



WAVELENGTH
ELECTRONICS

January, 2013

LDD P Series Laser Diode Drivers

Low Noise Driver for Laser Diodes



LDD P Series of Low Noise Laser Diode Drivers

GENERAL DESCRIPTION:

The LDD P Series of laser diode drivers come in three compact models to work with all laser diode / photodiode configurations. Each model is available in 200 mA and 400 mA versions to best fit your laser diode requirements.

When it is essential to have high performance in your application, these low noise drivers offer excellent current stability in constant current mode or power stability in constant power mode.

Precisely control the laser diode or photodiode setpoint current with the on-board Output Current Adjust trimpot or via a remote voltage to the modulation input. The modulation input's small signal 3 dB bandwidth is DC to 2 MHz in constant current mode and dependent on photodiode speed in constant power mode.

Measure laser diode and photodiode current from two buffered monitor outputs.

Optional evaluation boards are available to assist with operating and evaluating any LDD P series module.

FEATURES:

- Up to 400 mA Current Drive Capacity
- Operates in Constant Current or Constant Power Modes
- +5 to +12 V single supply operation
- Output power stability <0.02% typical (24 hours, ambient conditions)
- 12-Turn Trimpots control Current Setpoint and Limit Setpoint
- Operates all low power Laser Diodes
- Constant Current Modulation to 2 MHz
- Slow start circuitry
- Buffered Measurement Outputs

Online Design Tools at
www.teamwavelength.com

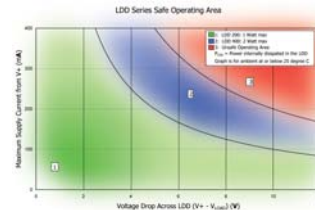
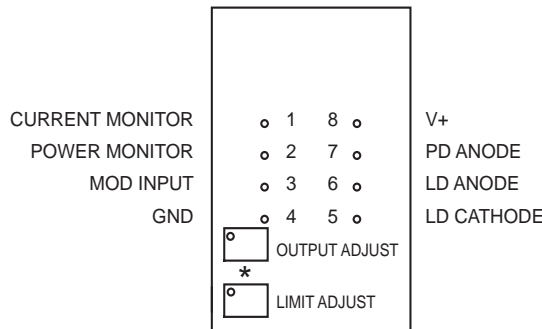


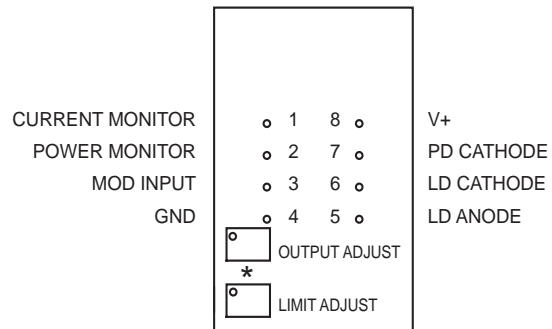
Figure 1
Top View Pin Layout
and Descriptions

