LD2000R
OEM Laser Diode Driver with Analog Modulation

User Guide

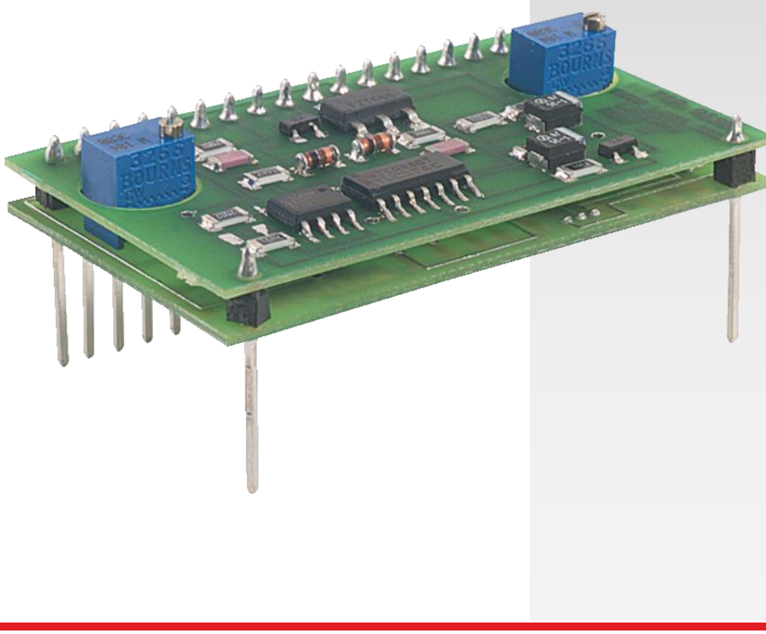
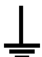
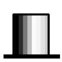


Table of Contents

Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

Chapter 2 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.

SHOCK WARNING

Warning is given when there is danger of injury to users.

CAUTION

Caution is given when there is a possibility of damage to the product.

WARNING

Given when there is danger of injury to users.

Chapter 3 Description

The LD2000R is a low-noise, stable laser diode current source that can be operated with laser diodes having a common laser anode and monitor photodiode cathode. The driver operates in an automatic power control (APC) mode using the built-in monitor photodiode integrated in the laser diode for feedback or a constant current (CC) mode. On board trimpots are provided for controlling the laser power and current limit. Both functions can also be controlled via an external voltage source. The LD2000R supports a wide range of laser diodes with drive currents up to 100 mA and photodiode currents from 20 µA to 2 mA. The LD2000R also has an external modulation input to support applications that require modulating the laser output.

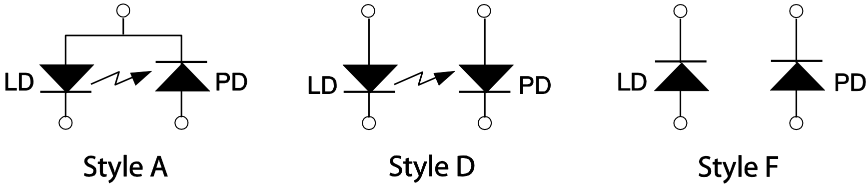


Figure 1 Compatible LD Pin Codes

NOTE

The Laser Diode case must remain floating with respect to both the power supply ground, and the chassis ground.

NOTE

Read the section on Operating Modes (page 11) before attempting to operate the LD2000R.

WARNING

The LD2000R uses CMOS circuitry to minimize power drain. Use anti-static precautions while handling the LD2000R to prevent permanently damaging the device.

Chapter 4 LD2000R Overview

The LD2000R is composed of three independent circuits: slow start circuit, limit current circuit, and output control circuit. Each is described below.

