EK2000
OEM Laser Diode Driver
Evaluation Kit

User Guide

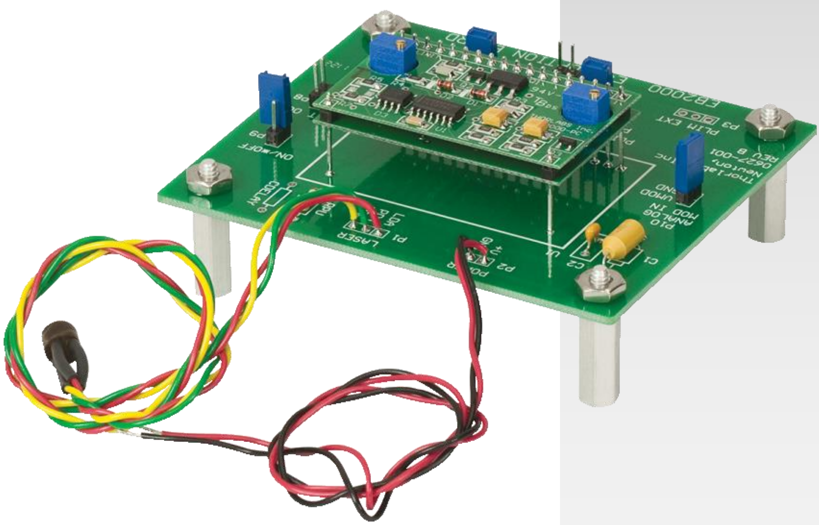
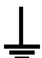
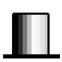


Table of Contents

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.

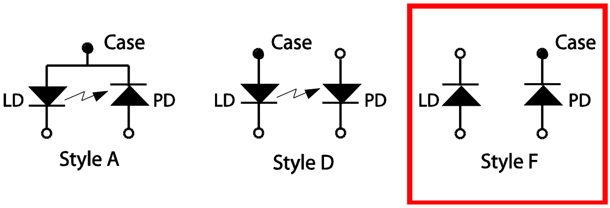
CAUTION
Caution is given when there is a possibility of damage to the product.

WARNING
Given when there is danger of injury to users.

Chapter 3 Description

The EK2000 integrates the LD2000R with an evaluation board pre-wired for use with a laser diode with an A-style pin configuration and a connection for a power supply. The EK2000 allows users to quickly set up the LD2000R with a laser and DC power supply without having to develop a custom PCB or extensive hand wiring.

All of the LD2000R features are supported with convenient, easy to use connector interfaces. 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 photo diode cathode (Pin Style A). The driver operates in an automatic power control (APC) mode using the built-in monitor photo diode integrated in the laser diode for feedback. On board trim pots 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 photo diode currents from 20 µA to 2 mA. The LD2000R also has an external modulation input to support applications that require modulating the laser output.



Style F is NOT supported. The PD is case grounded which is different than Style D's LD case grounded.

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 using the EK2000 (page 4) before attempting to operate the EK2000.

WARNING

The EK2000 uses CMOS circuitry to minimize power drain. Use anti-static precautions while handling the LD2000R to prevent permanently damaging the device.

3.1. Using the EK2000

The diagram below illustrates the typical set up for the EK2000. The user needs to supply their own power supply. We recommend the LDS2 9 VDC Power Supply.

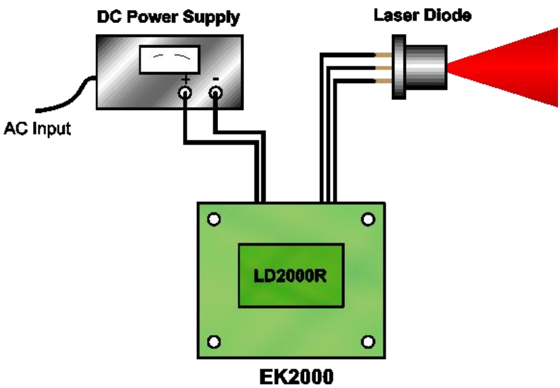


Figure 2 Setup Diagram

Important Note on Power Supplies
Although the LD2000R provides over 60 dB of power supply rejection, a clean DC power supply free of excessive transients and surges is required for ultimate laser protection.

3.1.1. Minimal Configuration

To set the EK2000 up for the simplest configuration (CW mode, no external modulation) follow the steps below:

1. Connect a DC power supply to P2.
2. Connect your laser to P1.
3. Install jumpers in P5 and P6 to enable the on-board trim pots (default position).
4. Install a jumper in P10 to disable the external modulation.
5. Install the appropriate value resistor in RFEXT (see LD2000R Application Notes).