TOP VIEW

LDD 1P or LDD 3P



LDD 2P

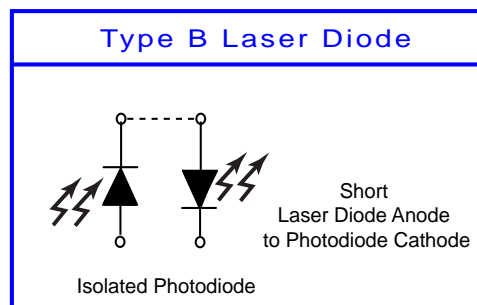
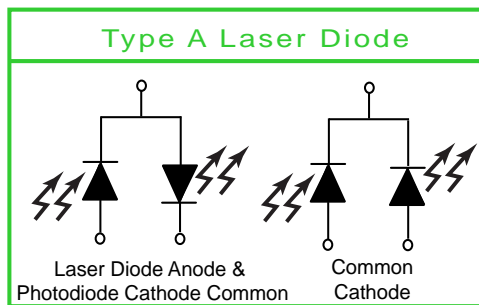
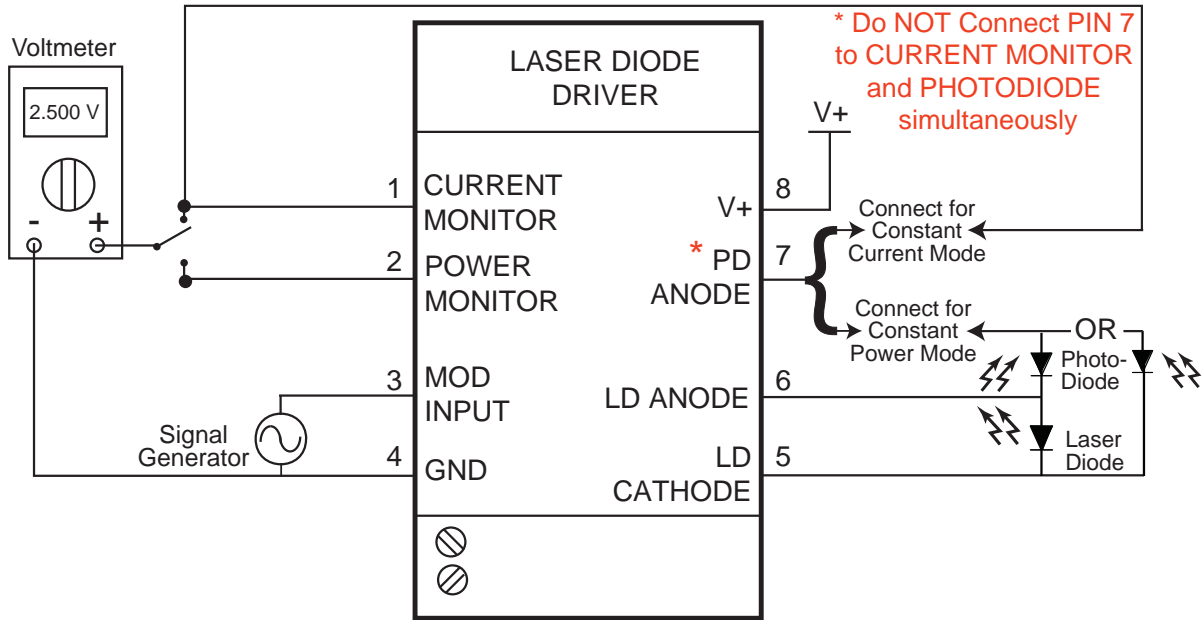


* Trimpots shown for proper orientation

QUICK CONNECT DIAGRAM

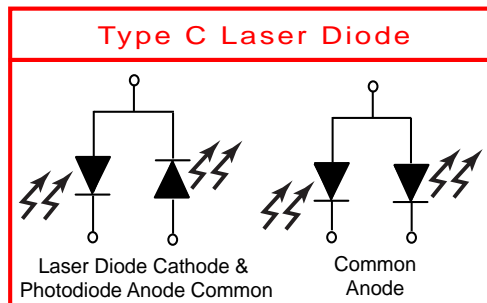
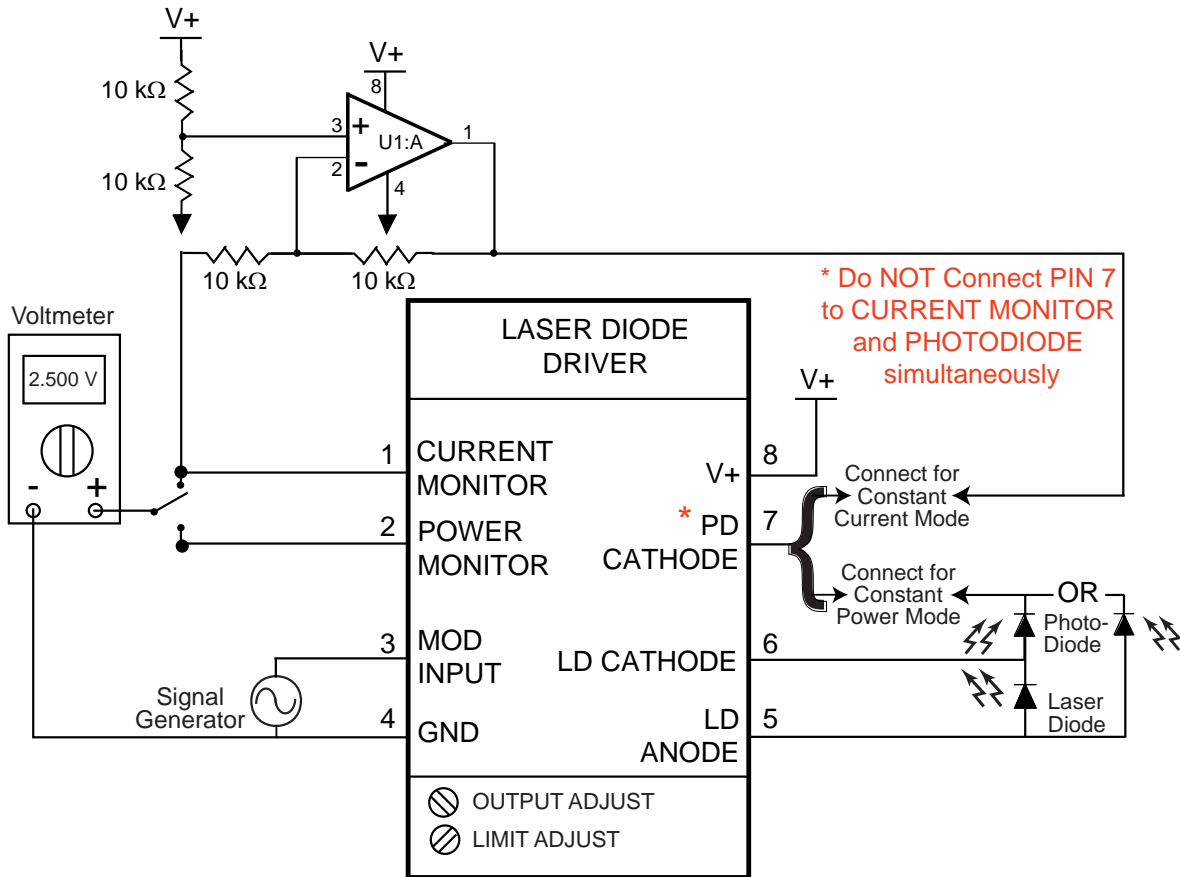
External Connections For LDD 1P or LDD 3P
(Type A/B Laser Diodes)