4.1. Slow Start Circuit

The slow start circuit is used to monitor the supply voltage and keep the laser output off until the power supply stabilizes. The slow start circuit uses a voltage reference and a comparator to monitor the supply voltage. An internal 2.5 V reference is compared to the voltage at the ON/OFF pin (pin 17). When this voltage exceeds 2.5 V, the laser is enabled. The comparator input (pin 17, ON/OFF) has an input impedance of 20 kΩ. This resistance is used with an external resistor to form a voltage divider that sets the LD2000R dropout voltage. For most applications a 15 kΩ resistor tied from the 12 V power supply to the ON/OFF pin which disables the laser when the power supply drops below 4.5 V is adequate.

Note, the ON/OFF pin can also be used to disable the laser by pulling this pin low to 0 V.

The slow start circuit uses an internal time constant formed by a 1 MΩ and a 1 µF capacitor to yield a 50 ms turn on delay. This can be extended by adding an external capacitor to the SLOW_START pin.

4.2. Limit Current Circuit

The limit current circuit is a constant current source which can be set by the on-board trim pot or an external control voltage. This determines the maximum drive current that can be supplied to the laser. The transfer function for this control is 40 mA/V. The current limit also determines the laser current when operating in the constant current mode.

4.3. Constant Power Feedback Loop

The constant power feedback loop circuit uses the laser monitor photodiode current (which is proportional to the laser output power) to regulate the laser output power. An internal transimpedance amplifier converts the photodiode current to a voltage used by the feedback circuit. The feedback loop varies the drive current to the laser such that the voltage derived from the photodiode monitor current matches an adjustable setpoint voltage (described below). The laser output can be adjusted by varying the setpoint voltage.

When the current limit is set higher than the laser current needed by the feedback loop the laser is operating in a constant power mode. If the current needed by the feedback loop is higher than the current limit, the laser drive current will be clipped to the current limit and the laser will then be operating in the constant current mode.

The photodiode transimpedance amplifier has an internal gain of 20 kΩ which yields a 50 µA/V output. Since the maximum voltage of the feedback loop is 2.5 V, this limits the maximum photodiode current to 125 µA. This upper limit can be easily increased by adding an external resistor (see page 15).

The setpoint voltage used by the feedback loop is the difference between the PD CURRENT SETPOINT voltage and the Analog Modulation Voltage as follows:

$$V_{Setpoint} = V_{PD\ Current\ Setpoint} - V_{Analog}$$

The control loop integrator has a time constant of approximately 16.5 µs set by a 0.033 µF integrating capacitor. The loop time constant can be extended by adding an external capacitor across CX1 and CX2 .

Note all control signals are based on the photodiode current. The user must refer to the manufactures spec sheets of the particular diode that will be used to correlate this to the laser output power.

4.4. Theory of Operation

The LD2000R uses the internal monitor photodiode provided on most low power diode lasers for feedback when operating in the Constant Power Mode. The following figure is a block diagram of the LD2000R laser driver.

