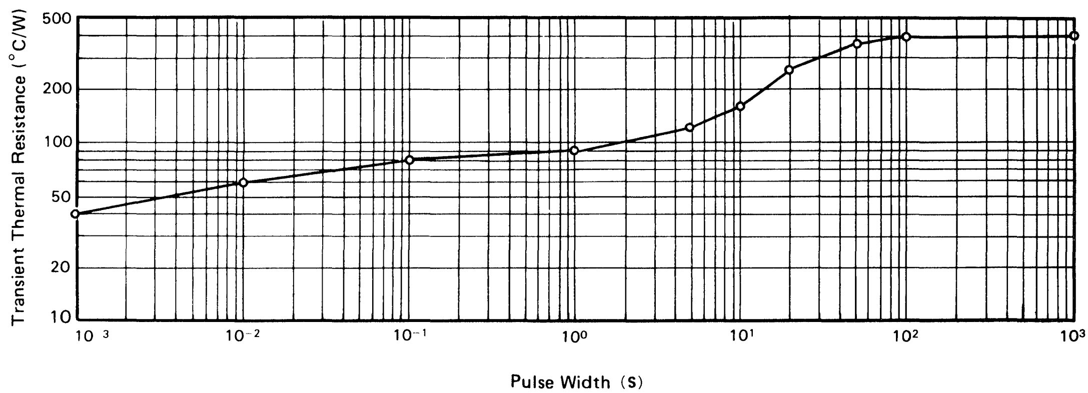


Figure 50 Thermal Resistance Characteristics (HLP30RG)

2.2.6 IRED Near Field Pattern (NFP)

Light intensity is highest at the edge of the light emitting area, due to the current concentration at the junction boundary. The light intensity profile is shown in Fig. 51.

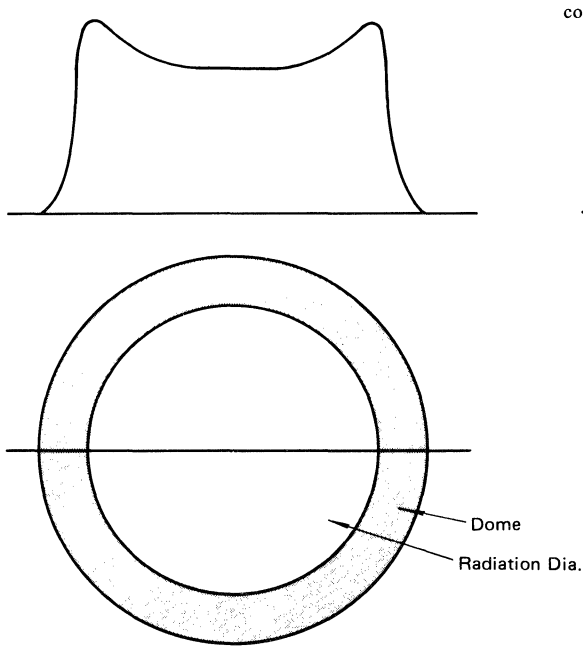


Figure 51 Near Field Pattern

2.2.7 IRED Radiation Diameter

Effective radiation diameter differs with chip structure. The effective radiation diameter of the HLP Series (600 μm dome diameter) is approximately 520 m. HE8801 and HE8811 (400 μm dome diameter) is approximately 360 μm (Fig. 52). The effective radiation diameter of HE8402F and HE8403R, with current concentration chip structure, is about 150 m.

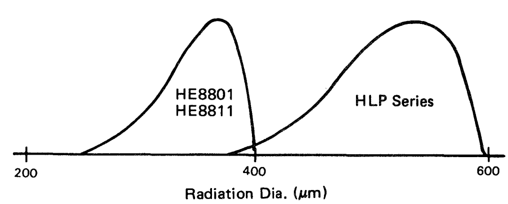


Figure 52 Effective Radiation Dia. Profile

APPLICATION NOTES

1. APPLICATION NOTES

1.1 LD Applications

A laser beam is classified by its monochromatic and directional characteristics, collimation capability, and coherency. In addition to these properties, LD advantages are size, light weight, and low voltage drive and direct high speed modulation capabilities. Laser technology is designed to control these properties in LD applications.

Table 7 shows application examples and suitable LD products.

Table 7 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	HLP1600
Information Terminal Equipment		Laser Beam Printer	High Speed and High Resolution Printing	HLP1400 HLP1600 HL7801E/G HL7802E/G HL8311E/G HL8312E/G 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/G 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

Communication with an optical fiber has the following advantages compared with conventional coaxial cable:

1) Higher bit rate and longer distance communication, due to reduced loss and wider bandwidth performance.
2) Smaller diameter and lighter weight.
3) Free from electroinductive noise caused by high voltage transmission or thunderbolts.
4) Free from spark, electric shock or heat when a fiber is broken.
5) Potential future cost advantages and material savings.

Various applications have materialized for these advantages. The transmission loss of a fiber depends on the amount of water component (OH radical) included in the silica glass as an impurity. Fig. 53 shows typical transmission loss characteristics of a silica fiber vs. wavelength. The fiber at the early stage of development shows 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 for minimum transmission loss is referred to as a fiber window. Major efforts in reserch and development have been concentrated to minimize 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 in the purification technology of silica fibers achieved transmission loss minimization close to the theoretical curve, as shown in Fig. 53.

Hitachi's HLP5000 series utilizes a 1.3 μm window, and is 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 equipment such as VHF or IF band TV signals, and base band picture signals require a wide bandwidth, and low noise and distortion. Therefore, excellent linearity of light output characteristics are required against a light signal source. However, 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 greater transmission quality than the conventional coaxial cable system.

Long distance transmission may require a repeater. Fig. 54 shows the block diagram of the repeater for digital systems. The feedback loop controls the laser driver, which compensates fluctuation of the LD output power. A circuit to compensate non-linearity of the LD may be added for analog modulation.

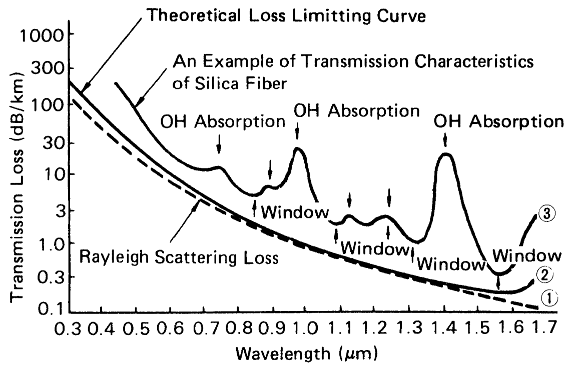


Figure 53 Transmission Loss of Typical Fiber

1.1.2 Optical Printer

Laser beam printers are commercially available for use as the computer off-line printer, with a printing speed of 10,000 ~ 18,000 lines per minute using a HeCd or HeNe gas laser as light source, and electrophotography techniques. Responding to office automation requirements, use of LD realizes printers of reduced size and weight, offering high speed operation and low energy consumption.

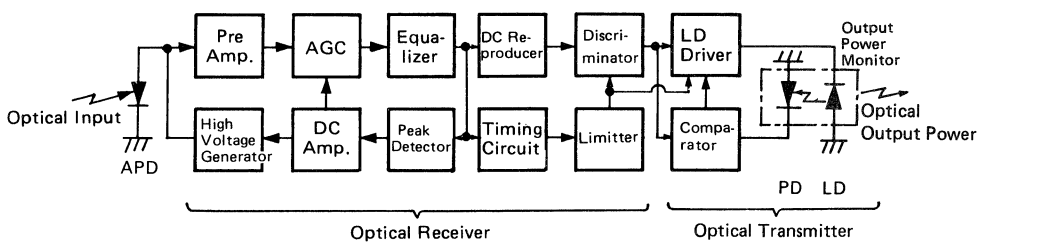


Figure 54 Block Diagram of Repeater for Digital System

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 applied, not only for public subscriber lines, but for long distance terrestrial trunk lines and intercontinental communication. Advances in network systemization will require frequency division multiplexing against a specific wavelength (super division multiplexing).

Problems associated with the analog modulation system are distortion and noise due to the non-linearity of a light signal source as described above. These problems, however, do not arise unless direct amplitude modulation is applied to a light source. An applicable method is to pre-modulate the carrier frequency with pulse signals in a preceeding electric circuit, and perform 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.

Fig. 55 shows the principle structure of a laser printer system. After the LD drive current is modulated with recording signals, a Polygon mirror or Galvano mirror scans the laser beam horizontally to form an electrostatic latent image on the constantly spinning photo sensitive drum.

The surface of the photo sensitive drum (an insulator) is initially charged with positive electricity by the corona discharge method. Negative electricity is charged between a conductive sub[illegible]d an insulator. After the surface electricity is discharged by application of an alternative electric field, the resistance lowers in the area where the laser beam is applied, and electricity discharges. The electrostatic latent image is developed by adhering toner (colored particles charged with opposite electricity) to the area of the charged surface. Then the image is printed on paper by corona discharge, and set by pressure and heat.

An organic photo conductor is usually used as a photo sensitive medium whose spectro-sensitivity is higher at shorter wavelengths. Development of an LD with short wavelength and improved photo sensitive medium with spectrosensitivity at longer wavelength are two areas of key technology.

High power LDs HL8311 series (15mW), HL8312 (20mW), and HL8314E (30mW) at 830 nm, and short wavelength LDs HL7801 series (5mW) and HL7802 (10mW) at 780 nm are available for this application.

plate turns the polarization direction by 90 degrees. When the laser beam hits a pit, the reflected light is diffracted to the outside of the aperture of an objective lens, resulting in a decrease in the amount of light returning to the lens. When the laser beam hits a mirror facet (concave portion), all light reflects to return to the inside of the aperture, and enters the detecting system. A polarized beam splitter leads the reflected beam from a mirror facet to a photo detector

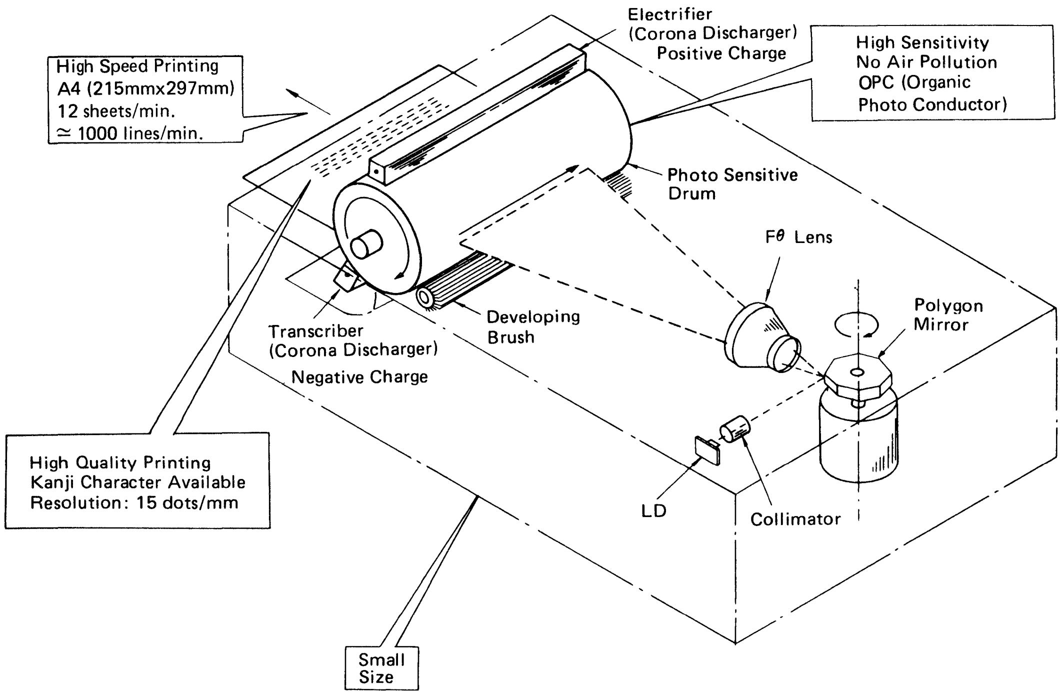


Figure 55 Laser Printer System

1.1.3 Optical Disc Memory System

The optical disc memory system writes and reads data with a laser beam optically focused to a $1 \sim 2$ μm diameter area. This minute spot corresponds to one bit. 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) developed mainly for computer terminal equipment, and audio and video disc systems for commercial use. The optical disc is formed with acrylic resin coated with Al and Te, and is written by the heat of a focused laser beam. The system does not have rewrite capability. An opto-thermal magnetic recording system is under development for a rewritable optical disc memory.

(1) PCM Digital Audio and Video Discs

A digital audio disc is standardized to a compact disc (CD) type commercially used. Fig. 56 shows CD system optics with a tracking function. At information signal pickup, tracking deviation and defocusing are detected, and each signal led into a servo control circuit. A coupling lens collimates the laser beam to a parallel beam. The λ4 wave

through a lens. In a CD system, a program source is sampled at 44.1 kHz, encoded with 16 bit linear quantization, and 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, the LD couples with reflected objects located within a few cm such as a disc surface forming an external cavity, which brings reflected light back into the laser cavity, and causes fluctuation of the lasing mode and optical output power. The phenomenon is referred to as Scope Noise (Self Coupled Optical Pickup), which should be considered along with Mode Hopping Noise, when designing player equipment.

A video disc system handles analog signals. 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 requires a much tighter noise level—20 ~ 30 dB, compared with CD—because of its wide signal bandwidth (1.7 ~ 9 MHz).

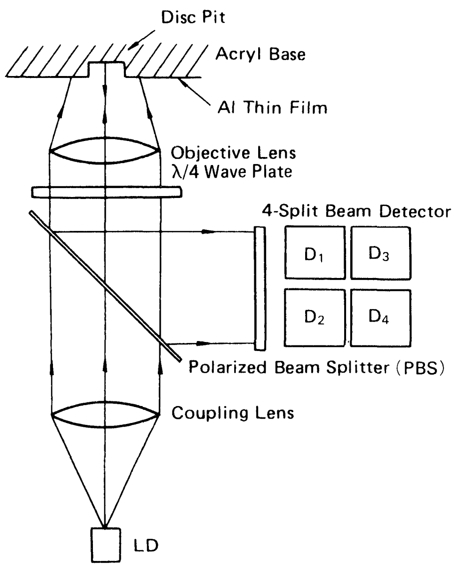


Figure 56 CD System Optics

The family tree for optical memory systems is exemplified in Fig. 57.

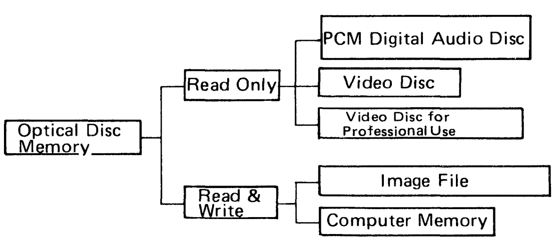


Figure 57 Family of Optical Disc Memory Systems

An office video disc has the same basic functions as home systems, enhanced with microcomputer software for a variety of features such as random access still photos and programmed photo display. Such systems will find greater use in information service, educational, and fashion product marketing applications.

(2) Image File and Computer Disc Memory Systems

Expected relative positioning of various memory systems is shown in Fig. 58 as cost per bit vs. access time. The optical memory disc system is in the lower cost region by about 3 digits, compared with the magnetic system, due to memory density (about 10^{10} bits). Therefore, a single side of a 30cm LP disc can record or memorize the information on approximately 50,000 tracks or 10,000 sheets of A4-size still pictures (215 x 297 mm^2). On writing signals, a beam of 15 ~ 25 mW focuses to a spot of 1 ~ 2 μm diameter through a lens. A disc surface can obtain 8 ~ 10 mW optical power. On reading signals, the pickup system is similar to that for other optical disc systems, with about 1 mW of focused beam power.

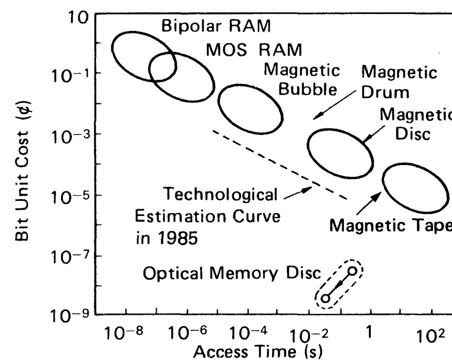


Figure 58 Access Time vs. Bit Unit Cost in Various Memory

Fig. 59 shows a document filing system using an optical disc memory and a laser beam printer designed to minimize paper usage.

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

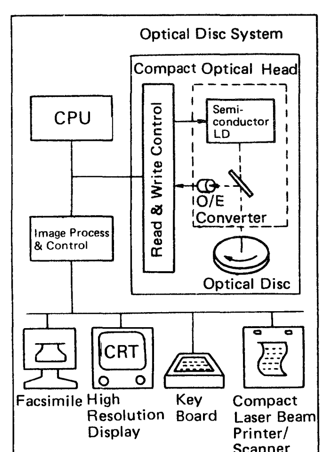


Figure 59 Document Filing System

1.1.4 Measuring and Control Equipment Applications

Various measuring equipment using laser beams require high output power. Use of LDs is limited due to their relatively low power output. Incorporation of LDs is best suited for applications which can utilize the LDs advantageous characteristics of size, efficiency and coherency.