LDD 1P or LDD 3P Models



QUICK CONNECT DIAGRAM

External Connections For LDD 2P (Type C Laser Diodes)

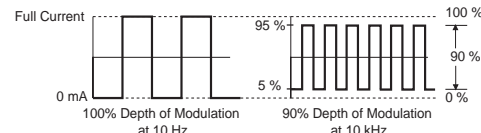


ELECTRICAL AND OPERATING SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS RATING	SYMBOL	VALUE	UNIT
Supply Voltage (Voltage on Pin 8)	V _{DD}	+5 to +12.5	Volts DC
Output Current (See SOA Chart)	I _{LD}	200 or 400	mA
Power Dissipation, T _{AMBIENT} = +25°C [1]	P _{MAX}	1 or 2	Watts
Operating Temp- case, T _{AMB} = +25°C [1]	T _{OPR}	0 to + 50	°C
Storage Temperature	T _{STG}	- 40 to +125	°C
Weight		< 1	oz
Soldering Temp		260°C (10 secs)	

PARAMETER	A or B		A or B		C	
For Laser Type	A or B		A or B		C	
MODEL NUMBER	LDD200-1P	LDD400-1P	LDD200-3P	LDD400-3P	LDD200-2P	LDD400-2P
CONSTANT CURRENT CONTROL	0 - 200 mA	0 - 400 mA	0 - 200 mA	0 - 400 mA	0 - 200 mA	0 - 400 mA
Temperature Coefficient	< 100 ppm / °C		< 100 ppm / °C		< 100 ppm / °C	
Long Term Stability, 24 hours [2]	< 50 ppm		< 50 ppm		< 50 ppm	
Noise and Ripple (rms) [3]	< 5 µA		< 5 µA		< 5 µA	
Current Limit Range	0 - 200 mA	0 - 400 mA	0 - 200 mA	0 - 400 mA	0 - 200 mA	0 - 400 mA
Current Monitor Transfer Function	80 mA / V	160 mA / V	80 mA / V	160 mA / V	80 mA / V	160 mA / V
CONSTANT POWER CONTROL						
Photodiode Range	15-2500 µA		5-125 µA		15-2500 µA	
Power Stability, 24 hours [2]	< 0.02%		< 0.02%		< 0.02%	
Power Monitor Transfer Function	1000 µA / V		50 µA / V		1000 µA / V	
MODULATION						
Input Impedance	1 MΩ		1 MΩ		1 MΩ	
Depth of Modulation (at 10kHz) [4]	90%		90%		90%	
Constant Current						
Bandwidth, small signal sine wave 3dB	up to 2 MHz		up to 2 MHz		up to 2 MHz	
Transfer Function [LD]	-40 mA / V	-80 mA / V	-40 mA / V	-80 mA / V	-40 mA / V	-80 mA / V
Constant Power						
Bandwidth, Constant Power [5]	Depends on PD		Depends on PD		Depends on PD	
Transfer Function [PD]	-500 µA / V		-25 µA / V		-500 µA / V	
Mod Input Safe Range	-0.5V < ModIn < V _{DD} + 0.5V		-0.5V < ModIn < V _{DD} + 0.5V		-0.5V < ModIn < V _{DD} + 0.5V	
POWER SUPPLY						
Voltage, V _{DD} , min	5 V		5 V		5 V	
Voltage, V _{DD} , max	12 V		12 V		12 V	
Current, V _{DD} supply, quiescent	50 mA		50 mA		50 mA	
Power Up Trip Point [6]	4.9 V		4.9 V		4.9 V	
Power Down Trip Point [6]	4.2 V		4.2 V		4.2 V	
Setpoint vs. Monitor Accuracy	< 5%		< 5%		< 5%	
Warm-up to rated accuracy	1 hour		1 hour		1 hour	