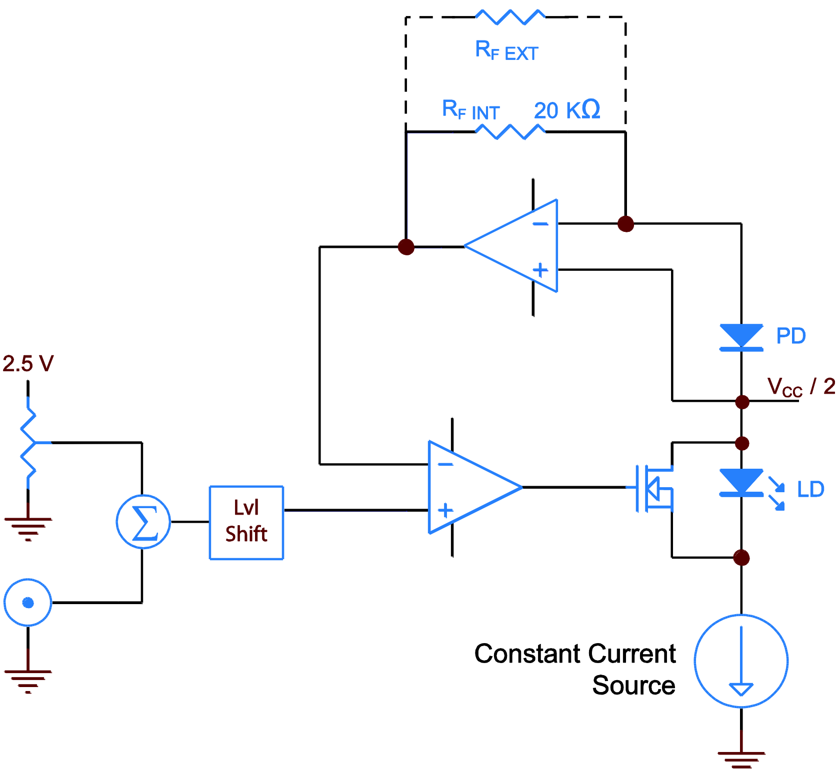


Figure 2 LD2000R Simplified Block Diagram

The laser power is regulated through an integrating feedback loop. The setpoint of the feedback is determined by the PWR LIMIT control trimpot and the OUTPUT ADJUST knob (in external modulation mode, the external voltage is used in place of the OUTPUT ADJUST). An internal transimpedance amplifier converts the laser feedback current to a voltage that is used as the error signal for the feedback loop.

Since all analog signal levels are based on a 2.5 V internal reference, we will use this to derive the feedback gain setting resistor value:

The LD2000R has an internal transimpedance gain of 20 kΩ. Without a user installed feedback resistor, the transimpedance gain is:

$$R_F = 20\ k\Omega$$

and V_{Error} is equal to:

$$V_{Error} = R_F(I_{Mon})$$

where I_{Mon} is the feedback monitor photocurrent. The total transimpedance gain should be set so that the photocurrent at the maximum laser power equals 2.5 V. Since V_{Error} has a maximum value of 2.5 V, we can derive the value of an external feedback resistor needed to set the transimpedance for any laser:

$$R_F = \frac{2.5\ \mathrm{V}}{I_{Mon}}$$

where R_F is the transimpedance gain needed, and I_{Mon} is the monitor photocurrent for your laser.

$$R_F = R_{F\ EXT} \mid\mid 20\ k\Omega$$

$$R_F = R_{F\ EXT} \frac{20\ \mathrm{k\Omega}}{(R_{F\ EXT} + 20\ \mathrm{k\Omega})}$$

solving for $R_{F\ EXT}$,

$$R_{F\ EXT} = \frac{20{,}000}{(8{,}000(I_{MO}) - 1)}$$

Chapter 5 Operating the LD2000R

5.1. Setup

The LD2000R is packaged as a component which, with minimal external components, can be integrated into a system to make a complete laser diode driver system. We recommend using printed circuit board construction to achieve optimum results. The pinouts for the LD2000R are provided in Figure 1 and described below. The LD2000R can be used with A, D, or F style diodes. The D and F style diodes will need to be configured like an A style diode (see page 3 for diagrams). Please note that the EK2000 is not compatible with the F Pin Style.