(1) Distance Meter

Fig. 60 indicates the principle of a light wave distance meter using modulated light. Distance is computed based on the detected phase difference between radiated light and reflected light. Measurement error depends on the wavelength of a signal light, modulation frequency, and temperature change.

Range finders utilize LDs to measure the distance to a moving target, geographical features, and buildings.

A high sensitivity photo detector is required to detect scattered weak light from objects.

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

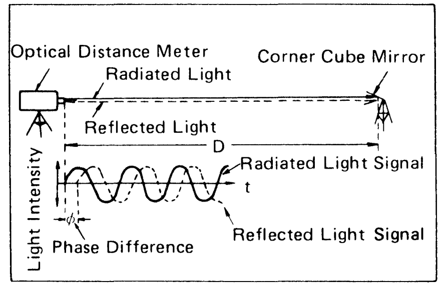


Figure 60 Light Wave Distance Meter

1.2 IRED Applications

Hitachi IRED advantages are high efficiency, power output and speed response, choice of variable emission wavelengths (760 nm to 880 nm), and package variation. Examples of application and recommended products are described in Table 8.

Table 8 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 analog transmission method. There are two methods to modulate light intensity with electric signals: the direct modulation method, in which a light source device is directly driven with the modulation signals, 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 an IRED changes porportionally to the drive current, as shown in Fig. 61.

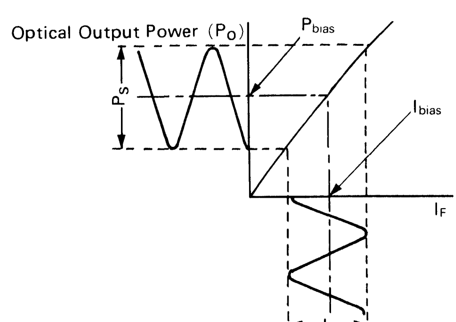


Figure 61 Fiber-optic Communication

A simple analog transmission system with direct modulation is described in Fig. 62. The electric circuit of a repeater requires amplification in this system. However, linearity of a light signal source is an important factor. For the nonlinearity distortion level required for analog communications, the second nonlinearity distortion is generally over -45 dB, and the third is over -55 dB.

Hitachi's HE series effectively meet these system requirements.

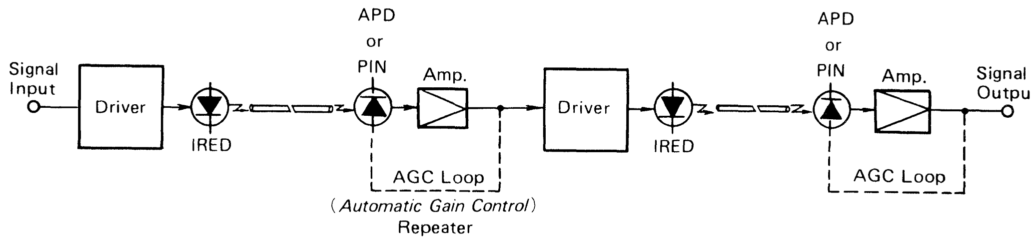


Figure 62 Direct Modulation Method Analog Transmission System

A digital transmission system with a typical repeater complex, having an equalizer, discriminator, and retiming functions is described in Fig. 63. Despite the fact that the electric circuit is complicated, compared with the analog transmission system, the digital transmission system is more advantageous because its transmission bandwidth is wider, and it provides more accurate transmission capability. Efficient coupling of IRED optical output to a fiber is of extreme importance in any fiberoptic communication system.

HE series such as HE8402F and HE8403R, designed with a small emitting area for high frequency response and light intensity are recommended for fiberoptic communication.

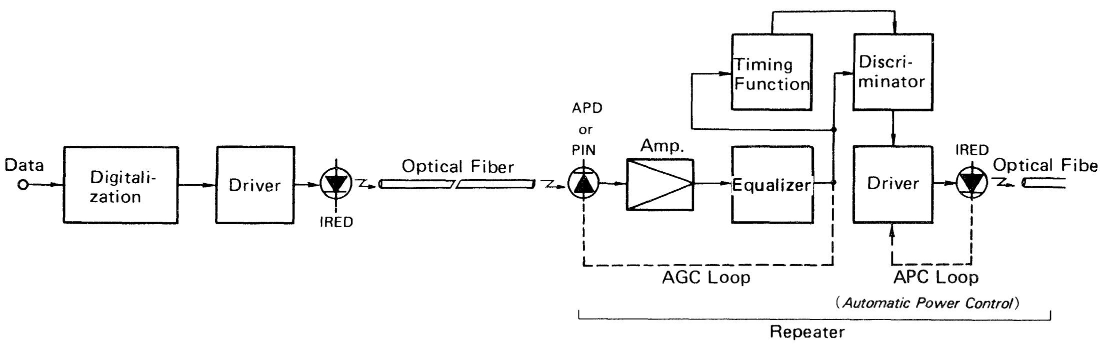


Figure 63 Digital Transmission System

1.2.2 Facsimile Systems

IREDs are also used as light source to illuminate objects. The high power capacity and hemispherical chip surface of Hitachi IREDs suit facsimile applications.

Fig. 64 demonstrates the principle of a contact type facsimile pickup head. The sensor part (pickup head) of a contact type facsimile consists of an IRED array (light source), a contact fiber, a sandwiched fiber, and a photo detector array. The IRED light reflected at the original with absorption input into a photo detector array sensor through a contact fiber and a sandwiched fiber is then converted to electric signals. Vertical scanning information is picked up along the direction of the original, and horizontal scanning information is picked up along the direction of the IRED and PD which are arrayed.

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

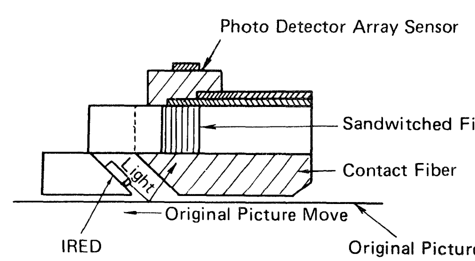


Figure 64 Principle of Contact Type Facsimile Pick-up Head

1.2.3 Auto Focus Cameras

Auto focus cameras have become popular due to features such as auto focus and shutter control functions. There are two methods for auto focus: one is to use the reflected natural light from an object, and the other is to use light emitted from a built-light source that reflects from an object, which offers error-free focusing. Light from the built-in source hits the specified object, and only the light reflected from the target is used to measure distance. Fig. 65 describes the operating principle of an auto focus camera with a built-in light source. Intensity modulated light is emitted from an IRED mounted at the center of a camera, and collimated by a lens toward an object. Part of it is received by photosensors through rotating lenses set at both edges of the camera. When the light reflected from the object is focused to the photo sensors through L_1 and L_2, the shutter releases.

Hitachi IREDs HLP20 ~ 60 series are recommended for this application.

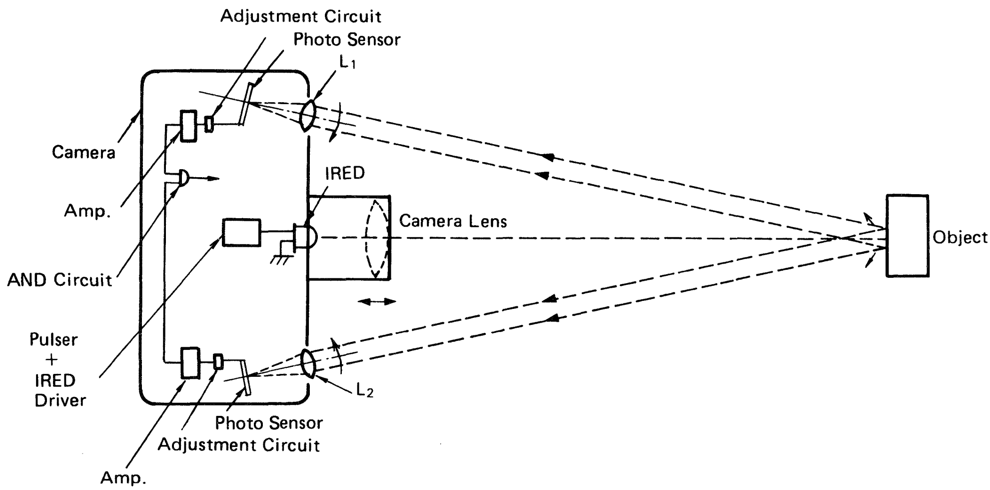


Figure 65 Operating Principle of an Auto Focus Camera

2. SUPPLEMENTARY INFORMATION

2.1 Light Wave Modulation

Coherency of an optical carrier wave used for optical communication largely depends on a light source ranging from monochromatic (coherent) light of a single mode LD, to quasi-monochromatic light of an LED. General descriptions of various light are given in Fig. 66. A carrier wave in radio frequency is purely coherent sinusoidal wave. Phase and amplitude (or envelope) of a light wave, however, usually exhibit random fluctuation even with adequate laser light. The amplitude of light is expressed in the following formula, and depicted in Fig. 67.

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

E(t) is the amplitude envelope of a light wave oscillating at frequency f(t) in electric fields and $\phi(t)$ is phase. A coherent pure sine wave has constant E(t) and $\phi(t)$ against time. In IREDs or LDs, f(t) and $\phi(t)$ change against time by a few nm to 10 nm in wavelength. Therefore intensity modulation or pulse modulation are the applicable methods 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. The modulation speed of laser light is basically limited by factors such as carrier life (the period required to recombine electrons and holes, and induce spontaneous emission), the photon life within the resonator, and the ratio of bias current to threshold current.

Carrier life limits maximum modulation speed among these factors. Since the carrier life of a GaAlAs laser diode is less than 1 ns, high speed modulation of 100 Mbit/s can be achieved. When modulation speed greater than Gbit/s order is required, the external modulation method is effective. Fig. 68 describes the principle of the direct modulation method. Light linearity vs. drive current is extremely important for analog signal modulation.

For high speed direct pulse modulation of 100 Mbit/s, minimal extra resonance, relaxed oscillation of optical output pulse, and carrier storage effect is required. Table 9 describes modulation systems in optical communication applications.

Table 9 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

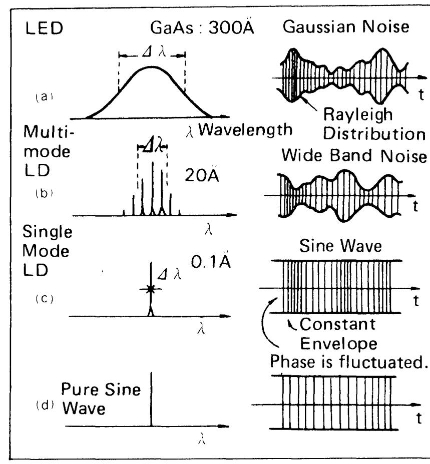


Figure 66 Spectrum of Light Carrier Wave and Modeling of Instant Waveform

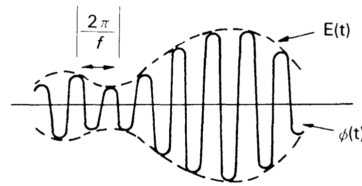


Figure 67 Light Wave Oscillation

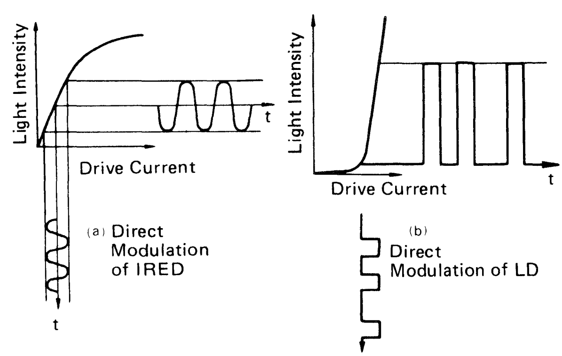


Figure 68 Principle of Direct Modulation

Om addition to direct modulation method of a light signal source, external modulation method with an external device is also effective. Since this method offers high sensitivity, wide bandwidth and high speed modulation, it is particularly applicable where extremely high speed calculation and data processing are required.

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

2.2 Optical Beam Deflection

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

A Galvano mirror or a Polygon mirror is a conventional deflector using mechanical rotation, which has the advantage of a wide deflection angle and many digits of deflection. However, the mechanical rotation limits the scanning frequency up to several 10 kHz. Optical compensation is required to offset the instability of the scanning position caused by inaccurate setting.

A deflector using electro-optical or acousto-optical effect is also available, and selection should be based on scanning time and deflection digit number characteristics (Fig. 69).

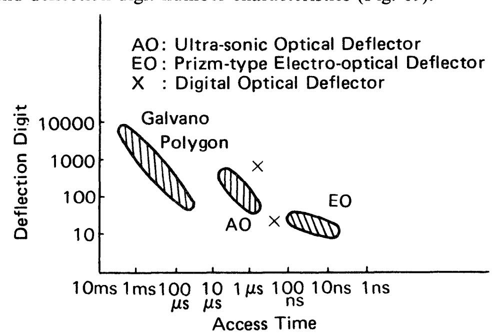


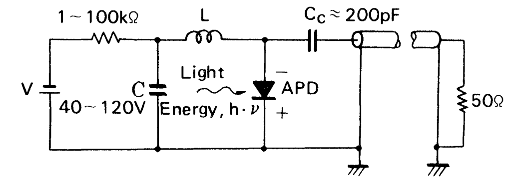
Figure 69 Diagram of Deflection Digit vs. Access Time

2.3 Photo Detection

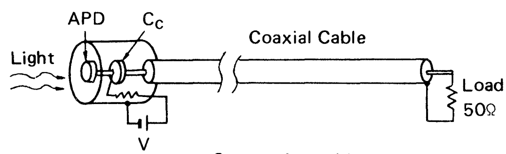
A pin photo diode and avalanche photo diode (APD) are typical photo detectors (PD). APD has a multiplication function. Its gain is approximately 100, the photo sensitive area is 100 ~ 200 µm diameter, and the pulse response is approximately 100 ps. Ge-APD is suitable for a 0.9 ~ 1.7 µm wavelength, and Si-APD for 0.4 ~ 0.9 µm.

The theoretical limit of Si-APD is expressed by the product of gain M and the bandwidth B, $M \cdot B \cong 450$ GHz. This is referred to as the gain bandwidth product and its gain (which varies with bias voltage) is chosen by referring to S/N and the minimum detection signal level required for photo detection.

Of course, the gain and the excessive noise figure are interrelated due to the avalanche multiplication expressed as $F(M) = M^x$ ($x = 0.35$ for Si-APD). Fig. 70 shows a simple example of a power source (a) and a system assembly (b) for APD.



(a) Power Source



(b) System Assembly

Figure 70 Receiving Unit Used with APD

2.4 Peripheral Technology of Fiber Optics Application Status

A fiber light wave path consists of a center portion (core), which has a higher refractive index, surrounded by a layer (clad), with less refractive index. A light wave travelling 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 coated with nylon or plastic.

2.4.1 Basic Structure of Optical Fiber and Light Wave Propagation

Fig. 71 depicts the basic structure of an optical fiber. The light should incident within a critical angle, so that all 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 folows:

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

Propagation mode, group velocity and phase speed are important factors of optical waveguide theory.

The refractive index profile of optical fibers falls into two categories: step index and graded index. Light wave propagation mode in a fiber is also categorized into single mode and multimode. The single mode fiber with a core diameter of 5 ~ 10 m has wide transmission bandwidth, and is suitable for high bit rate and long distance communication applications. Fig. 72 details typical optical fiber characteristics.

The wavelength regions of the lowest dissipation in transmission characteristics of an optical fiber are referred to as fiber windows. Low transmission loss characteristics are maintained at the theoretical limit even in a longer wavelength area.

Information speed (transmission capacity) of an optical transmission system and repeater span depends on light signal source, optical fiber, and photo detector performance. Therefore, optical parts must be properly selected to match system requirements. Fig. 73 shows the general domain of optical transmission. Fig. 74 shows optical fiber characteristics and applications.

Improvements in optical fibers have resulted in various new applications such as sensing or energy transfer, and may lead to such future applications as transmission of power energy.