The EK2000 is now set up to operate the laser in a CW mode using the LD2000R on-board trim pots to control the laser drive current.

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.

Table 2. EK2000 Component Descriptions

Ref Des	Description	Pin EK2000	Pin LD2000R	Connection
P1	Laser Connections	1 2 3	11 12 13	Laser Diode Anode Monitor Photodiode Anode Laser Diode Cathode
P2	Power Supply Hookup	1 2	9 10	Power Supply Positive +8 to +12 VDC Power Supply Return
P3	Power Limit External Trim pot (50 kΩ)	1 2 3	7 6 10	CW Terminal (Vref 2.5 V) Wiper Terminal CCW Terminal (GND)
P4	Current Limit External Trim pot (50 kΩ)	1 2 3	7 14 10	CW Terminal (Vref 2.5 V) Wiper Terminal CCW Terminal (GND)
P5	On-Board Current Limit Trim pot Enable.	1 2	14 15	Jumper these 2 pins to enable on-board trim pot.
P6	On-Board Power Limit Trim pot Enable.	1 2	5 6	Jumper these 2 pins to enable on-board trim pot.
P7	Photodiode Amplifier Output Monitor Attach a DVM to these pins to monitor the photo diode transimpedance amp output.	1 2	8 12	These pins can be used to monitor the laser photo diode feedback current. The voltage sensed here will be determined by the transimpedance gain : (i.e. $V= I_{MON} * 20\ k\Omega * RF_{EXT} / (20\ k\Omega + RF_{EXT})$)
P8	Current Limit Monitor (40 mA/V)	1 2	18 10	LIMIT OUT GND
P9	ON/*OFF Shorting these two pins will disable the laser output.	1 2	17 10	ON/*OFF input GND
P10	Analog Modulation Input If external analog modulation is not required, these 2 pins must be jumpered together.	1 2	3 10	ANALOG MOD GND

Ref Des	Description	Pin EK2000	Pin LD2000R	Connection
C2	Power Supply Bypass (0.1 µF ceramic recommended)	1 2	9 10	Unpolarized
CDLY	Adding an external capacitor will extend the turn-on delay cycle.	1 2	17 10	The pad nearest the LD2000R has a positive potential. Attach the + lead of an electrolytic to this pad.
RF EXT	An external resistor can be added here to modify the transimpedance gain of the LD2000R photo diode feedback circuit. This is connected in parallel with the internal 20 kΩ resistor. A mounting location is also provided above the RF EXT to mount a trim pot (e.g. Bournes 3266 series, 1 MΩ) to provide continuous adjustable transimpedance gain.	1 2	8 12	Unpolarized (Refer to the LD2000R Application Notes for a detailed description of the photo diode feedback circuit operation.)
RPU	A 15 kΩ resistor must be installed here in order to operate a laser.	1 2	17 10	Unpolarized

3.1.2. CW Operation

To operate the EK2000 in a CW mode, do the following steps:

1. Connect your laser diode to the pre-wired connector assembly.
2. Attach a suitable DC voltage supply across P2 on the Eval Board. A 1' long prewired cable assembly will be provided. Connect the + voltage to the red wire and the ground to the black wire. The power supply will be bypassed near the LD2000R with a 10 µF tantalum capacitor (C1) and a 0.1 µF ceramic capacitor (C2).
3. Short P6 on the Eval Board to use the on-board PD Current Trim pot (factory default setting).
4. Short P5 on the Eval Board to use the on-board Current Limit Trim pot (factory default setting).

5. Short P10 on the Eval Board to set analog modulation to FULL ON (factory default setting).
6. Short P9 on Eval Board to set ON/*OFF to off position (factory default setting).
7. Turn both the PD Current Trim pot and the Current Limit Trim pot counter-clockwise 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 (P8 on Eval Board).
9. Adjust the Current Limit Trim pot 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 40mA/V.
10. Remove the shorting jumper across P9. Using a calibrated power meter to monitor the diode laser output, slowly adjust the PD Current Setpoint trim pot clockwise to obtain the desired operating power level. The laser will begin to emit upon reaching the drive current threshold.

3.1.3. Analog Modulation

To operate the EK2000 analog modulation feature, follow the setup procedures for CW Operation to establish the laser operating conditions. Once the EK2000 has been setup for your laser, remove the shorting jumper from P10 and apply a positive voltage from P10-VMOD to P10-GND to modulate the laser.