- [1]. Maximum Operating Power derates above 25°C. The online Safe Operating Area (SOA) Chart includes this derating. <http://www.teamwavelength.com/support/calculator/soa/soald.php>
- [2]. Stability tests were performed in an ambient air environment.
- [3]. Laser diode forward current noise. Test was performed by measuring the AC voltage across a 50 Ω metal film resistor in series with a laser diode.
- [4]. As squarewave modulation frequency increases, the peak-to-peak output amplitude diminishes. For example, these graphs show the waveform shape at 10 Hz and 10 kHz. Depth of modulation continues to decrease after 10 kHz.
- [5]. Modulation bandwidth in constant power mode depends on photodiode response.
- [6]. The LDD P Series has internal control circuitry which turns the output on and off depending on the voltage at pin 8. When the voltage reaches the power up trip point, the module soft starts the laser diode. When the voltage reaches the power down trip point, the module shunts current around the laser diode, powering it down in a controlled fashion.



LDD 1 P AND LDD 3P

Pin #	Name	Function
1	CURRENT MONITOR	Current Monitor (measures Laser Diode current). 0 to 2.5 V range.
2	POWER MONITOR	Power Monitor (measures Photodiode current). 0 to 2.5 V range.
3	MOD INPUT	Inverting modulation input. 0 to 5 V range.
4	GND	Power supply and monitor common connection.
5	LD CATHODE	Laser Diode Cathode.
6	LD ANODE	Laser Diode Anode. (Pin 6 internally shorted to pin 8.)
7	PD ANODE	Photodiode Anode.
8	V+	Power supply voltage connection. (Pin 6 internally shorted to pin 8.) Supply range: +5 V to +12 VDC

LDD 2 P

Pin #	Name	Function
1	CURRENT MONITOR	Current Monitor (measures Laser Diode current). 0 to 2.5 V range.
2	POWER MONITOR	Power Monitor (measures Photodiode current). 0 to 2.5 V range.
3	MOD INPUT	Inverting modulation input. 0 to 5 V range.
4	GND	Power supply and monitor common connection. (Pin 4 internally shorted to pin 6.)
5	LD ANODE	Laser Diode Anode.
6	LD CATHODE	Laser Diode Cathode. (Pin 6 internally shorted to pin 4.)
7	PD CATHODE	Photodiode Cathode.
8	V+	Power supply voltage connection. Supply range: +5 V to +12 VDC

ORDERING INFORMATION

LDD -
MODEL

200 -
LASER DIODE
CURRENT RANGE

200 = 0 to 200 mA
400 = 0 to 400 mA

1
PHOTODIODE
CURRENT RANGE
&
LASER DIODE PIN
CONFIGURATION

1 = 50 to 2500 μ A (Type A or B lasers)
2 = 50 to 2500 μ A (Type C lasers)
3 = 5 to 125 μ A (Type A or B lasers)

P
FUNCTIONS

P = Laser Diode Current Limit &
Analog Modulation Input



*Evaluation Board and Cable**

Laser Type	Model Number	Description
A, B, or C	LDDPCB-P	Evaluation Board
A, B or C	LDDCAB-50	50 cm cable with 3-pin teflon connector

*LDD P sold separately

Caution:

Do not exceed the Safe Operating Area (SOA). Exceeding the SOA voids the warranty.

To determine if the operating parameters fall within the SOA of the device, the maximum voltage drop across the driver and the maximum current must be plotted on the SOA curves. An online tool for calculating your load line is at <http://www.teamwavelength.com/support/calculator/soa/soald.php>. For any application that includes the LDD Evaluation PCB, be sure to include the appropriate R_D and R_{4a} resistance values in the series resistance in order to achieve an accurate SOA analysis. Resistances are detailed on page 22.