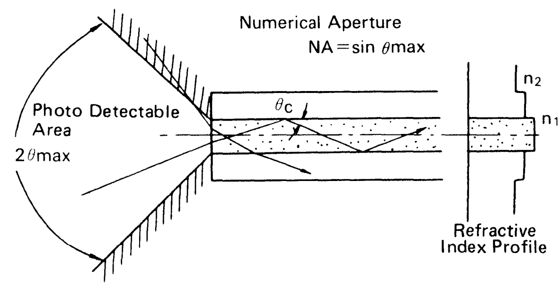


Figure 71 Step Index Fiber Structure

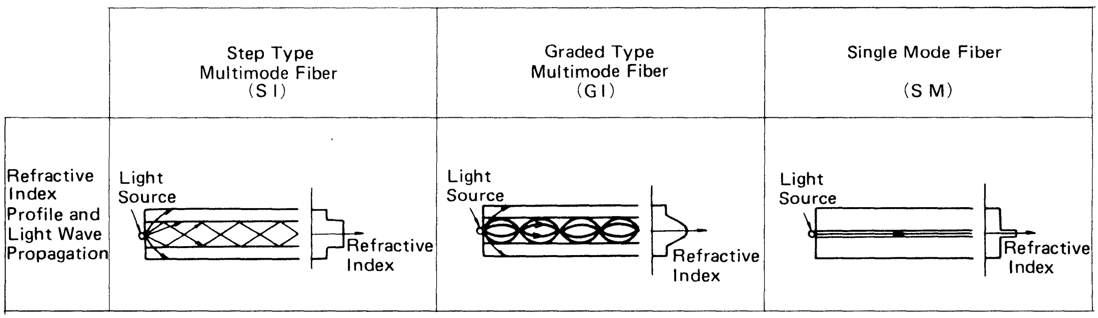


Figure 72 Classified Optical Fiber into Refractive Index Structure

Table 10 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
Transmission 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 a cost standpoint. Graded index type silica fiber or single mode fiber is suitable for high speed and long distance systems from a performance requirement.

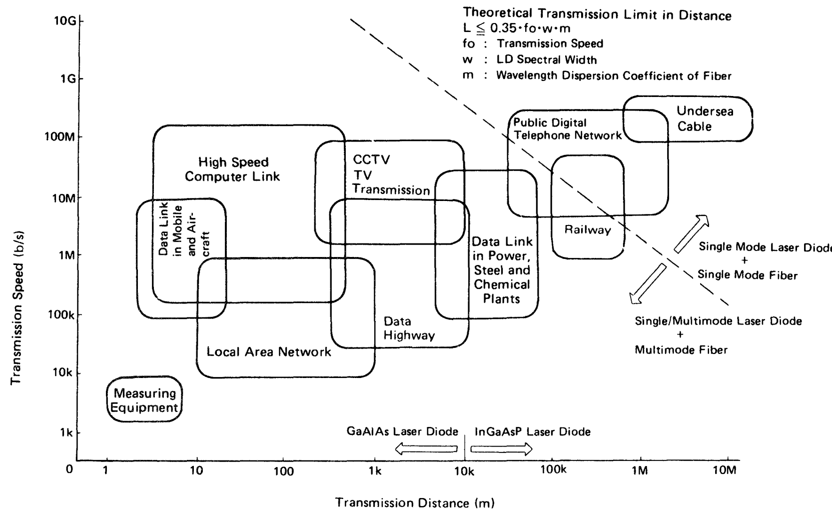


Figure 73 Light Transmission Domain Map

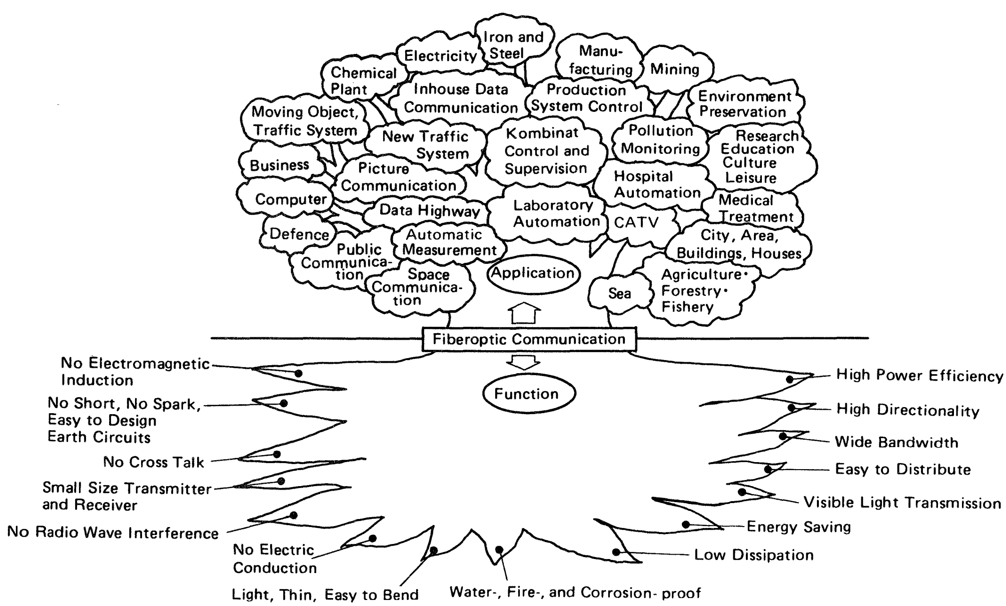


Figure 74 Optical Fiber Functions and Applications

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. Therefore, specifications are subject to change without notice and Hitachi reserves the right to discontinue these products without notice.

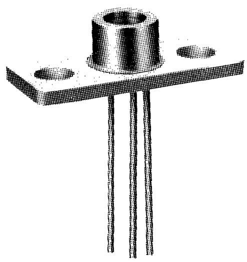
HL7801E, HL7801G

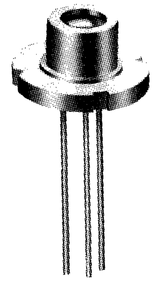
GaAlAs LD

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

■ **FEATURE**
- Short wavelength: Visible band is from 760 to 800nm.
- High reliability, Long life.

■ **PACKAGE**


①②③
HL7801E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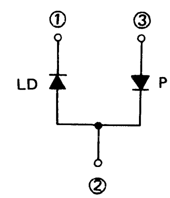
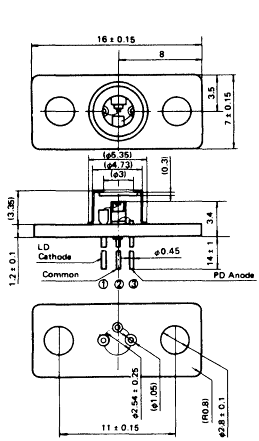
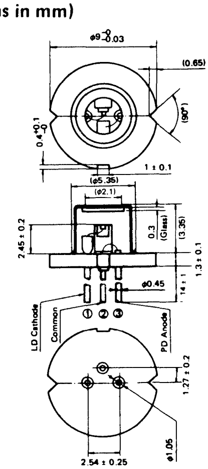
HL7801G



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


HL7801E


HL7801G

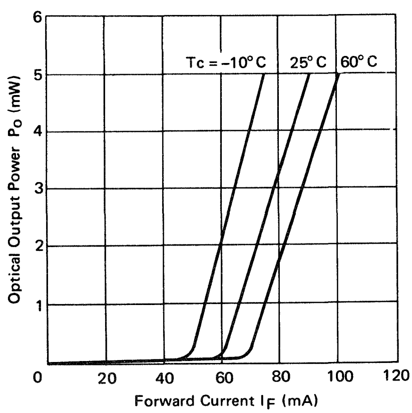
■ **ABSOLUTE MAXIMUM RATINGS (Tc=25°C)**

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

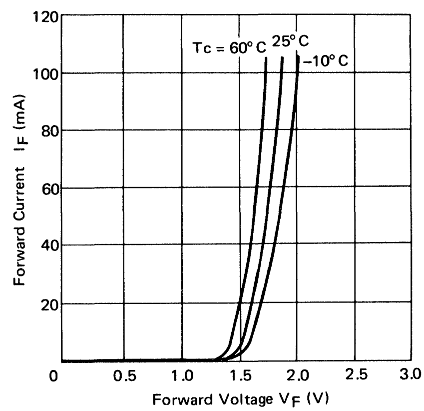
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

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	16	20	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 3mW	20	30	40	deg.
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 3mW	0.1	0.3	–	mA

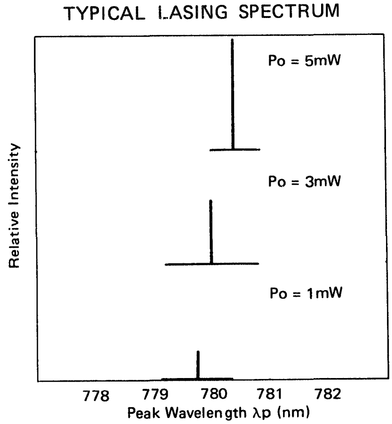
LIGHT – CURRENT



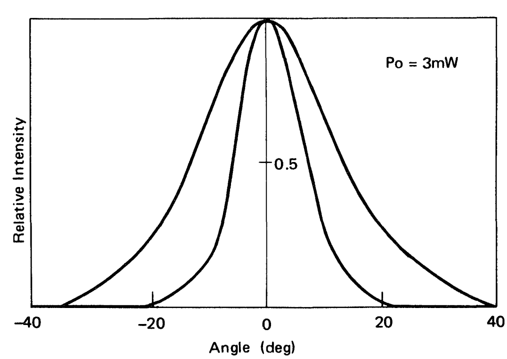
CURRENT – VOLTAGE



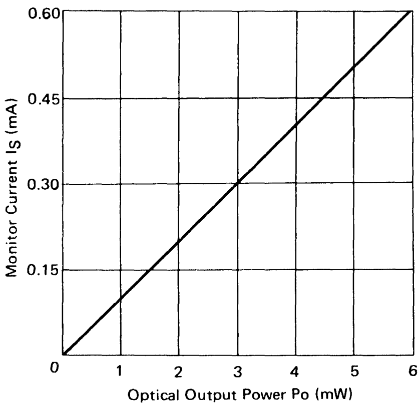
TYPICAL LASING SPECTRUM



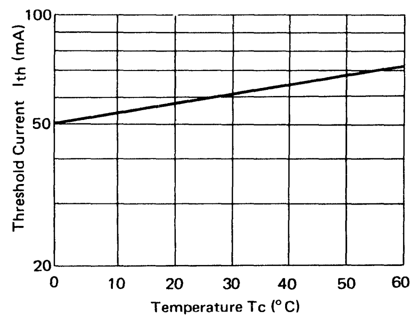
TYPICAL FAR FIELD PATTERN



TYPICAL MONITOR CURRENT — OPTICAL OUTPUT POWER



TYPICAL THRESHOLD CURRENT — TEMPERATURE



HL7802E

—PRELIMINARY—

GaAlAs LD

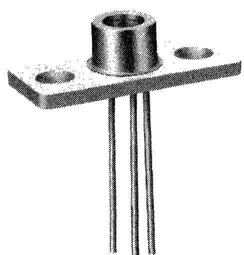
■ **APPLICATION**

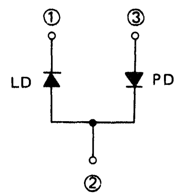
- Audio disc, Memory disc.
- Laser beam printer.
- Light source for any other optical equipments.

■ **FEATURE**

- Short wavelength: Visible band is from 760 to 800nm.
- Photo detector built in for monitoring.

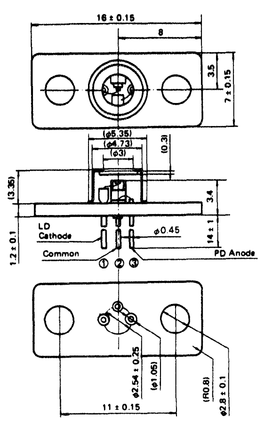
■ **PACKAGE**





HL7802E

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



HL7802E

■ **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 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

■ OPTICAL AND ELECTRICAL CHARACTERISTICS (T_c=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	760	780	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	0.2	0.9	–	mA

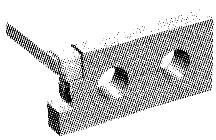
HLP1400, HLP1500, HLP1600

GaAlAs LD

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

■FEATURE
- 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.

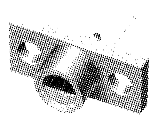
■PACKAGE



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

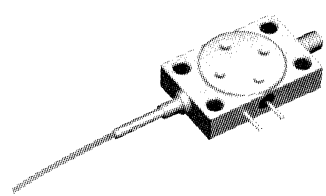
Caution: Since the chip is exposed to the air, this type is not recommended for commercial application.

HLP1400



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

HLP1600



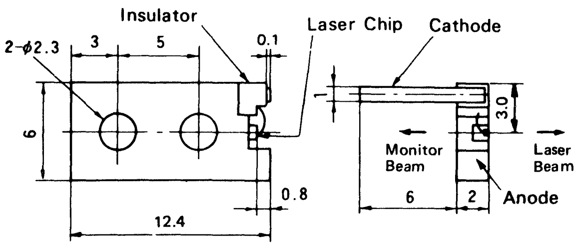
A monitor output guide is provided for external monitoring.

[Standard Fiber]

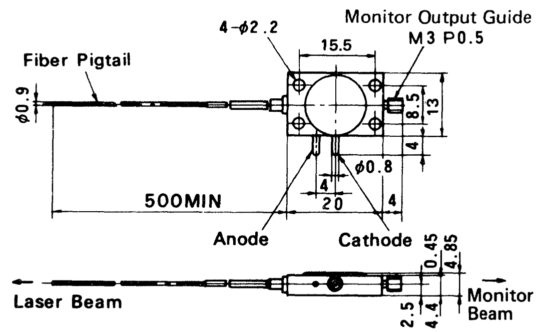
Numerical Aperture	: 0.2
Core Diameter	: 50 μm
Outer Diameter	: 125 μm
Jacket Diameter	: 900 μm
Refractive Index	: GI
Pigtail Length	: 500 mm min.

HLP1500

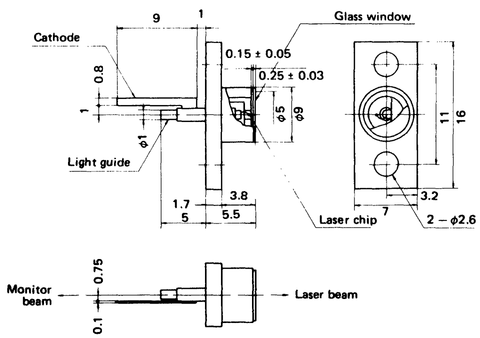
■ PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)



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

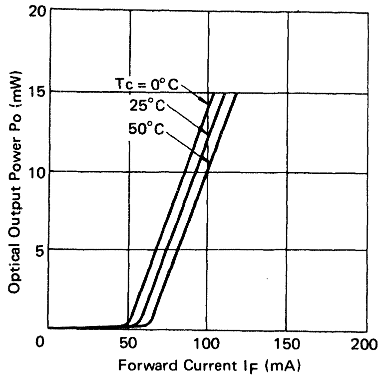
* At the fiber end.

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

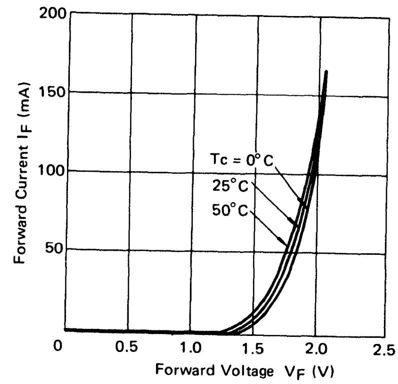
Item	Symbol	Test Condition	HLP1400			HLP1500			HLP1600			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		–	60	90	–	60	90	–	60	90	mA
Optical Output Power	P_O	Kink free	15	–	–	6*	–	–	15	–	–	mW
		$I_F = I_{th} + 25mA$	4	5	–	2*	3*	–	4	5	–	
Monitor Power	P_m		2	–	–	0.5	–	–	0.2	–	–	
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	$\theta_{\perp}$		–	24	–	–	–	–	–	24	–	
Rise and Fall Time	t_r, t_f		–	–	0.5	–	–	0.5	–	–	0.5	ns

* At the fiber end.