1. The analog modulation voltage has a negative transfer function characteristic. That is, at 0 volts, the laser is fully on, at 2.5 volts the laser should be fully 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 photo diode current specified by the laser manufacturer for the maximum operating output power. Note: the LD2000R includes an internal 20KΩ resistor. R_F is the net resistance of the internal 20KΩ resistor with any external resistance added in parallel on pins 8 and 12. To calculate the external resistance (R_{Fext}) needed to operate at a particular monitor current (I_{MON}), use the following equation:

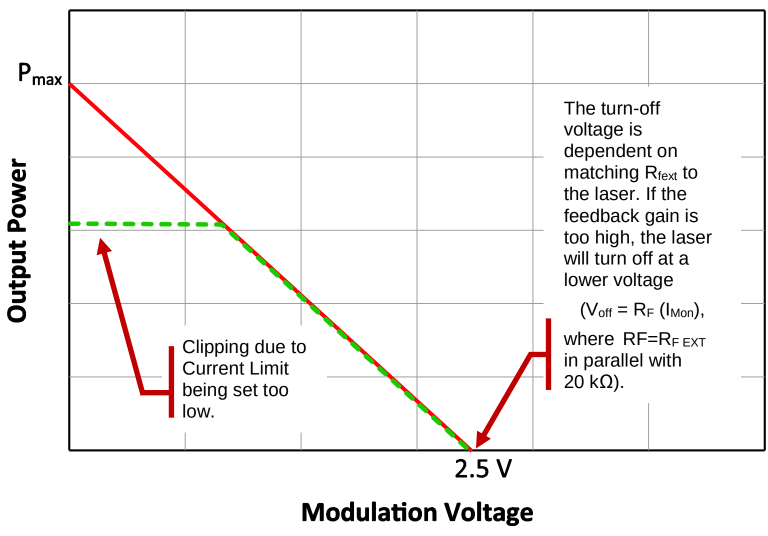
$$R_{F\,EXT} = \frac{50{,}000}{(20{,}000 I_{MO} - 2.5)}$$

3.1.4. 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.

To use the external modulation, perform the following steps:

1. Set up the LD2000R for Constant Power.
2. Attach an external modulation source (e.g. function generator, D/A converter, etc.) to the Analog Modulation Input (P10).
3. Apply power to the EK2000 and adjust the modulation input amplitude and frequency for the desired output.
4. 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.

The table on page 14 lists the descriptions of all the pin outs of the LD2000R. The following sections discuss the operation of the LD2000R.

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.

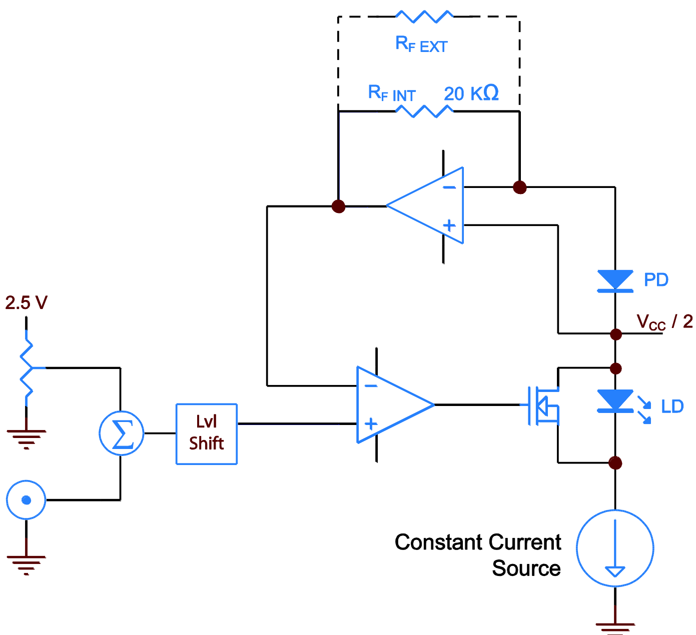


Figure 3 LD2000R Simplified Block Diagram

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:

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

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

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

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

solving for $R_{F\ EXT}$,

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

4.5. 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 17 for diagrams). Please note that the EK2000 is not compatible with the F Pin Style.