These values are used for the example SOA determination:

$$V_S = 8 \text{ volts}$$

$$V_{LOAD} = 2.5 \text{ volts}$$

$$I_{LOAD} = 300 \text{ mA}$$

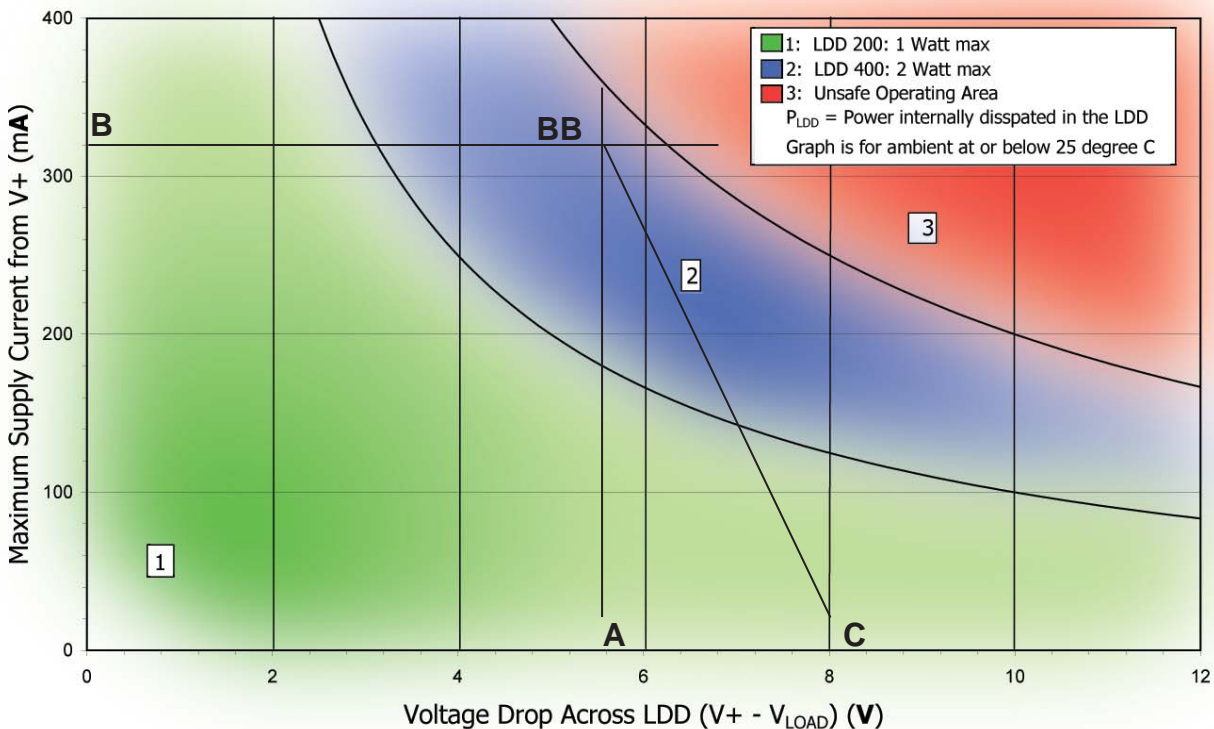
} These values are determined from the specifications of the laser diode.

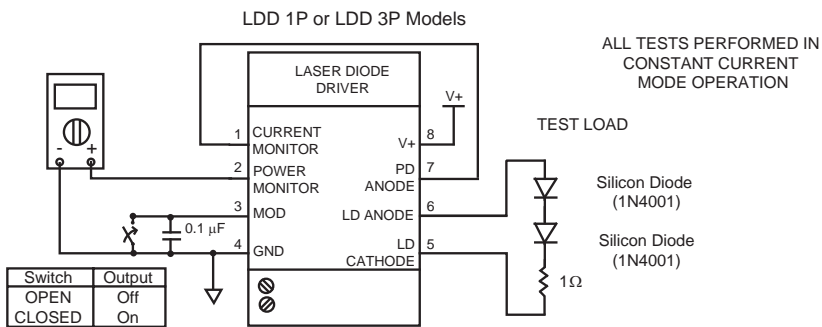
Follow these steps:

1. Determine the maximum voltage drop across the driver, $V_S - V_{LOAD}$, and mark on the X axis.
Example: 8 volts - 2.5 volts = 5.5 volts, Point A)
2. Determine the maximum current, I_{LOAD} , through the driver and mark on the Y axis:
(300 mA, Point B)
3. Draw a horizontal line through Point B across the chart. (Line BB)
4. Draw a vertical line from Point A to the maximum current line indicated by Line BB.
5. Mark V_S on the X axis. (Point C)
6. Draw the Load Line from where the vertical line from point A intersects Line BB down to Point C.