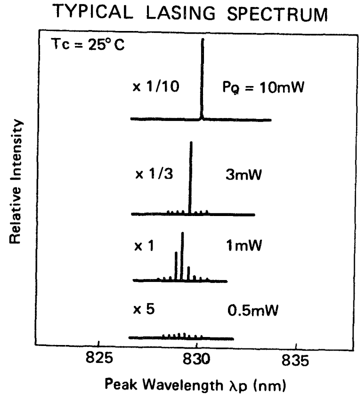
LIGHT – CURRENT



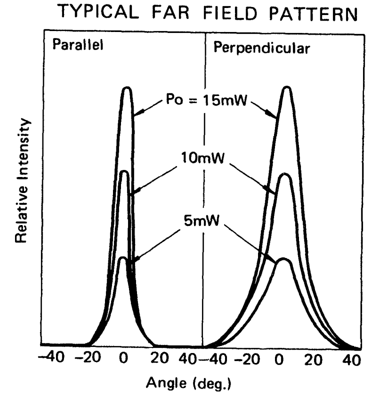
CURRENT – VOLTAGE



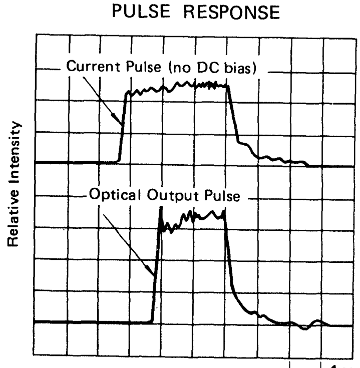
TYPICAL LASING SPECTRUM



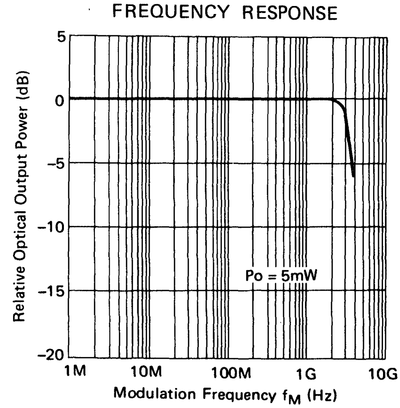
TYPICAL FAR FIELD PATTERN



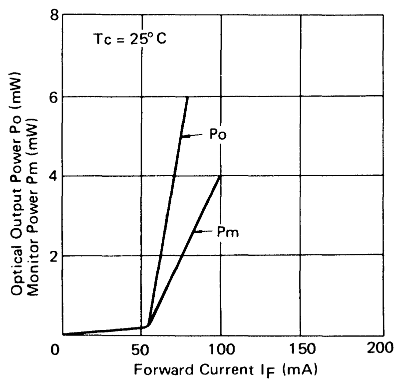
PULSE RESPONSE



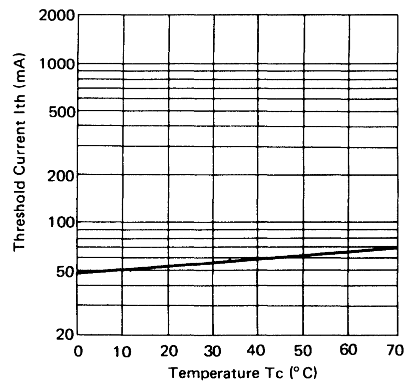
FREQUENCY RESPONSE



LIGHT – CURRENT (HLP1500)



THRESHOLD CURRENT – TEMPERATURE



HL8311E, HL8311G

GaAlAs LD

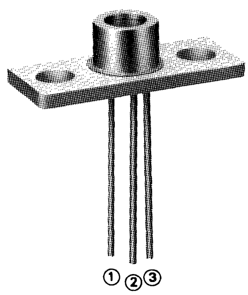
■ **APPLICATION**

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

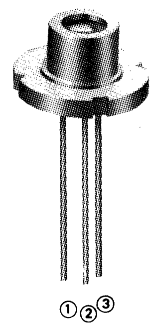
■ **FEATURE**

- Lasing between 800 and 850nm.
- Photo detector 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.

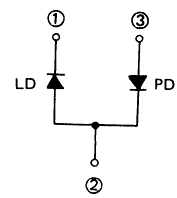
■ **PACKAGE**



HL8311E

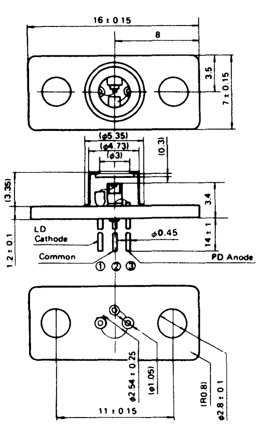


HL8311G

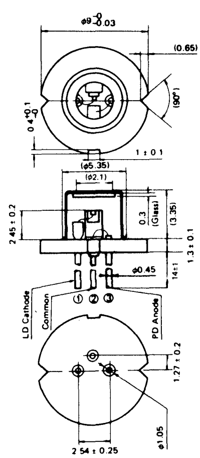


The photo detector built in for power monitoring simplifies an automatic power control circuit.

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



HL8311E



HL8311G

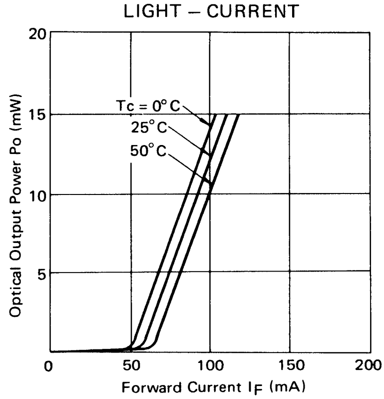
■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

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

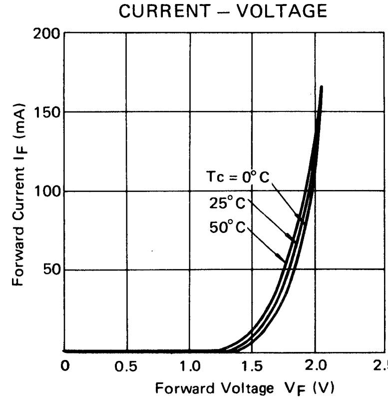
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

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
		$I_F = I_{th} + 25mA$	4	5	–	
Peak Wavelength	λp	P_O = 10mW	800	830	850	nm
Beam Divergence Parallel to the Junction	$\theta_{//}$		–	10	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$		–	24	–	
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

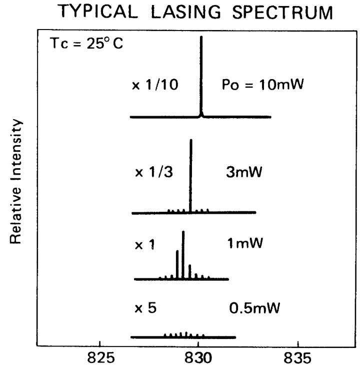
LIGHT – CURRENT



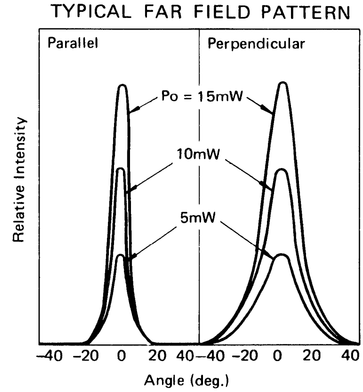
CURRENT – VOLTAGE



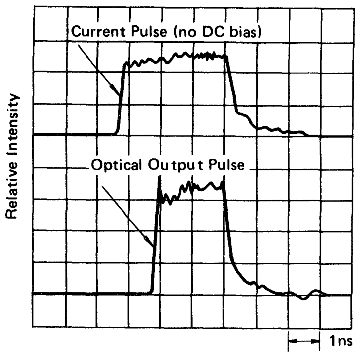
TYPICAL LASING SPECTRUM



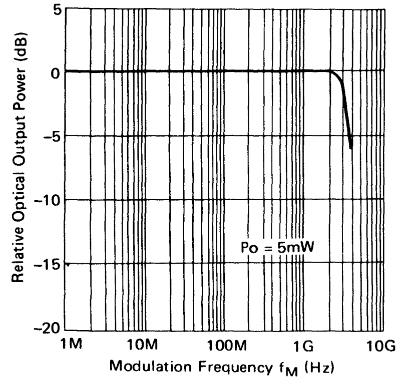
TYPICAL FAR FIELD PATTERN



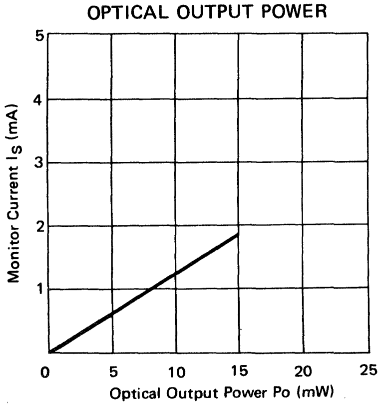
PULSE RESPONSE



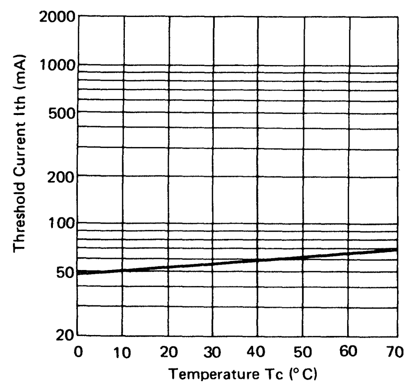
FREQUENCY RESPONSE



MONITOR CURRENT – OPTICAL OUTPUT POWER



THRESHOLD CURRENT – TEMPERATURE



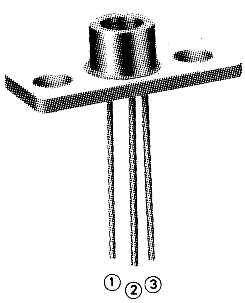
HL8312E

GaAlAs LD

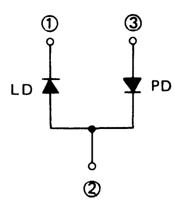
■ **APPLICATION**
- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipments.

■ **FEATURE**
- Lasing between 810 and 850nm.
- Photo detector 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**

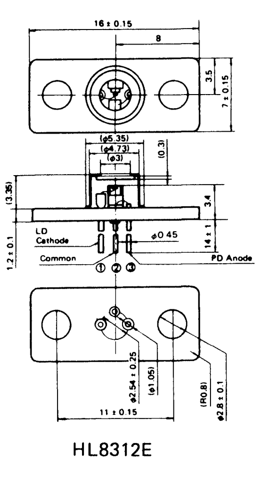


HL8312E



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

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



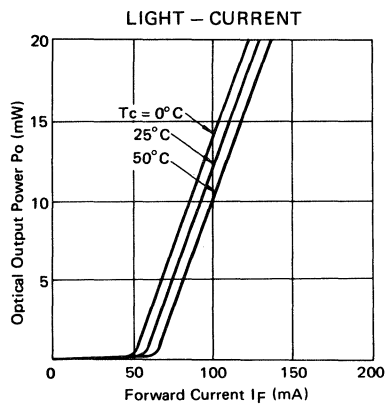
HL8312E

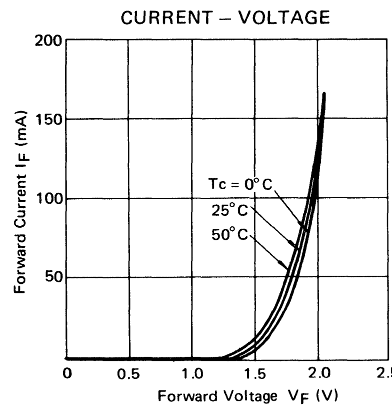
■ ABSOLUTE MAXIMUM RATINGS (Tc=25°C)

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

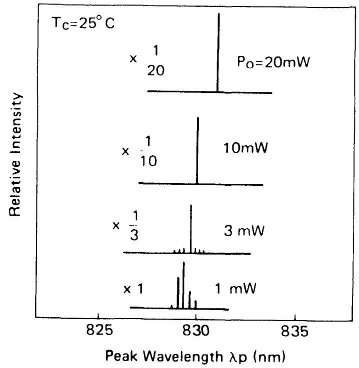
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=25°C)

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	–	24	–	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

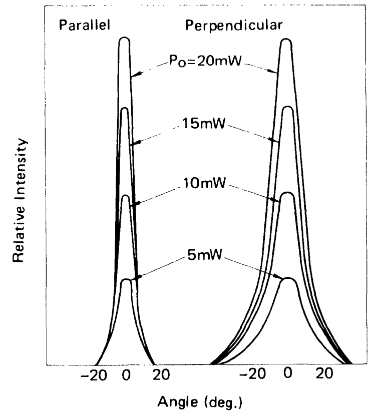




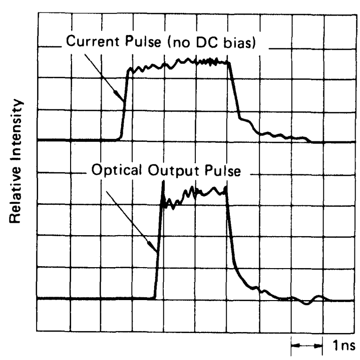
TYPICAL LASING SPECTRUM



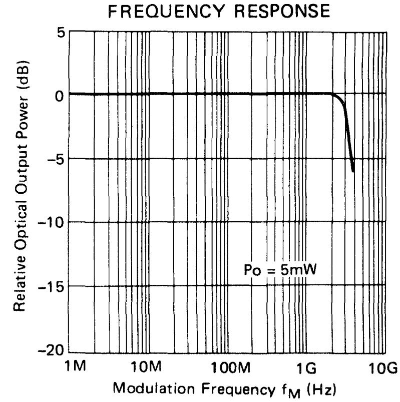
TYPICAL FAR FIELD PATTERN



PULSE RESPONSE



FREQUENCY RESPONSE



HL8314E

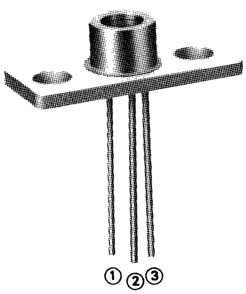
—PRELIMINARY—

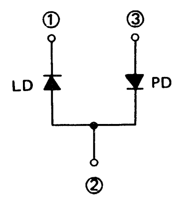
GaAlAs LD

■APPLICATION
- Optical memory disc.
- Laser beam printer.
- Light source for any other optical equipments.

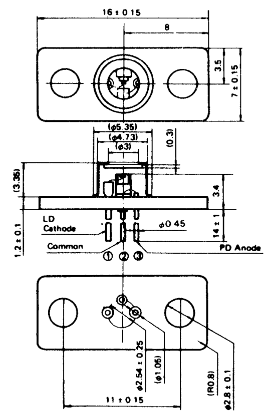
■FEATURE
- Lasing between 810 and 850nm.
- Photo detector built in for monitoring.

■PACKAGE





■ PACKAGE DIMENSIONAL OUTLINE
(Dimensions in mm)



■ ABSOLUTE MAXIMUM RATINGS (Tc=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}	0 ~ +50	°C
Storage Temperature	T_{stg}	-40 ~ +80	°C

■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc=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}		–	60	90	mA
Peak Wavelength	λp	P_O = 20mW	810	830	850	nm
Beam Divergence Parallel to the Junction	$\theta_{/\!/}$	P_O = 20mW	–	10	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$	P_O = 20mW	–	24	–	deg.
Monitor Current	I_S	$V_{R(PD)}$ = 5V, P_O = 3mW	20	–	–	μA

HL1221A,HL1221B,HL1221C

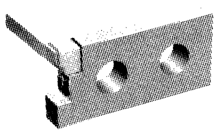
—PRELIMINARY—

InGaAsP LD

■APPLICATION
- Fiberoptic communication.
- Light source for any other optical equipments.

■FEATURE
- 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.

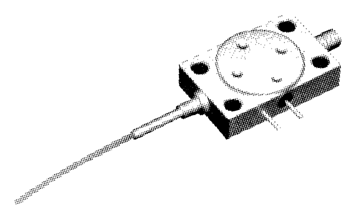
■ PACKAGE



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]

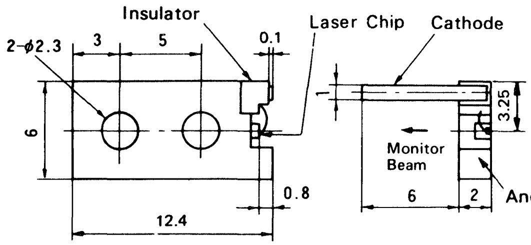
Numerical Aperture	: 0.2
Core Diameter	: 50 μm
Outer Diameter	: 125 μm
Jacket Diameter	: 900 μm
Refractive Index	: GI
Pigtail Length	: 500mm min.

HL1221B

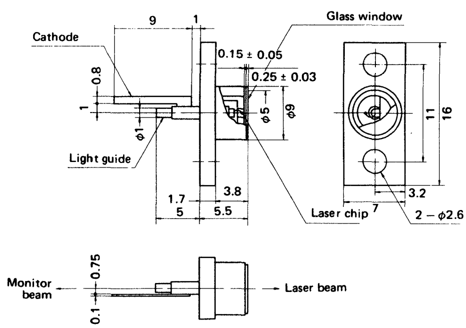
This is general-purpose package with AR-coated glass window.
A monitor output guide is provided for external monitoring.

HL1221C

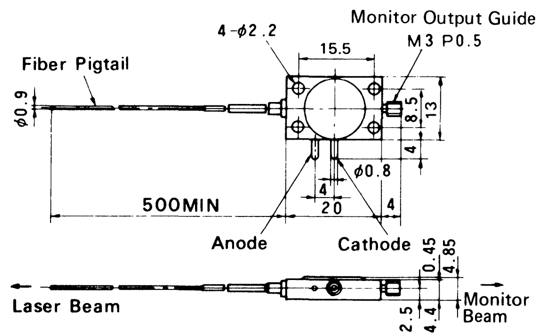
■ PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)



HL1221A



HL1221C



HL1221B

■ 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		

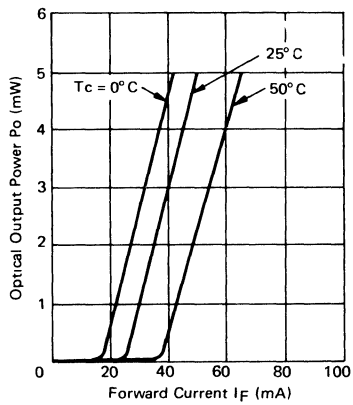
* At the fiber end.