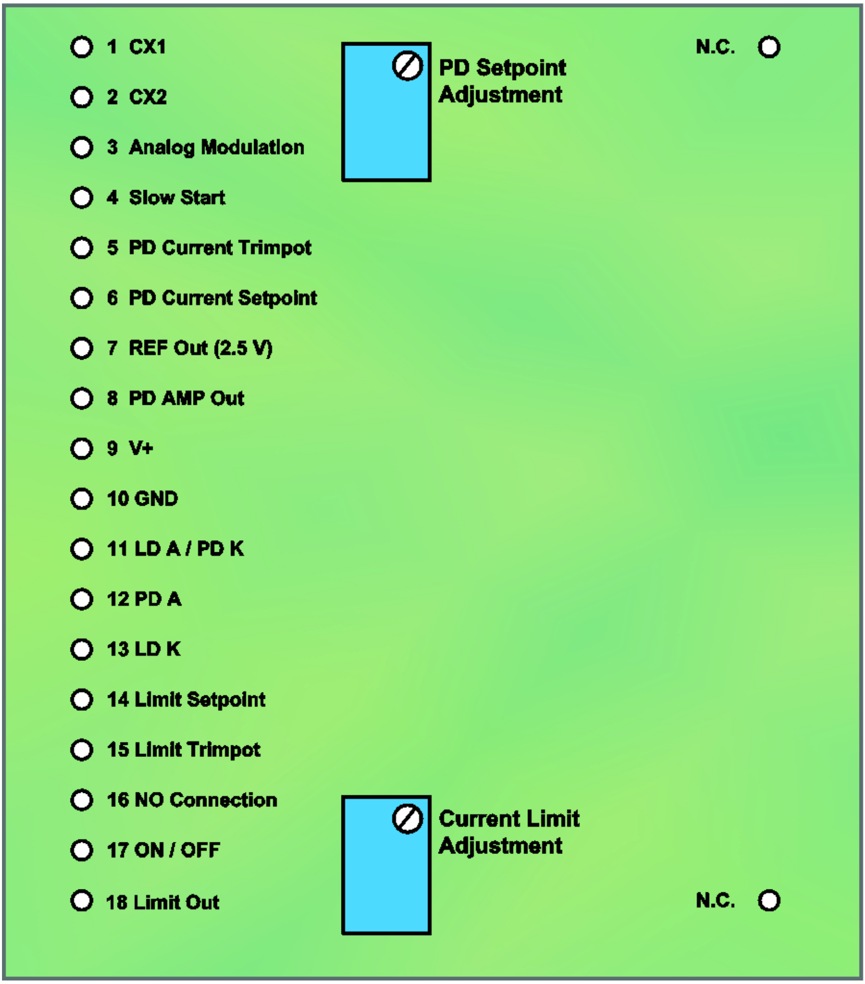


Figure 4 LD2000R Pin Out

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.

4.5.1. 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.

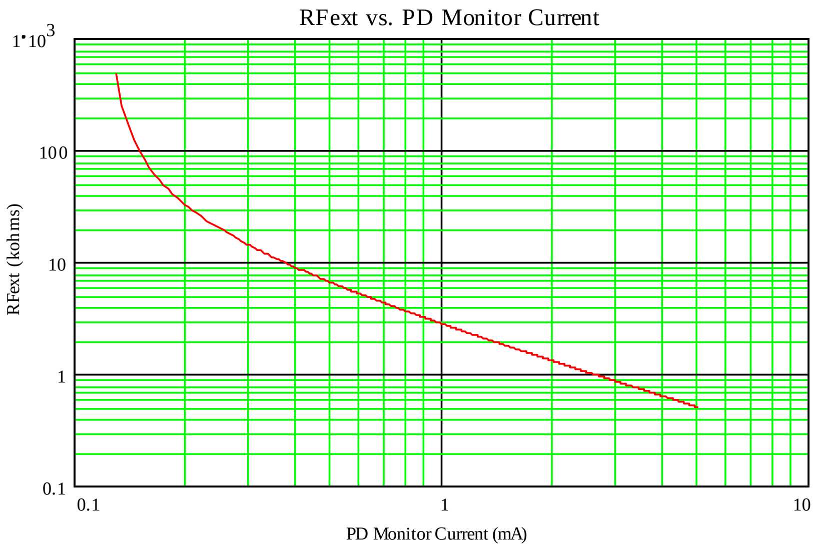
For most lasers, the photodiode current is greater than 120 μA and the feedback gain will have to be reduced to drive the laser at full drive current. This can be done by following the procedure below.

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.