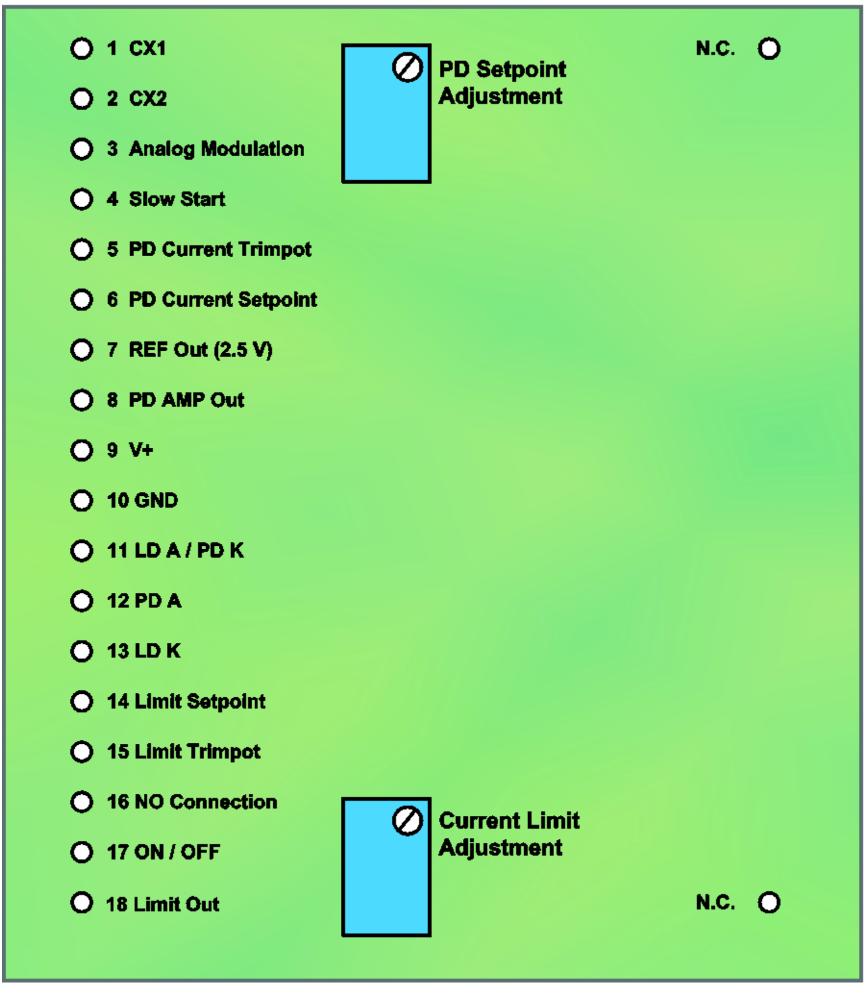


Figure 3 LD2000R Pin Out

Pin	Name	Description
1	CX1	These pins are provided for connecting an external capacitor to the control loop integrator to extend the integrator time constant. This may be necessary to get maximum bandwidth when using TTL modulation. Connect the positive terminal of the cap to CX2.
2	CX2	
3	Analog Modulation	This pin is used with an external voltage signal source to provide analog modulation. The transfer function (referenced to the photodiode current) is -50 µA/V with 0 V being the laser completely on. The laser output decreases as this voltage increases with the laser being completely off at 2.5 V. Connect this pin to ground when not using the analog modulation.
4	Slow Start	This output pin is high during the startup period and goes low when the laser is enabled. It can be used as a LASER EMISSION indicator. An external capacitor can be connected from this pin to ground to extend the slow start delay time. Note: this output will not drive an LED directly and must be buffered. Contact Tech Support for more details.
5	PD Current Trimpot	This pin is connected to the wiper of the on-board PD Current Trimpot. Connect this pin to the PD Current Setpoint to control the PD current with the on-board trimpot.
6	PD Current Setpoint	This pin controls the PD Current according to a transfer function of 50 µA/V with 0 V being the laser is completely off (0 PD current). The laser output increases as this voltage increases.
7	REF Out	This is a buffered 2.5V voltage reference.
8	PD AMP Out	This is an analog voltage proportional to the photodiode current and referenced to one half the supply voltage as follows: $V_{PD\ Amp} = \frac{V^+}{2} - R_F(I_{PD})$, where R_F = PD Amp Transimpedance gain (internal 20 kΩ in parallel with $R_{F\ EXT}$)
9	V^+	Positive supply voltage (8 to 12 VDC).
10	GND	Power supply common.
11	LD A/PD K	Common laser diode anode, photodiode cathode.
12	PD A	Photodiode anode.
13	LD K	Laser diode cathode.
14	Limit Setpoint	This voltage determines the maximum laser drive current according to the transfer function 40 mA/V.
15	Limit Trimpot	This is connected to the wiper of the Limit Current trimpot. Connect this to the Limit Setpoint pin to use the on-board trimpot to set the current limit.
16	Not used	This must be tied to ground to operate the laser.
17	ON/OFF	This pin is used to externally turn the laser on and off through the slow start circuit and to set the low voltage dropout point. It has an internal 20 kΩ resistor to ground. Connect a 15 kΩ resistor to the power supply voltage to set the dropout voltage to 4.5 V.
18	Limit Out	This is an output voltage proportional to the limit current with a transfer function of 40 mA/V. Use this pin to assist in setting the laser current limit.