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

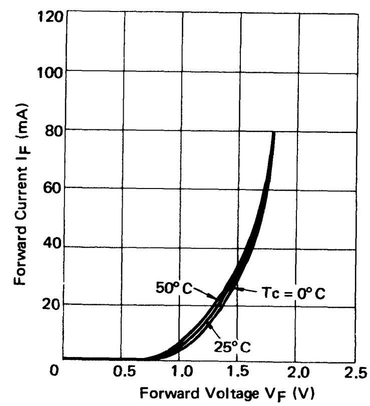
Item	Symbol	Test Condition	HL1221A			HL1221B			HL1221C			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		–	25	50	–	25	50	–	25	50	mA
Optical Output Power	P_O	Kink free	5	–	–	1.2*	–	–	1.2	–	–	mW
		$I_F = I_{th} + 20mA$	2.0	4.0	–	1.0*	–	–	2.0	4.0	–	
Monitor Power	P_m		1	–	–	0.05	–	–	0.5	–	–	
Peak Wavelength	λp	P_O = 3mW	1170	1200	1230	–	–	–	1170	1200	1230	nm
		P_O = 0.5mW*	–	–	–	1170	1200	1230	–	–	–	
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 3mW	–	30	–	–	–	–	–	30	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$		–	40	–	–	–	–	–	40	–	
Rise and Fall Time	t_r, t_f		–	–	0.5	–	–	0.5	–	–	0.5	ns

* At the fiber end.

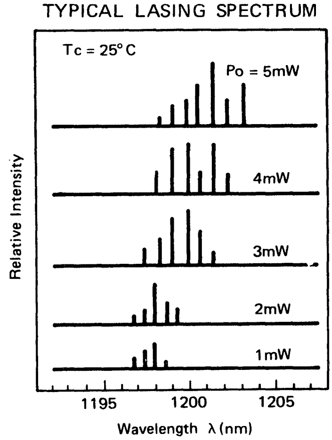
LIGHT – CURRENT



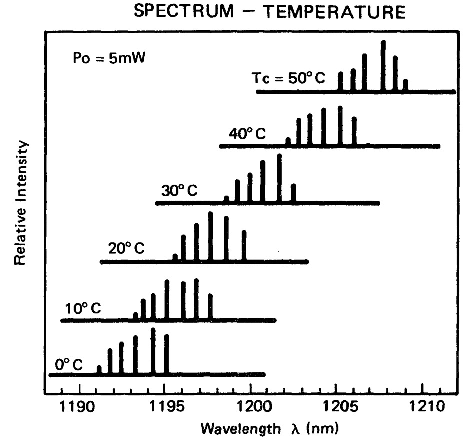
CURRENT – VOLTAGE



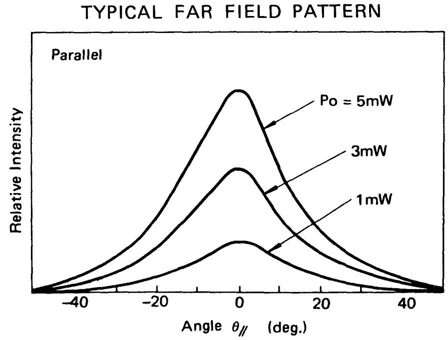
TYPICAL LASING SPECTRUM



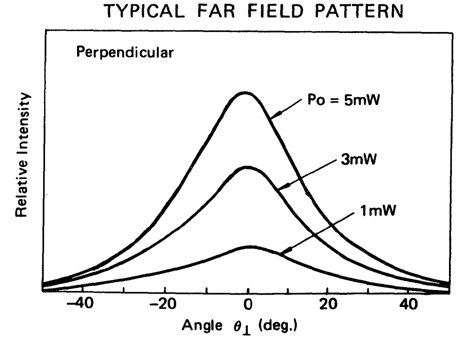
SPECTRUM – TEMPERATURE



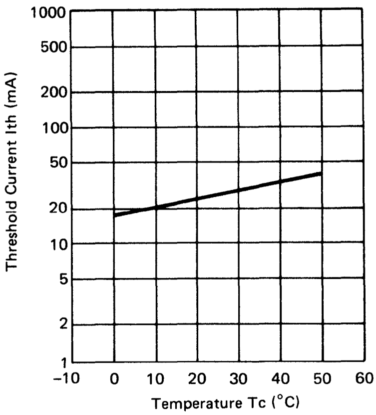
TYPICAL FAR FIELD PATTERN



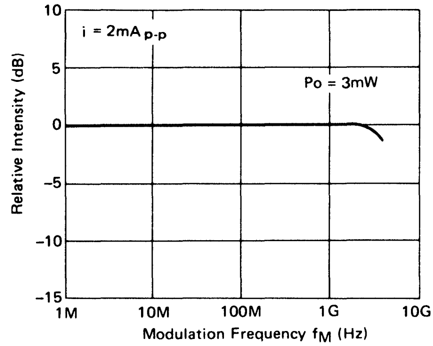
TYPICAL FAR FIELD PATTERN



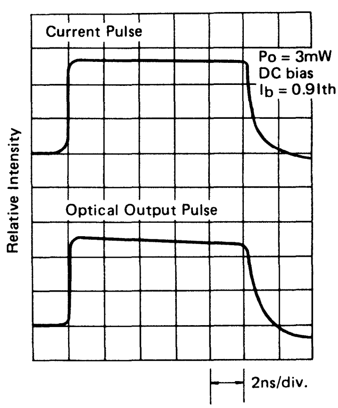
THRESHOLD CURRENT – TEMPERATURE



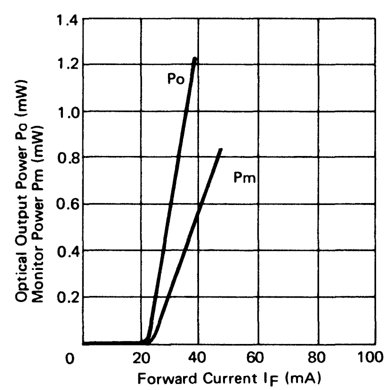
FREQUENCY RESPONSE



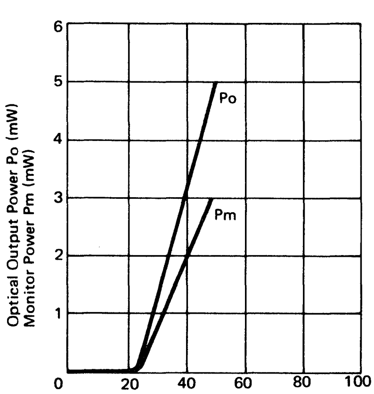
PULSE RESPONSE



LIGHT – CURRENT (HL1221B)



LIGHT – CURRENT (HL1221C)



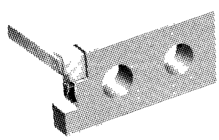
HLP5400,HLP5500,HLP5600

InGaAsP LD

■ **APPLICATION**
- Fiberoptic communication.

■ **FEATURE**
- 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.

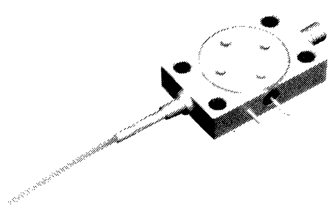
■ **PACKAGE**



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

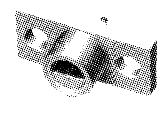


A monitor output guide is provided for external monitoring.

[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.

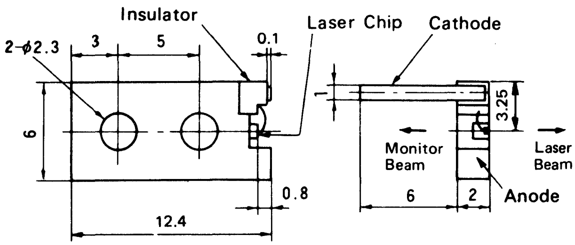
HLP5500



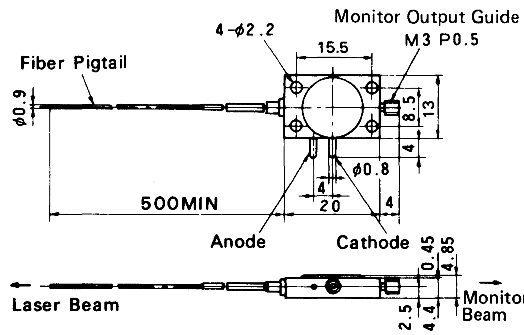
This is general-purpose package with AR-coated glass window.
A monitor output guide is provided for external monitoring.

HLP5600

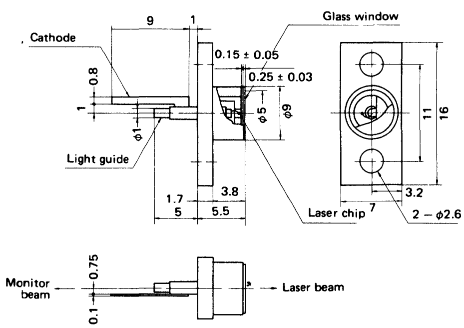
■ **PACKAGE DIMENSIONAL OUTLINE (Dimensions in mm)**



HLP5400



HLP5500



HLP5600

■ **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		

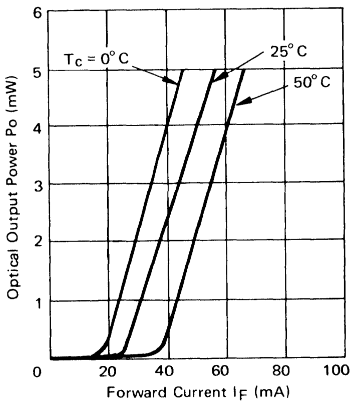
* At the fiber end.

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

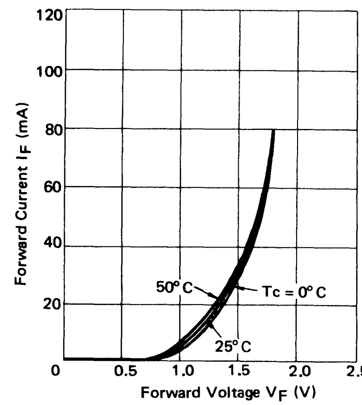
Item	Symbol	Test Condition	HLP5400			HLP5500			HLP5600			Unit
			min	typ	max	min	typ	max	min	typ	max	
Threshold Current	I_{th}		–	25	50	–	25	50	–	25	50	mA
Optical Output Power	P_O	Kink free	5	–	–	1.2*	–	–	5	–	–	mW
		$I_F = I_{th} + 20mA$	2.0	3.0	–	0.4*	0.7*	–	2.0	3.0	–	
Monitor Power	P_m		1	–	–	0.05	–	–	0.5	–	–	
Peak Wavelength	λp	P_O = 3mW	1270	1300	1330	–	–	–	1270	1300	1330	nm
		P_O = 0.5mW*	–	–	–	1270	1300	1330	–	–	–	
Beam Divergence Parallel to the Junction	$\theta_{//}$	P_O = 3mW	–	30	–	–	–	–	–	30	–	deg.
Beam Divergence Perpendicular to the Junction	$\theta_{\perp}$		–	40	–	–	–	–	–	40	–	
Rise and Fall Time	t_r, t_f		–	–	0.5	–	–	0.5	–	–	0.5	ns

* At the diber end.

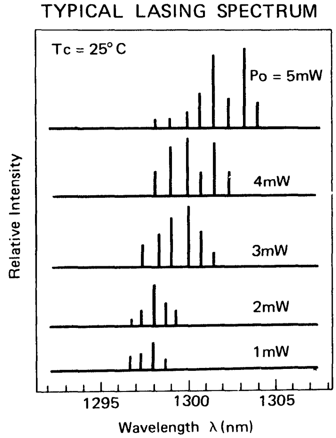
LIGHT – CURRENT



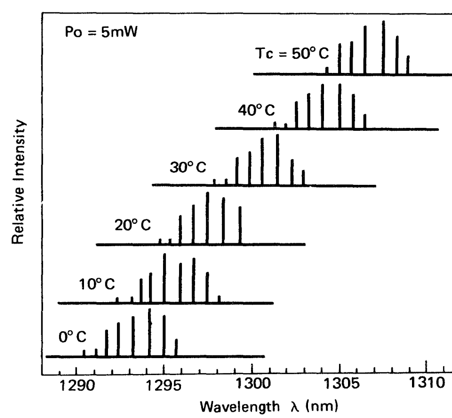
CURRENT – VOLTAGE



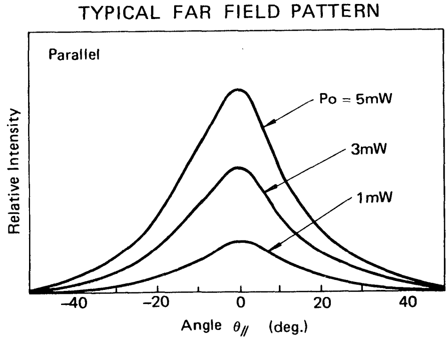
TYPICAL LASING SPECTRUM



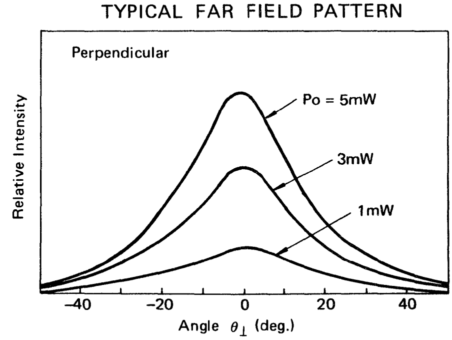
SPECTRUM – TEMPERATURE



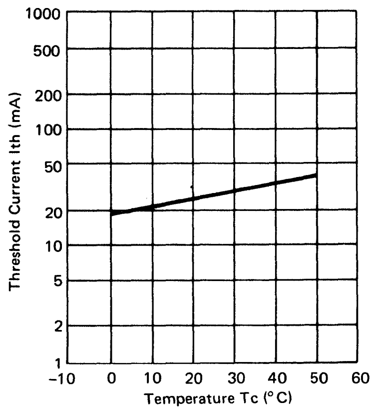
TYPICAL FAR FIELD PATTERN



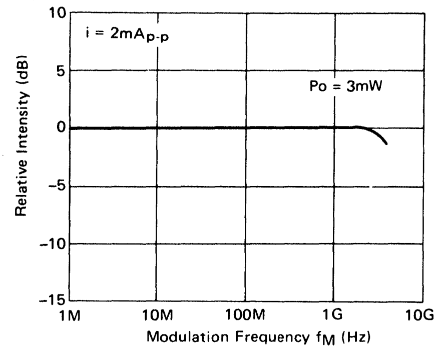
TYPICAL FAR FIELD PATTERN



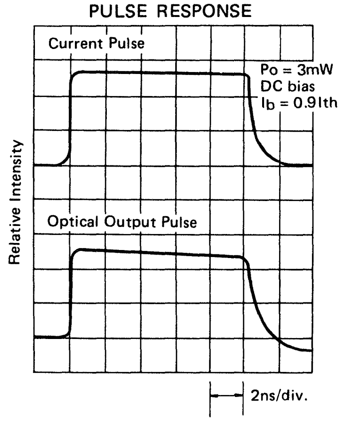
THRESHOLD CURRENT – TEMPERATURE



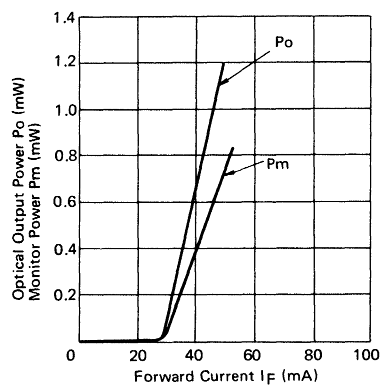
FREQUENCY RESPONSE



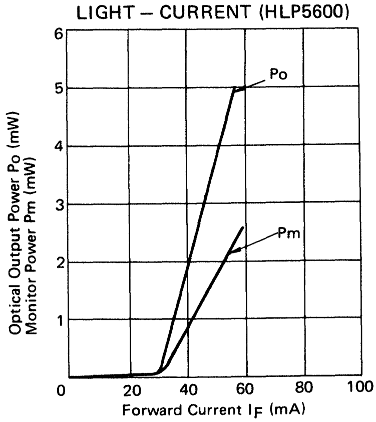
PULSE RESPONSE



LIGHT – CURRENT (HLP5500)



LIGHT – CURRENT (HLP5600)



HL1321P

—PRELIMINARY—

InGaAsP LD

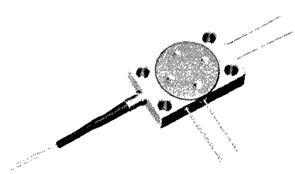
■APPLICATION

- Fiberoptic communication.