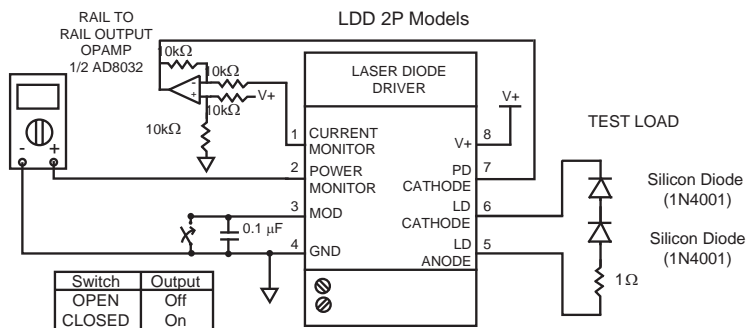
Refer to the chart shown below and note that the Load Line is in the Safe Operating Areas for the LDD400 at 25°C ambient. Note that only Area 1 is safe for the LDD200. Both Areas 1 and 2 are safe for the LDD400.

LDD Series Safe Operating Area





ALL TESTS PERFORMED IN CONSTANT CURRENT MODE OPERATION



Timing Characteristics

Symbol	Parameter	Test Points	Test Conditions *	Typical
t_{DELAY}	Time delay between Power ON and Laser Diode current start	Load	LDD400-1P - 1.0 Ω LDD400-2P - 1.0 Ω LDD400-3P - 1.0 Ω	27.5 ms 27.5 ms 27.5 ms
t_{RISE}	Square Wave Response, 10% to 90%	Load	LDD400-1P - 1.0 Ω LDD400-2P - 1.0 Ω LDD400-3P - 1.0 Ω	120 nsec 220 nsec 120 nsec
t_{FALL}	Square Wave Response, 90% to 10%	Load	LDD400-1P - 1.0 Ω LDD400-2P - 1.0 Ω LDD400-3P - 1.0 Ω	120 nsec 220 nsec 120 nsec
$t_{\text{SOFT START}}$	Minimum (current setpoint 10% full scale)	Load	LDD400-1P - 1.0 Ω LDD400-2P - 1.0 Ω LDD400-3P - 1.0 Ω	140 msec 180 msec 140 msec
	Maximum (current setpoint 100% full scale)	Load	LDD400-1P - 1.0 Ω LDD400-2P - 1.0 Ω LDD400-3P - 1.0 Ω	300 msec 300 msec 300 msec

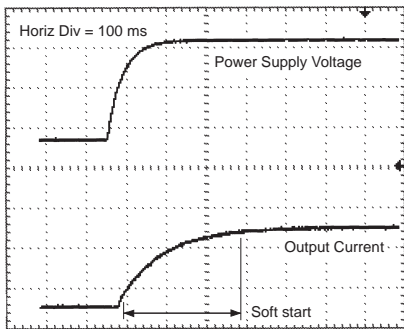
* LDD200 model results are comparable

Note: Keep Operating Setpoint Below Current Limit Setting. These graphs do not represent the LDD P performance while the Current Limit Circuit is triggered.

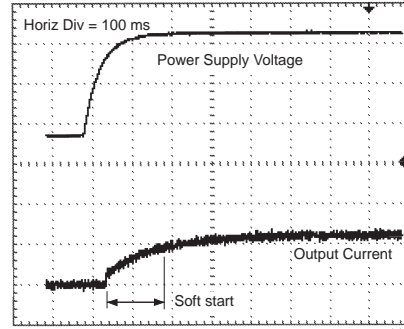
Warning: The Current Limit Circuit is not an absolute/failsafe clamp. If the operating setpoint exceeds the limit setting, and a fast modulation signal is input, very short overshoots of the current limit are possible (150 nsec). If the photodiode feedback signal is lost or very slow, the LDD P can drive to its maximum output current.