5.2. Setting the Feedback Resistor

The LD2000R is configured at the factory for a maximum feedback gain. This gain setting is appropriate for lasers that have low monitor currents in the range of 20 to 120 μA.

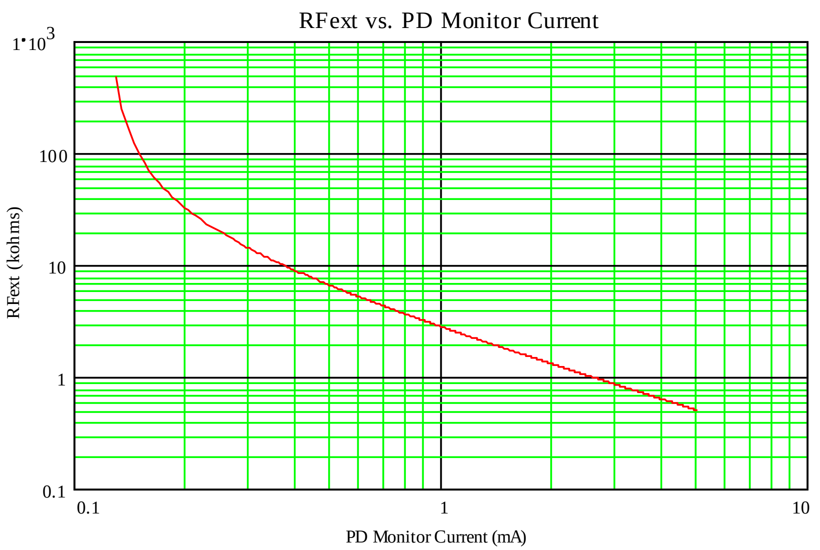
For most lasers, the photodiode current is greater than 120 μA and the feedback gain will have to be reduced to drive the laser at full drive current. This can be done by following the procedure below.

1. Determine the appropriate feedback gain using the following calculation:

$$R_{F\ EXT} = \frac{20{,}000}{(8{,}000 I_{MO} - 1)}$$

   where $R_{F\ EXT}$ is the external gain setting resistor to be added in ohms and I_{MON} is the monitor current for a particular laser in Amps.

2. Pick the nearest standard value resistor (0.25 W, 5% or better).
3. Connect $R_{F\ EXT}$ across pins 8 and 12 of the LD2000R.



SHOCK WARNING

The LD2000R uses CMOS circuitry to minimize power drain. Use anti-static precautions while handling the LD2000R to prevent permanently damaging the device.

5.3. Operating Modes

NOTE

For all modes of operation, we recommend using a linear DC power supply or battery. Although the LD2000R provides over -60 dB of power supply suppression, switch-mode power supplies should be avoided due to the inherent transients in their output.

5.3.1. CW Operation

To operate the LD2000R in a CW mode, follow the steps below.