■FEATURE

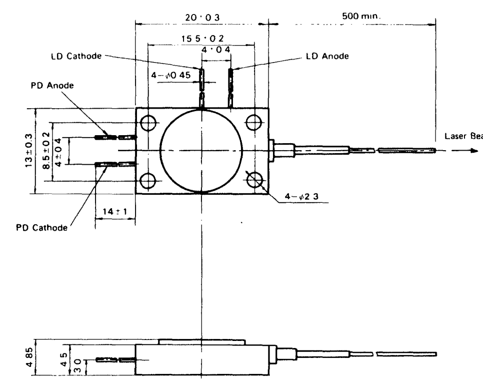
- Lasing between 1270 and 1330nm.
- Continuous and pulsed wave operation up to 1.2 mW at room temperature.
- Fast pulse response: t_r and t_f are less than 0.5ns.
- Photo detector built in for monitoring.
- Hermetic seal for high reliability.

■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

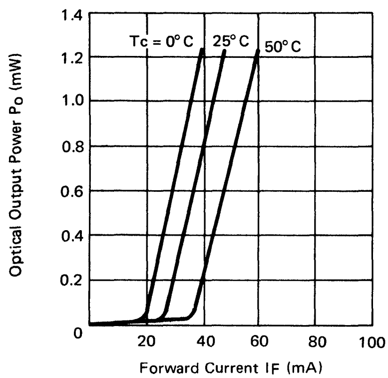
* At the fiber end.

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

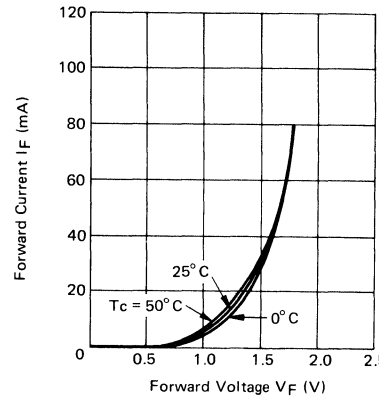
Item	Symbol	Test Condition	HL1321P min	HL1321P typ	HL1321P max	Unit
Threshold Current	I_{th}		–	25	50	mA
Optical Output Power	P_O	Kink free	1.2*	–	–	mW
		$I_F = I_{th}$ + 20mA	0.4*	–	–	
Peak Wavelength	λp	P_O = 0.5mW *	1270	1300	1330	nm
Dark Current	I_D	$V_{R(PD)}$ = 10V	–	–	200	nA
Monitor Current	I_S	$V_{R(PD)}$ = 10V, P_O = 1.0mW *	70	–	–	μA
Capacitance (PD)	C_j	$V_{R(PD)}$ = 10V, f = 1MHz	–	–	3.5	pF

* At the fiber end.

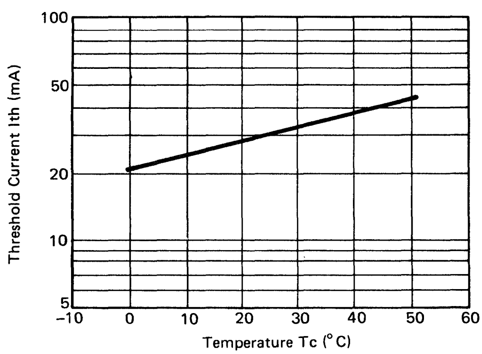
LIGHT – CURRENT



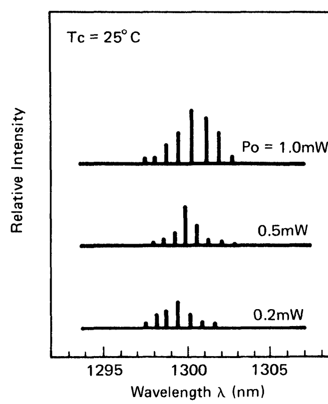
CURRENT – VOLTAGE



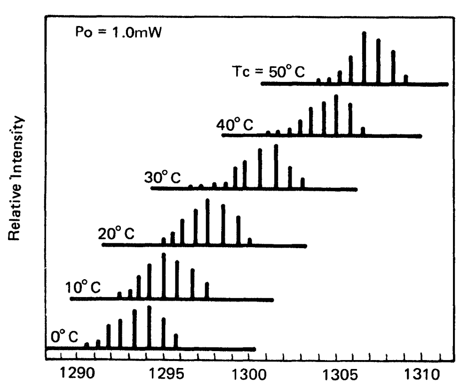
THRESHOLD CURRENT – TEMPERATURE



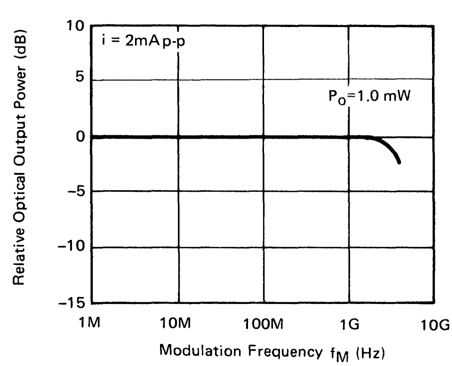
TYPICAL LASING SPECTRUM



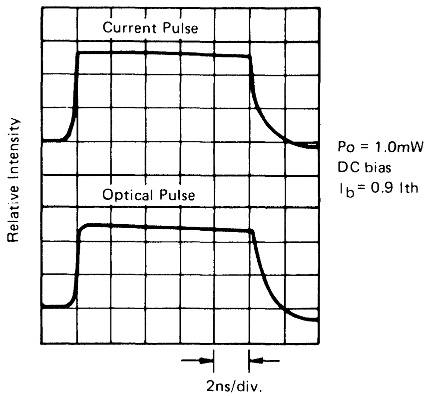
SPECTRUM – TEMPERATURE



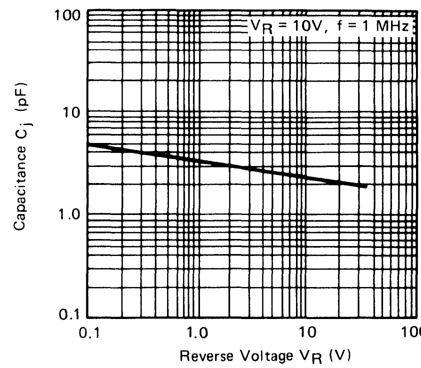
FREQUENCY RESPONSE OF LD



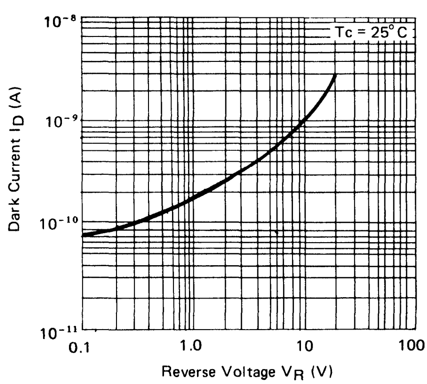
PULSE RESPONSE OF LD



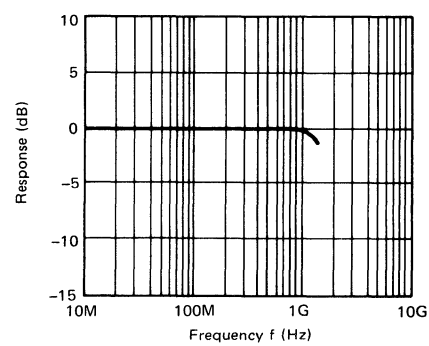
CAPACITANCE – REVERSE VOLTAGE OF PD



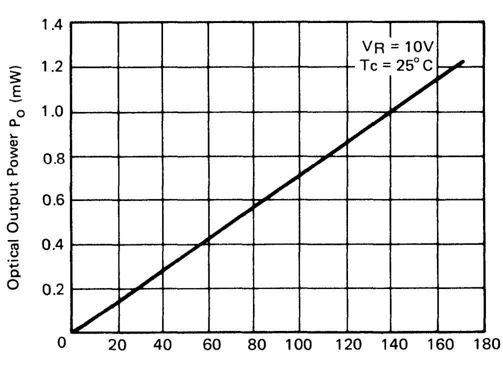
DARK CURRENT – REVERSE VOLTAGE OF PD



FREQUENCY RESPONSE OF PD



OPTICAL OUTPUT POWER – MONITOR CURRENT



HL1321SP

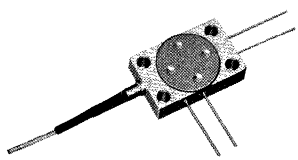
—PRELIMINARY—

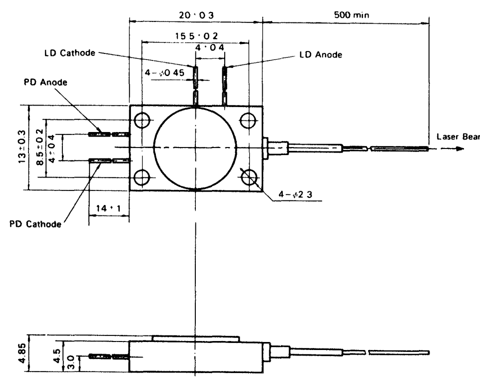
InGaAsP LD

■APPLICATION
- Fiberoptic communication.

■FEATURE
- 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.
- Photo detector built in for monitoring.
- Single mode fiber coupled.
- Hermetic seal for high reliability

■PACKAGE





[Standard Fiber]
$\Delta = 0.30\%$
$\lambda_C = 1.24\ \mu m$
Core Diameter : 10 μm
Outer Diameter : 125 μm
Pigtail Length : 500mm min.

■ 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

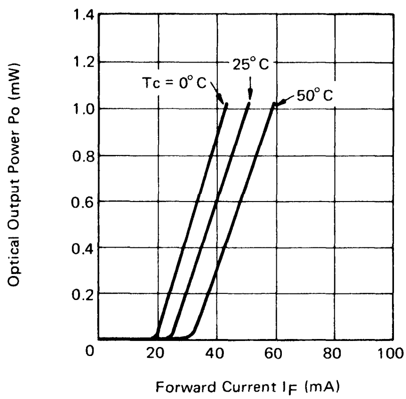
* At the fiber end.

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

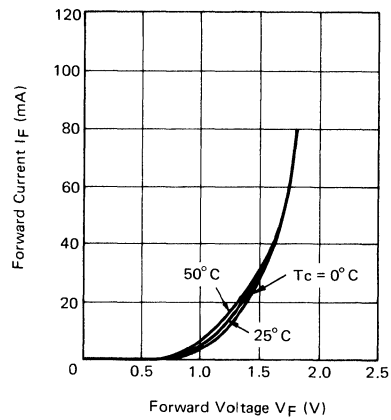
Item	Symbol	Test Condition	HL1321SP			Unit
			min	typ	max	
Threshold Current	I_{th}		–	30	50	mA
Optical Output Power	P_O	Kink free	1.0*	–	–	mW
		$I_F = I_{th} + 20mA$	0.6*	–	–	
Peak Wavelength	λp	P_O = 1.0mW*	1270	1300	1330	nm
Dark Current	I_D	$V_{R(PD)}$ = 10V	–	–	200	nA
Monitor Current	I_S	$V_{R(PD)}$ = 10V, P_O = 1.0mW*	100	–	–	μA
Capacitance (PD)	C_j	$V_{R(PD)}$ = 10V, f = 1MHz	–	–	3.5	pF

* At the fiber end.

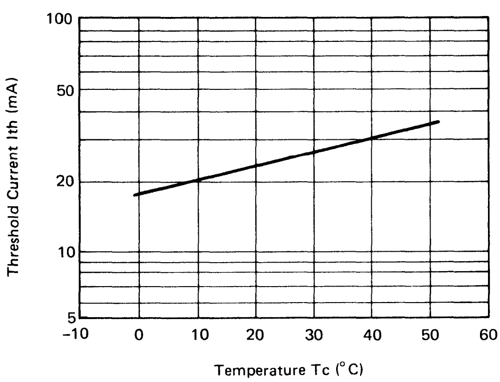
LIGHT – CURRENT



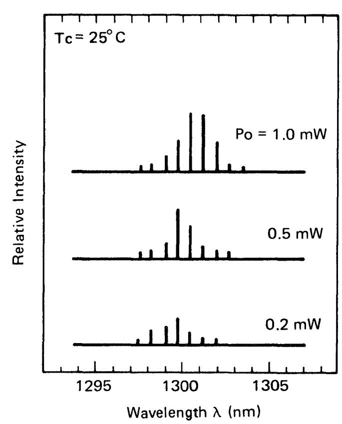
CURRENT – VOLTAGE



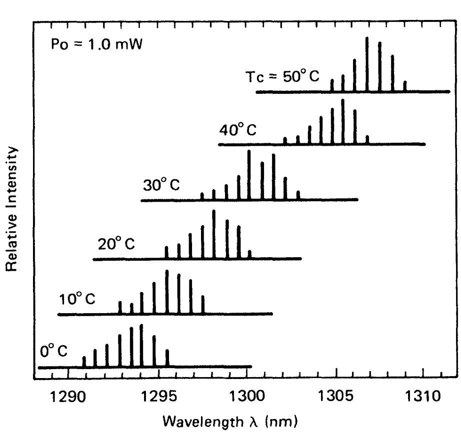
THRESHOLD CURRENT – TEMPERATURE



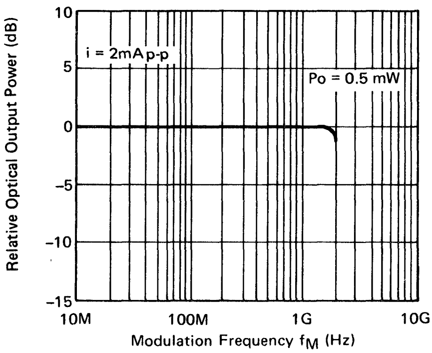
TYPICAL LASING SPECTRUM



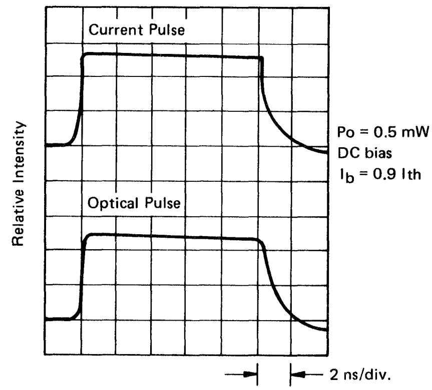
SPECTRUM – TEMPERATURE



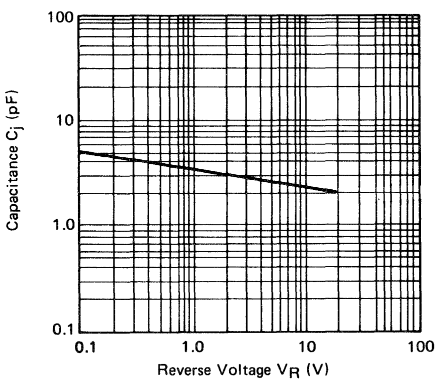
FREQUENCY RESPONSE OF LD



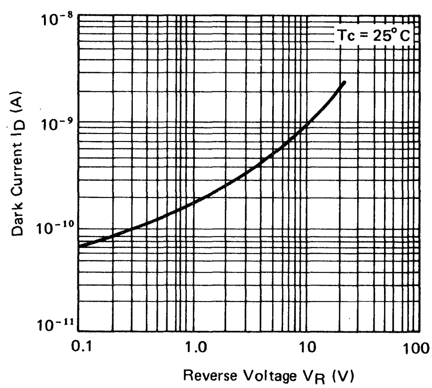
PULSE RESPONSE OF LD



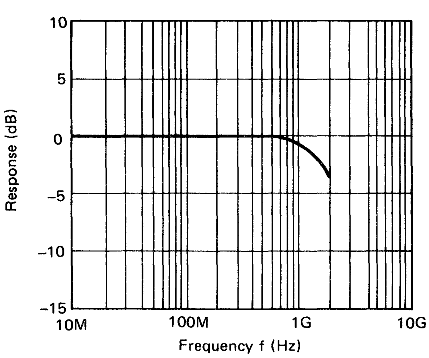
CAPACITANCE –
REVERSE VOLTAGE OF PD



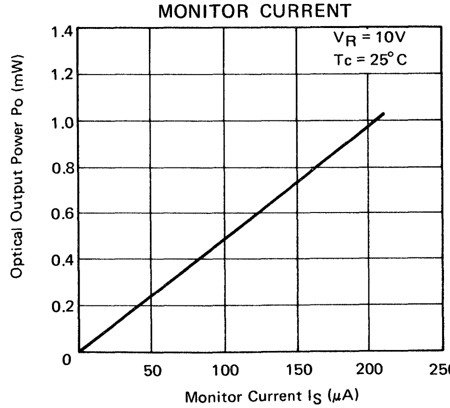
DARK CURRENT –
REVERSE VOLTAGE OF PD



FREQUENCY RESPONSE OF PD



OPTICAL OUTPUT POWER –
MONITOR CURRENT



INFRARED EMITTING DIODES

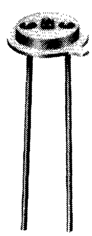
HLP20, HLP30, HLP40, HLP50, HLP60

GaAlAs IRED

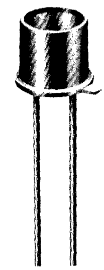
■ **APPLICATION**
- Infrared emitting source.

■ **FEATURE**
- 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.