TYPICAL PERFORMANCE GRAPHS
LDD 1P & LDD 3P: WHEN NOT IN CURRENT LIMIT

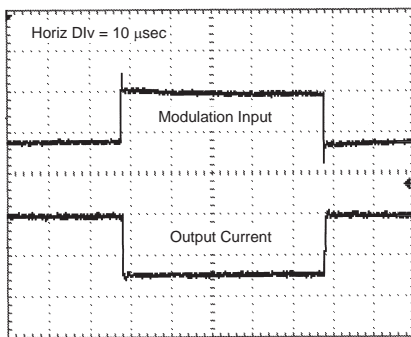
Typical Soft Start Timing
(current setpoint at 100% full scale)



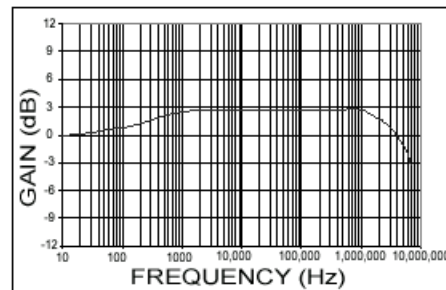
Typical Soft Start Timing
(current setpoint at 10% full scale)



10 kHz square wave response

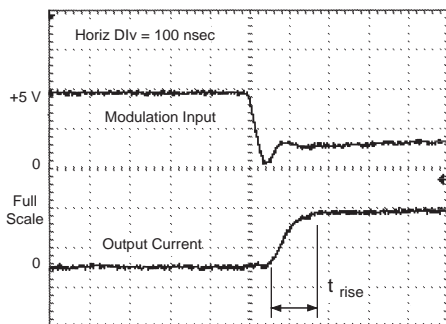


Large Signal Frequency Response

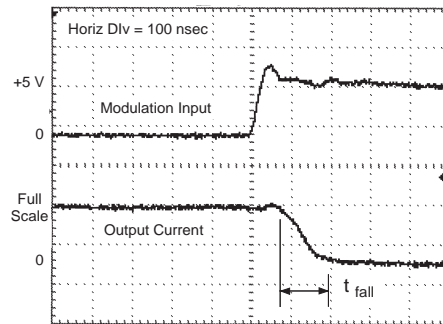


Note: Gain normalized to output at 10 Hz.

10 kHz square wave rise time



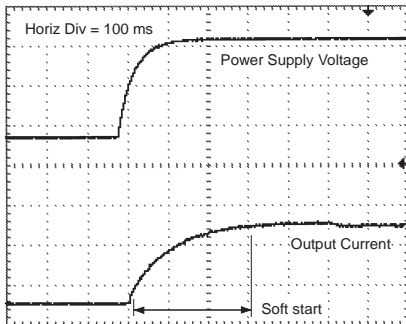
10 kHz square wave fall time



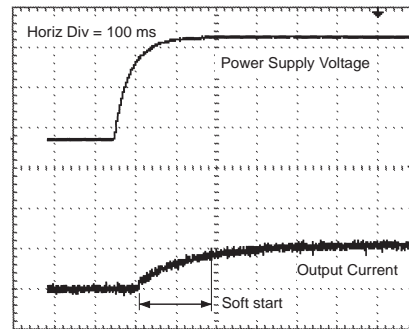
Note: Keep Operating Setpoint Below Current Limit Setting. These graphs do not represent the LDD P performance while the Current Limit Circuit is triggered.

Warning: The Current Limit Circuit is not an absolute/failsafe clamp. If the operating setpoint exceeds the limit setting, and a fast modulation signal is input, very short overshoots of the current limit are possible (150 nsec). If the photodiode feedback signal is lost or very slow, the LDD P can drive to its maximum output current.

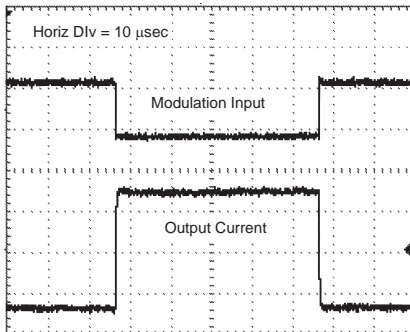
**Typical Soft Start Timing
(current setpoint at 100% full scale)**



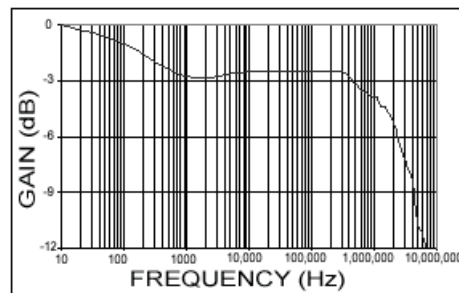
**Typical Soft Start Timing
(current setpoint at 10% full scale)**