1. Connect your laser diode to the appropriate pins (11, 12, 13)
2. Attach a suitable DC voltage supply to pins 9 and 10. The power supply should be bypassed near the LD2000R with a 10 µF tantalum capacitor and a 0.1 µF ceramic capacitor.
3. Short pins 5 and 6 to use the on-board PD Current Trimpot.
4. Short pins 14 and 15 to use the on-board Current Limit Trimpot.
5. Short pin 3 to ground to set analog modulation to FULL ON.
6. Short pin 16 to ground.
7. Turn both the PD Current Trimpot and the Current Limit Trimpot counterclockwise 20 turns each to set these at their minimum operating points.
8. Turn the DC power supply on and use a voltmeter to monitor the LIMIT OUT on pin 18.
9. Adjust the Current Limit Trimpot clockwise slowly while observing the LIMIT OUT to set the maximum operating current for your laser (refer to laser manufacturer's data sheets). Note, this output is 40 mA/V.
10. Using a calibrated power meter to monitor the diode laser output, slowly adjust the PD Current Setpoint trimpot clockwise to obtain the desired operating power level. The laser will begin to emit upon reaching the drive current threshold.

5.3.2. Analog Modulation

To operate the LD2000R analog modulation feature, follow the setup procedures for CW Operation to establish the laser operating conditions. Once the LD2000R has been setup for your laser, remove the short from pin 3 to ground and apply a positive voltage to pin 3 to modulate the laser.

1. The analog modulation voltage has a negative transfer function characteristic. That is, at 0 V, the laser is fully on, at 2.5 V the laser should be completely off.

2. The linear operating range of the analog modulation is determined by the transimpedance gain of the PD Amplifier, R_F. The appropriate transimpedance gain for your laser can be calculated as follows:

$$R_F = \frac{2.5\ \text{V}}{I_{MON}}$$

Where I_{MON} is the PD current specified by the laser manufacturer for the maximum operating output power.

Note, the LD2000R includes an internal 20 kΩ resistor. R_F is the net resistance of the internal 20 kΩ resistor with any external resistance added in parallel on pins 8 and 12. To calculate the external resistance ($R_{F\ EXT}$) needed to operate at a particular monitor current (I_{MON}), use the following equation:

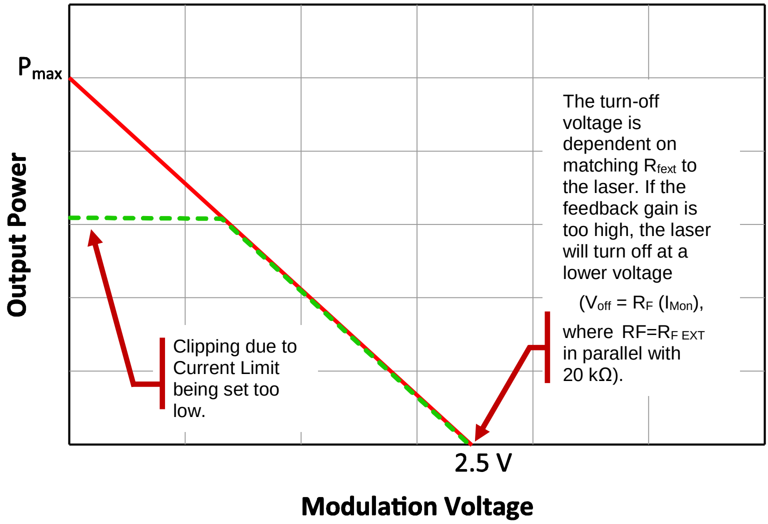
$$R_{F\ EXT} = \frac{50{,}000}{(20{,}000 I_{MO} - 2.5)}$$

5.3.3. External Modulation Operation

The laser output power can be controlled via an external modulation voltage while operating in the Constant Power Mode. The laser output is inversely proportional to the modulating voltage with 0 V being the laser fully on and 2.5 V turning the laser fully off.

1. To use the external modulation, perform the following steps:
2. Set up the LD2000R for Constant Power.
3. Attach an external modulation source (e.g. function generator, D/A converter, etc.) to the Analog Modulation Input (pin 3).
4. Apply power to the LD2000R and adjust the modulation input amplitude and frequency for the desired output.
5. The laser output will now be controlled by the external modulation voltage.