■ **PACKAGE**

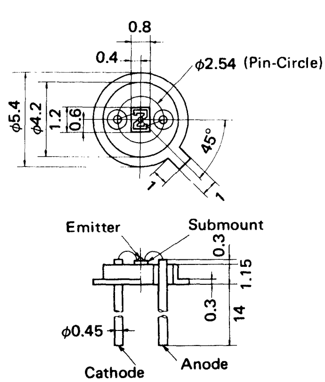


(R-Type)

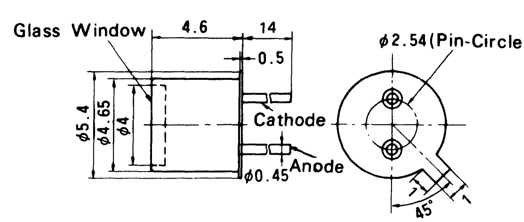


(RG-Type)

■ **PACKAGE DIMENSIONAL OUTLINE (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.

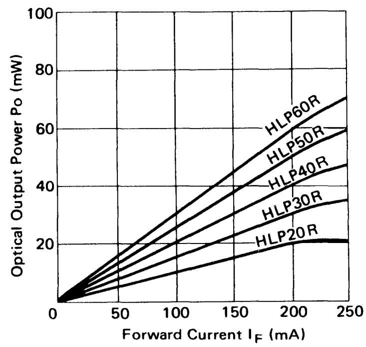
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)

Item		Symbol	Test Condition	min	typ	max	Unit
Output Power		P_O	I_F = 200mA	(cf. Note)**			mW
Wavelength Accuracy		λp					nm
Spectral Width		Δλ		–	30	35	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 λp 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			

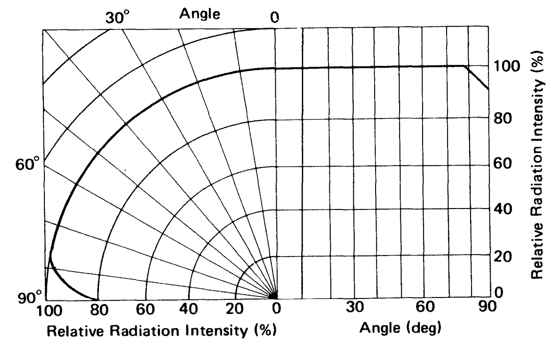
LIGHT – CURRENT



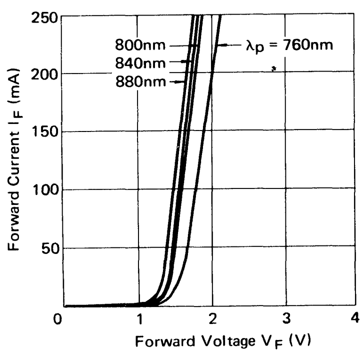
Note) Output Power P_O of RG-Type is half value of R-Type.

RADIATION PATTERN

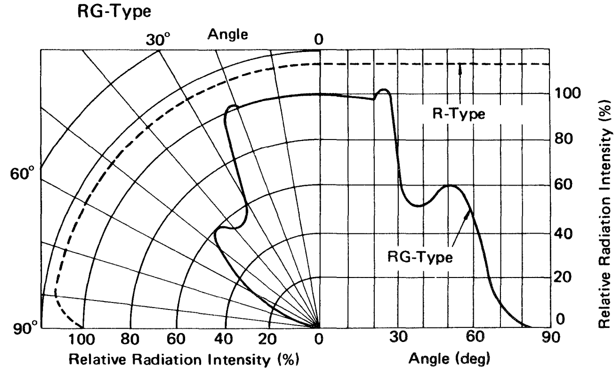
R-Type



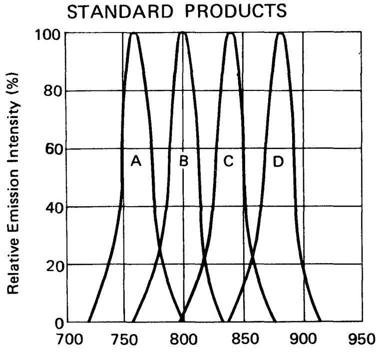
CURRENT – VOLTAGE



RG-Type



EMISSION SPECTRA OF THE STANDARD PRODUCTS



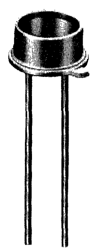
HE8801

GaAlAs IRED

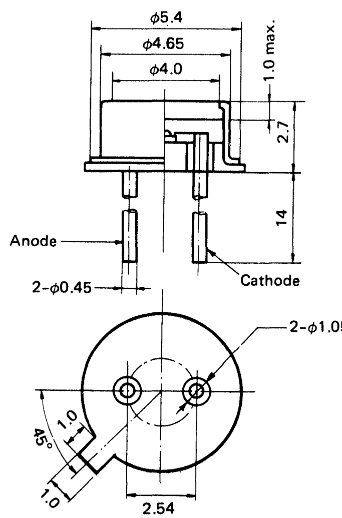
■ **APPLICATION**
- Light source for measuring or any other optical equipments.

■ **FEATURE**
- 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)

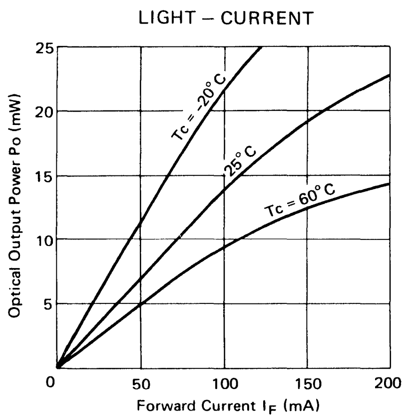


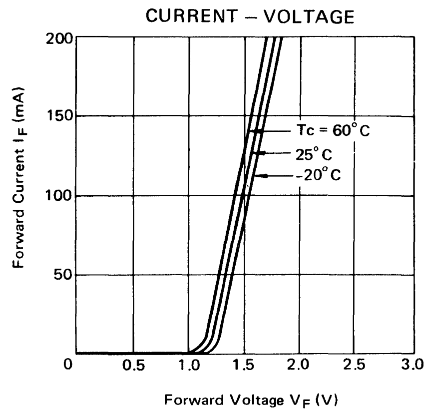
■ **ABSOLUTE MAXIMUM RATINGS** (T_c = 25°C)

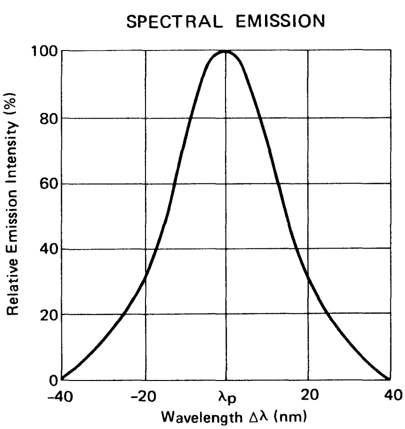
Item	Symbol	HE8801	Unit
Forward Current	I_F	200	mA
Reverse Voltage	V_R	3	V
Power Dissipation	Pd	400	mW
Operating Temperature	T_{opr}	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +90	°C

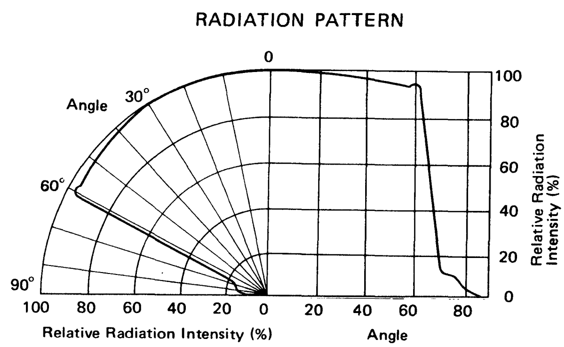
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS** (T_c = 25°C)

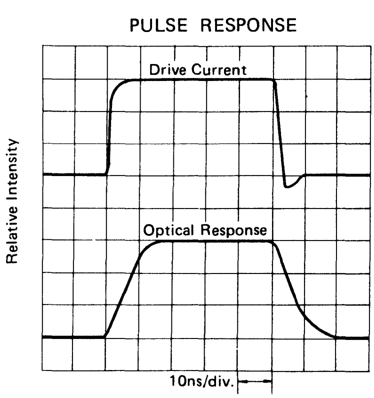
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po	I_F = 150mA	6	20	–	mW
Wavelength Accuracy	λp		800	880	900	nm
Spectral Width	$\Delta\lambda$		–	30	60	nm
Forward Voltage	V_F		–	1.7	2.3	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise and Fall Time	t_r,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


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


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


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


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.

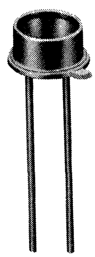
HE8811

GaAlAs IRED

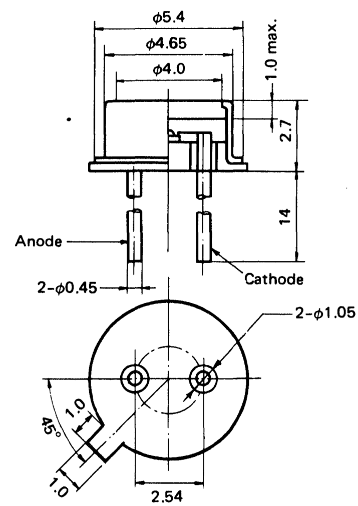
■ **APPLICATION**
- Light source for measuring, optical beam transmission equipments.

■ **FEATURE**
- 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)



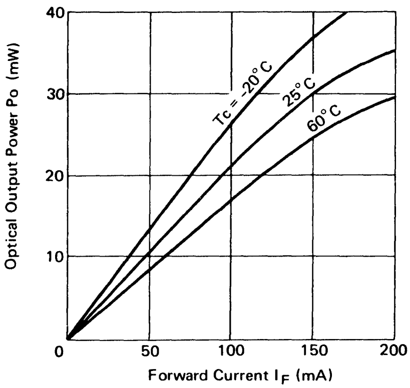
■ **ABSOLUTE MAXIMUM RATINGS** ($T_c = 25°C$)

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

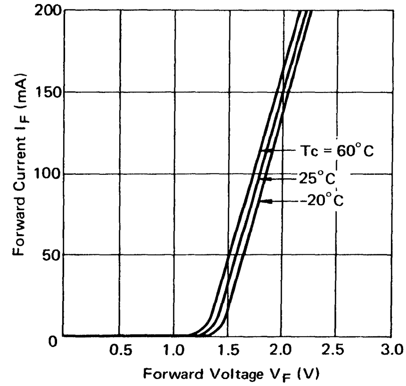
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS** ($T_c = 25°C$)

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

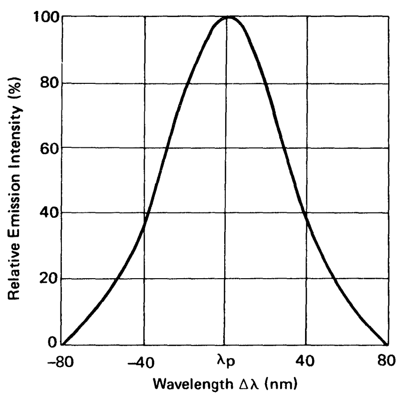
LIGHT – CURRENT



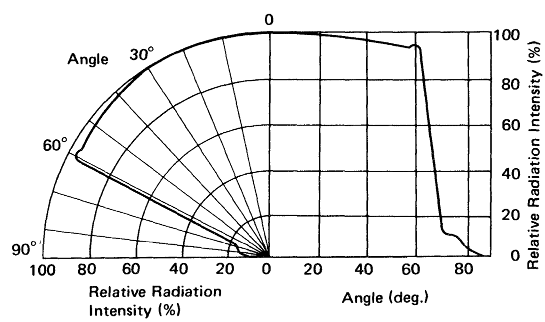
CURRENT – VOLTAGE



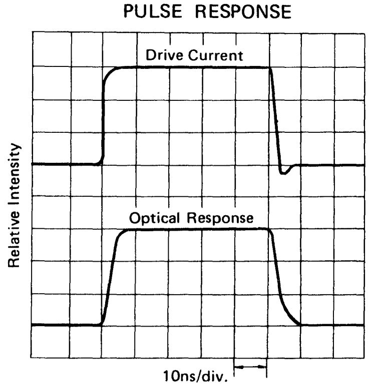
SPECTRAL EMISSION



RADIATION PATTERN



PULSE RESPONSE



HE8402F

GaAlAs IRED

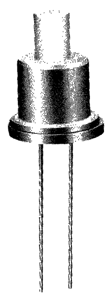
■ **APPLICATION**

- Fiberoptic communication.

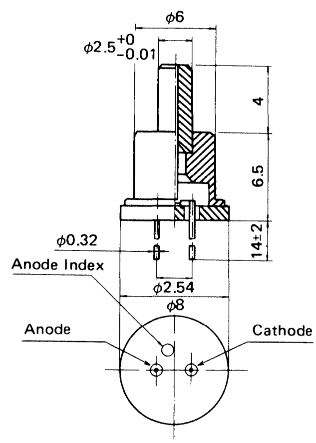
■ **FEATURE**

- 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 ($T_c = 25°C$)

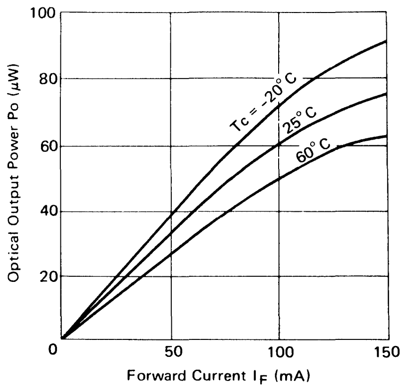
Item	Symbol	HE8402F	Unit
Forward Current	I_F	150	mA
Reverse Voltage	V_R	3	V
Power Dissipation	Pd	350	mW
Operating Temperature	T_{opr}	-20 ~ +60	°C
Storage Temperature	T_{stg}	-40 ~ +90	°C

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

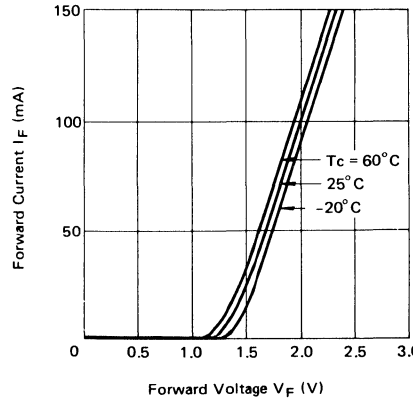
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po	I_F = 100mA	40*	60*	–	μW
Wavelength Accuracy	λp		800	840	900	nm
Spectral Width	$\Delta\lambda$		–	50	–	nm
Forward Voltage	V_F		–	–	2.5	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	10	–	pF
Rise Time	t_r	I_F =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

* Fiber Output Power.

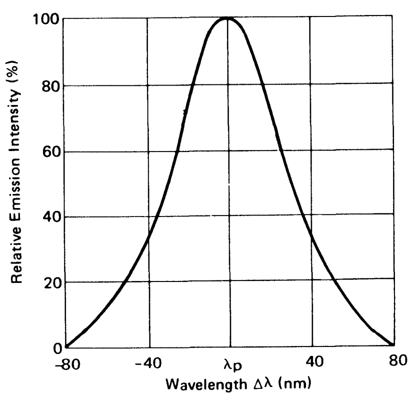
LIGHT – CURRENT



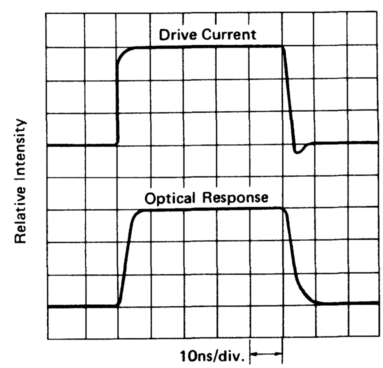
CURRENT – VOLTAGE



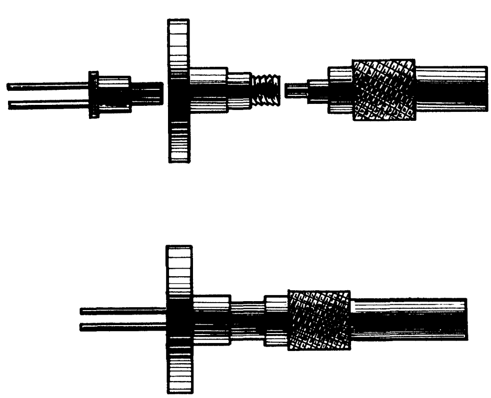
SPECTRAL EMISSION



PULSE RESPONSE



■ **EXAMPLE OF ACTUAL USE**



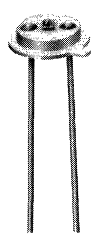
HE8403R

GaAlAs IRED

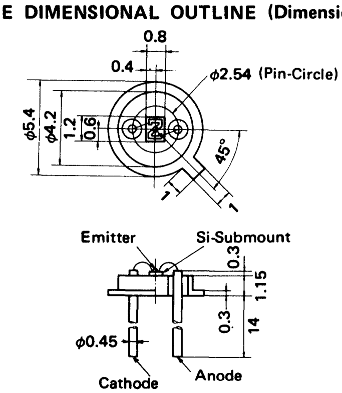
■ **APPLICATION**
- Fiberoptic communication.