Chapter 5 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	-20 to 60 °C
Storage Temperature	-65 to 150 °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 6 Mechanical Drawings

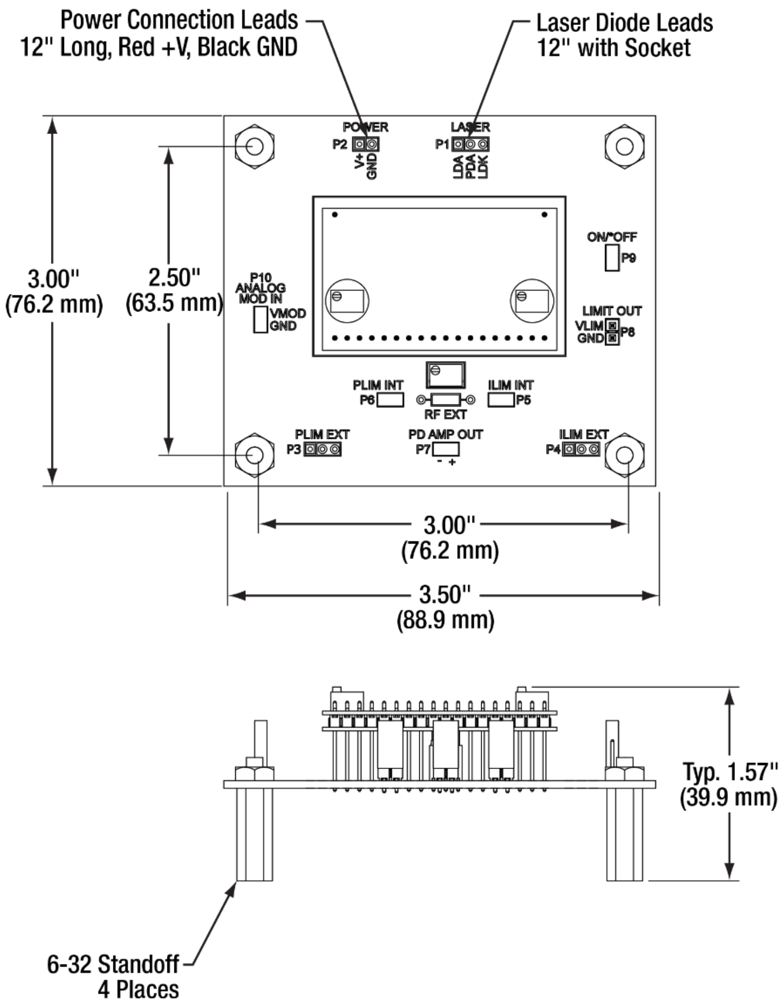


Figure 5 EK2000 Mechanical Drawing

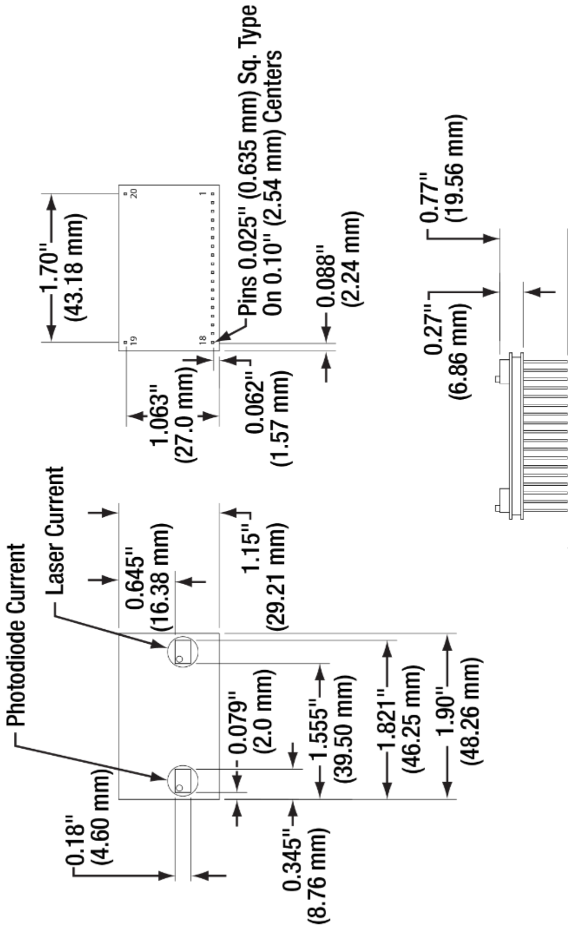


Figure 6 LD2000R Mechanical Drawing

Chapter 7 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 8 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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