The graph above describes the characteristic of the modulation voltage. If the LD2000R is set up to match a particular laser, the solid curve would represent the output power of the laser as a function of the modulation voltage. A couple of notes of interest:



1. If the PWR Limit control is set below the maximum output power, the laser output will plateau (clip) at the PWR Limit level for modulations below the PWR limit.

2. If the total feedback gain, RF, is not optimized for the operating laser, the laser turn off point of the output will be different than 2.5V (usually somewhere below 2.5V since the default feedback gain is usually too high for most lasers).

3. If the feedback gain is too low for a laser (i.e. the maximum laser power can be reached at a point somewhere below the maximum setting of PWR Limit, than use care to set the PWR Limit control to the maximum desired operating power before applying the modulating voltage.

Chapter 6 Specifications

Specification	Value
Current Output	
Limit Current Control	Trimpot or External Analog Voltage
Limit Current Range	0 to 100 mA
Limit Accuracy	±1%
Compliance Voltage	$\left(\frac{V^+}{2}\right) - 5I_{Limit}$
Power Output	
Photodiode Current Control	Trimpot or External Analog Voltage
Photodiode Current Range	20 to 125 μA (Factory Configured[1])
Long Term Drift (24 hrs)	<0.1%
Temperature Coefficient	<100 ppm/°C
Analog Bandwidth	
3 db Bandwidth (Nominal)	10 kHz[2]
Power Supply	
Supply Voltage (V^+)	8 to 12 VDC
Supply Current	30 mA Plus Laser Current
General	
Dimensions	2" x 1.3" x 0.5"
Operating Temperature	0 to 40 °C
Storage Temperature	0 to 70 °C
Packaging	PCB DIP, Plastic Encapsulated

[1] *Higher photodiode currents are easily supported by adding a single external resistor.*

[2] *The actual bandwidth is laser dependent.*

Chapter 7 Mechanical Drawing

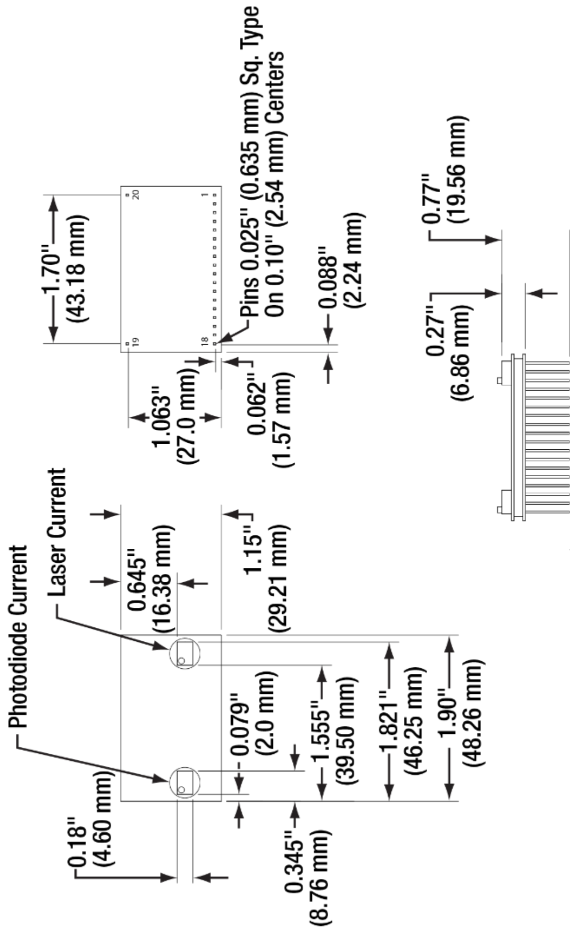
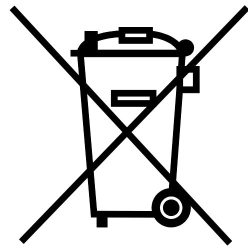


Figure 4 LD2000R Mechanical Drawing

Chapter 8 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e.g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB’s, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 9 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.

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