■ **FEATURE**
- 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%.

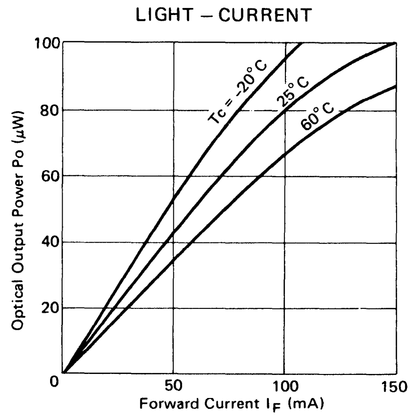
■ **PRECAUTION**

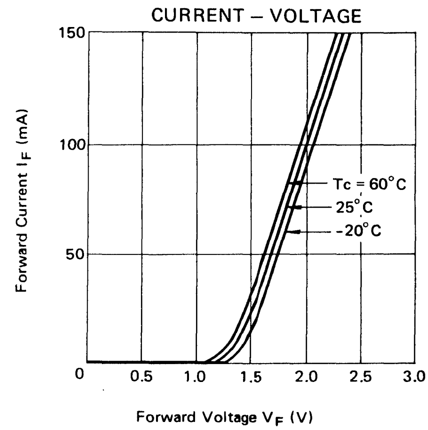
Hermetic seal for the system of this package is recommended, since the chip is exposed to the air.

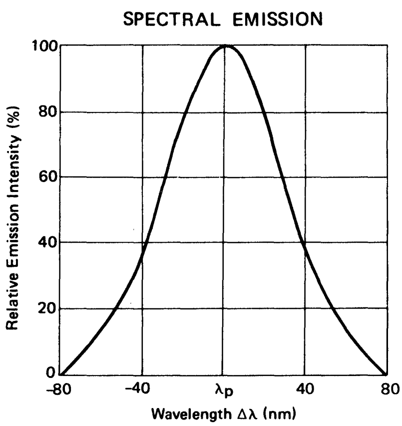
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS ($T_c = 25°C$)**

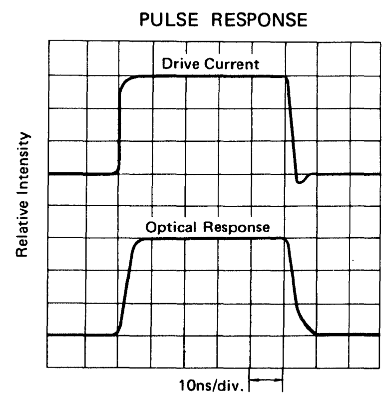
Item	Symbol	Test Condition	min	typ	max	Unit
Output Power	Po *	I_F = 100mA	50	80	–	μW
Wavelength Accuracy	λp	I_F = 100mA	800	840	900	nm
Spectral Width	$\Delta\lambda$	I_F = 100mA	–	50	–	nm
Forward Voltage	V_F	I_F = 100mA	–	–	2.5	V
Reverse Current	I_R	V_R = 3V	–	–	100	μA
Capacitance	C_j	V_R = 0, f = 1MHz	–	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
Optical Output Power Po (μW)
100
80
60
40
20
0
50
100
150
Forward Current I_F (mA)
Tc = -20°C
25°C
60°C


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


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


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

HE1301

InGaAsP/InP IRED

—ADVANCED INFORMATION—

■ **APPLICATION**

- Fiberoptic communication.

■ **FEATURE**

- High frequency response.
- Excellent linearity of light-current characteristics.

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

Item	Symbol	HE1301	Unit
Forward Current	I_F	150	mA
Operating Temperature	T_{opr}	−40 ~ +70	°C
Storage Temperature	T_{stg}	−40 ~ +70	°C

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

Item	Symbol	Test Condition	min	typ	max	Unit
Optical Output Power	P_o	I_F = 100mA	25	–	–	μW
Peak Wavelength	λp	I_F = 100mA	–	1300	–	nm
Spectral Width	$\Delta\lambda$	I_F = 100mA	–	125	–	nm
Reverse Voltage	V_R	I_R = 10μA	1.0	–	–	V
Rise Time	t_r	I_F = 100mA	–	1.5	–	ns
Fall Time	t_f	I_F = 100mA	–	4.0	–	ns

PHOTO DETECTORS

HR8101

—PRELIMINARY—

SILICON PIN DIODE

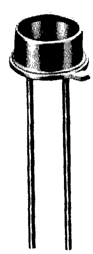
■ **APPLICATION**

- Measuring, communication or any other optical equipments.

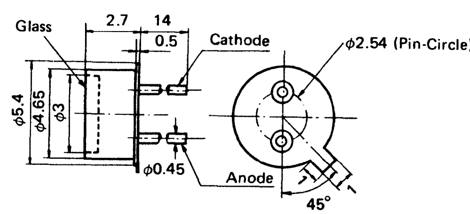
■ **FEATURE**

- Fast response: t_r and t_f are 2ns.
- Hermetic seal for high reliability.

■ **PACKAGE**



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

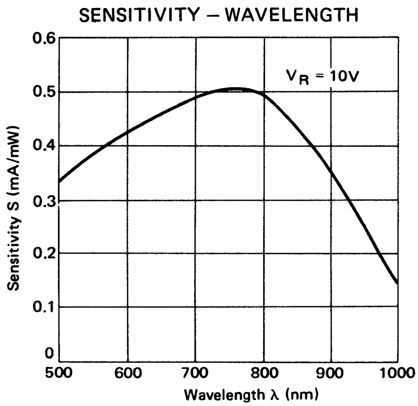


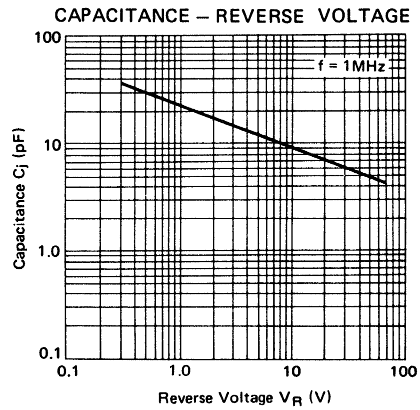
■ **ABSOLUTE MAXIMUM RATINGS (Tc = 25°C)**

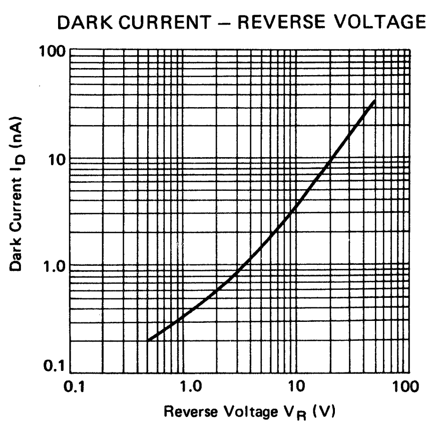
Item	Symbol	HR8101	Unit
Reverse Voltage	V_R	60	V
Forward Current	I_F	100	mA
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	°C

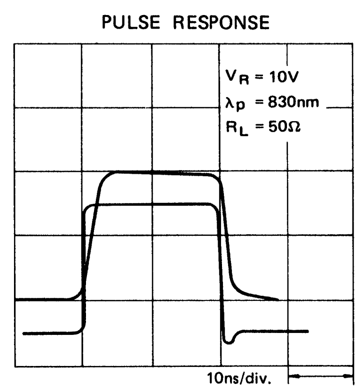
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)**

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_D	V_R = 10V	–	2	10	nA
Capacitance	C_j	V_R = 10V, f = 1MHz	–	10	15	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	–	2	–	ns









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

HR8102

—PRELIMINARY—

SILICON PIN DIODE

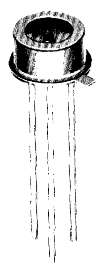
■APPLICATION

- High speed optical communication equipment.

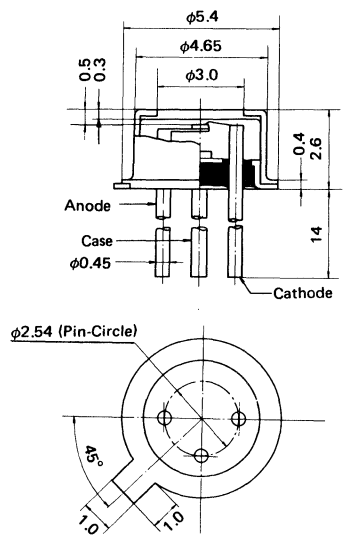
■FEATURE

- 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)



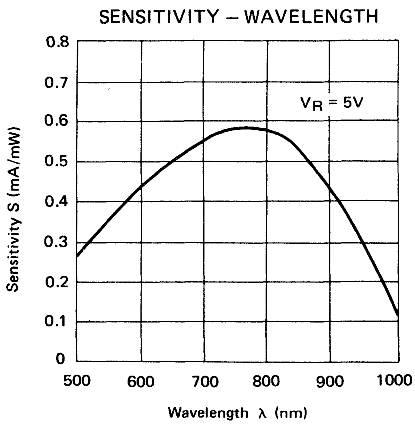
(Bottom View)

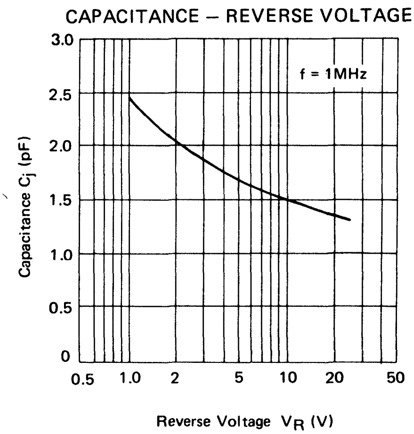
■ ABSOLUTE MAXIMUM RATINGS (T_c = 25°C)

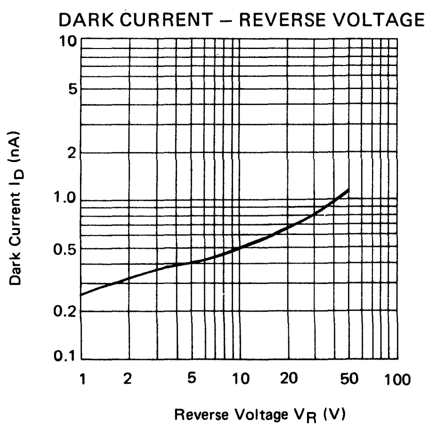
Item	Symbol	HR8102	Unit
Forward Current	I_F	100	mA
Reverse Voltage	V_R	100	V
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	°C

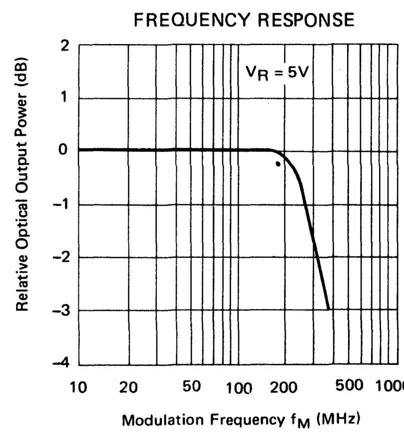
■ OPTICAL AND ELECTRICAL CHARACTERISTICS (Tc = 25°C)

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_D	V_R = 5V	–	0.5	3	nA
Capacitance	C_j	V_R = 5V, f = 1MHz	–	1.5	3	pF
Sensitivity	S	V_R = 5V, λp = 830nm	0.4	–	–	mA/mW
Rise and Fall Time	t_r, t_f	V_R = 5V, λp = 830nm, R_L = 50Ω	–	1	–	ns


SENSITIVITY – WAVELENGTH
Sensitivity S (mA/mW)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
VR = 5V
500
600
700
800
900
1000
Wavelength λ (nm)


CAPACITANCE – REVERSE VOLTAGE
Capacitance Cj (pF)
3.0
2.5
2.0
1.5
1.0
0.5
0
f = 1MHz
0.5
1.0
2
5
10
20
50
Reverse Voltage VR (V)


DARK CURRENT – REVERSE VOLTAGE
Dark Current ID (nA)
10
5
2
1.0
0.5
0.2
0.1
1
2
5
10
20
50
100
Reverse Voltage VR (V)


FREQUENCY RESPONSE
Relative Optical Output Power (dB)
2
1
0
–1
–2
–3
–4
VR = 5V
10
20
50
100
200
500
1000
Modulation Frequency fM (MHz)

HR1101

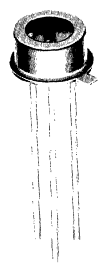
—PRELIMINARY—

InGaAsP PIN DIODE

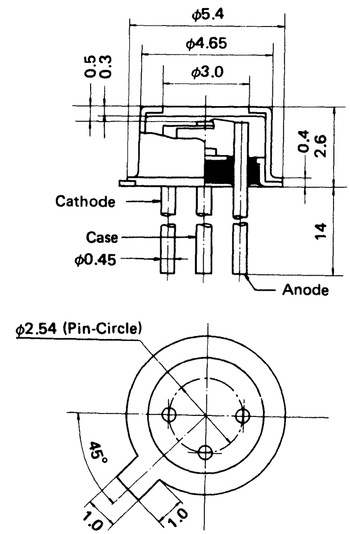
■ **APPLICATION**
- High bit rate fiberoptic communication.

■ **FEATURE**
- High sensitivity.
- High frequency response.
- Hermetic seal for high reliability.

■ **PACKAGE**



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



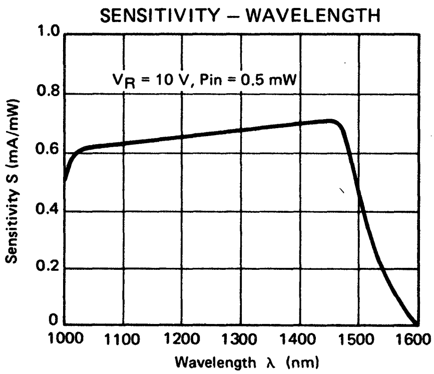
(Bottom View)

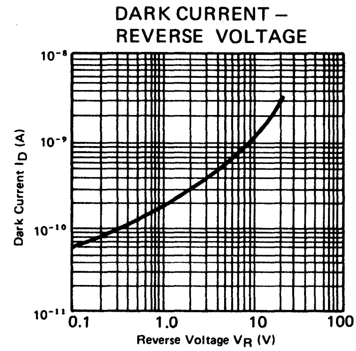
■ **ABSOLUTE MAXIMUM RATINGS** ($T_c = 25°C$)

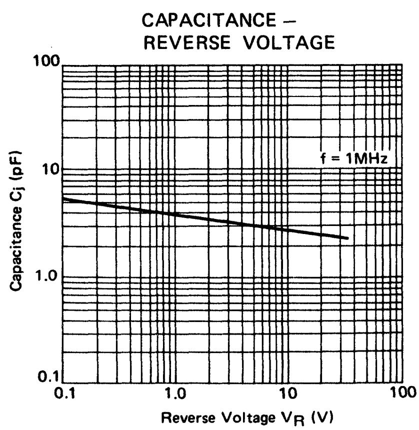
Item	Symbol	HR1101	Unit
Reverse Voltage	V_R	20	V
Forward Current	I_F	1	mA
Operating Temperature	T_{opr}	-40 ~ +80	°C
Storage Temperature	T_{stg}	-45 ~ +100	

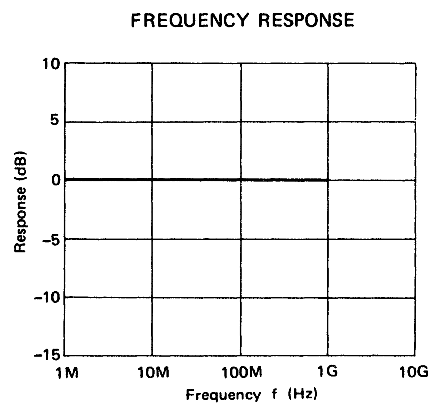
■ **OPTICAL AND ELECTRICAL CHARACTERISTICS** ($T_c = 25°C$)

Item	Symbol	Test Condition	min	typ	max	Unit
Dark Current	I_D	$V_R = 10V$	—	7	200	nA
Capacitance	C_j	$V_R = 10V$, f = 1MHz	—	2.0	3.0	pF
Sensitivity	S	$V_R = 10V$, $\lambda p = 1300nm$, Pin = 0.5mW	0.55	0.7	—	mA/mW
Rise and Fall Time	t_r, t_f	$V_R = 10V$, $\lambda p = 1300nm$, $R_L = 50\Omega$	—	0.5	1.0	ns


SENSITIVITY – WAVELENGTH
VR = 10 V, Pin = 0.5 mW
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 ID (A)
10⁻⁸
10⁻⁹
10⁻¹⁰
10⁻¹¹
0.1
1.0
10
100
Reverse Voltage VR (V)


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


FREQUENCY RESPONSE
Response (dB)
10
5
0
–5
–10
–15
1M
10M
100M
1G
10G
Frequency f (Hz)

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