10 kHz square wave response

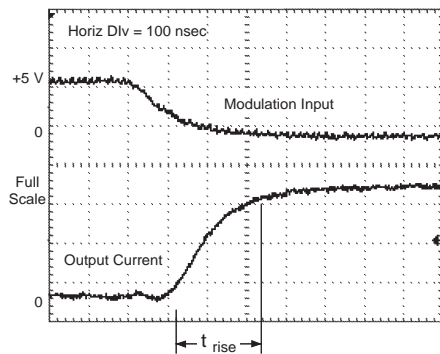


Large Signal Frequency Response

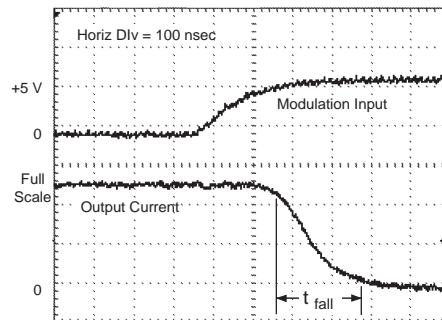


Note: Gain normalized to output at 10 Hz.

10 kHz square wave rise time



10 kHz square wave fall time



Note: Keep Operating Setpoint Below Current Limit Setting. These graphs do not represent the LDD P performance while the Current Limit Circuit is triggered.

Warning: The Current Limit Circuit is not an absolute/failsafe clamp. If the operating setpoint exceeds the limit setting, and a fast modulation signal is input, very short overshoots of the current limit are possible (150 nsec). If the photodiode feedback signal is lost or very slow, the LDD P can drive to its maximum output current.

POWER SUPPLY AND NOISE

The LDD P Series Laser Diode Drivers are designed for stable, low noise operation. The power supply you select will directly affect the noise performance of the driver. We recommend using a regulated, linear supply for optimum performance. Depending on your requirements, you may be able to use a switching power supply. Each case must be evaluated independently because a switching power supply will affect noise, transient, and stability performance. The LDD P series can be purchased with the LDDPCB series evaluation kit for easy initial operation.

LASER SAFETY ISSUES

ATTENTION: If you plan to operate the LDD P with any Wavelength temperature controller, you **may** need to use separate power supplies. If the TE cooler or thermistor is connected to the laser diode, please contact the factory for technical assistance.

ATTENTION: Exceeding the maximum specified operating current ($I_{OP\ MAX}$) will damage your laser diode. Become familiar with the LDD P Series module operation and the exact specifications of your laser diode before attaching it to the LDD P module. Seek assistance from someone with experience working with laser diodes if you have not operated one before.

ATTENTION: The following instruments may cause momentary opens, shorts, or impedance changes that will damage a laser diode if attached to the output of a laser diode driver.

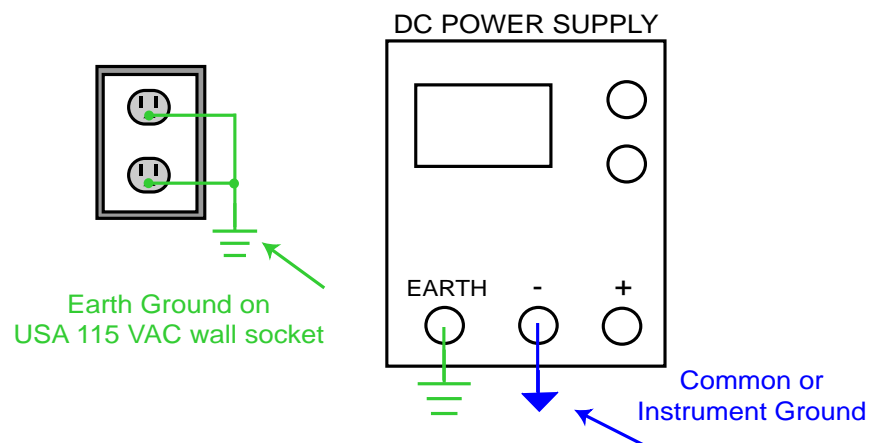
1. A **voltmeter** across the laser diode.
2. An **oscilloscope** across the laser diode.
3. A **current meter** in series with the laser diode.

All measurements made with these instruments on the output should be made with a simulated load attached and not a laser diode.

ATTENTION: IF LASER DIODE AND PHOTODIODE ARE ISOLATED (TYPE B LASER DIODE) Short the laser diode anode to the photodiode cathode. The LDD P Series laser diode drivers require the photodiode be connected to the laser diode. If no connection is made between the laser diode and the photodiode, then the LDD P will not operate properly in constant power mode, and the power monitor will not read the proper photodiode current.

GROUNDING

Some laser diode packages short either the laser diode anode or cathode to the case, which may connect the laser electrically to earth ground. Review the internal connections of the LDD P to make sure ground loops are not inadvertently created by this situation. Special attention to the details of grounding will ensure safe operation.



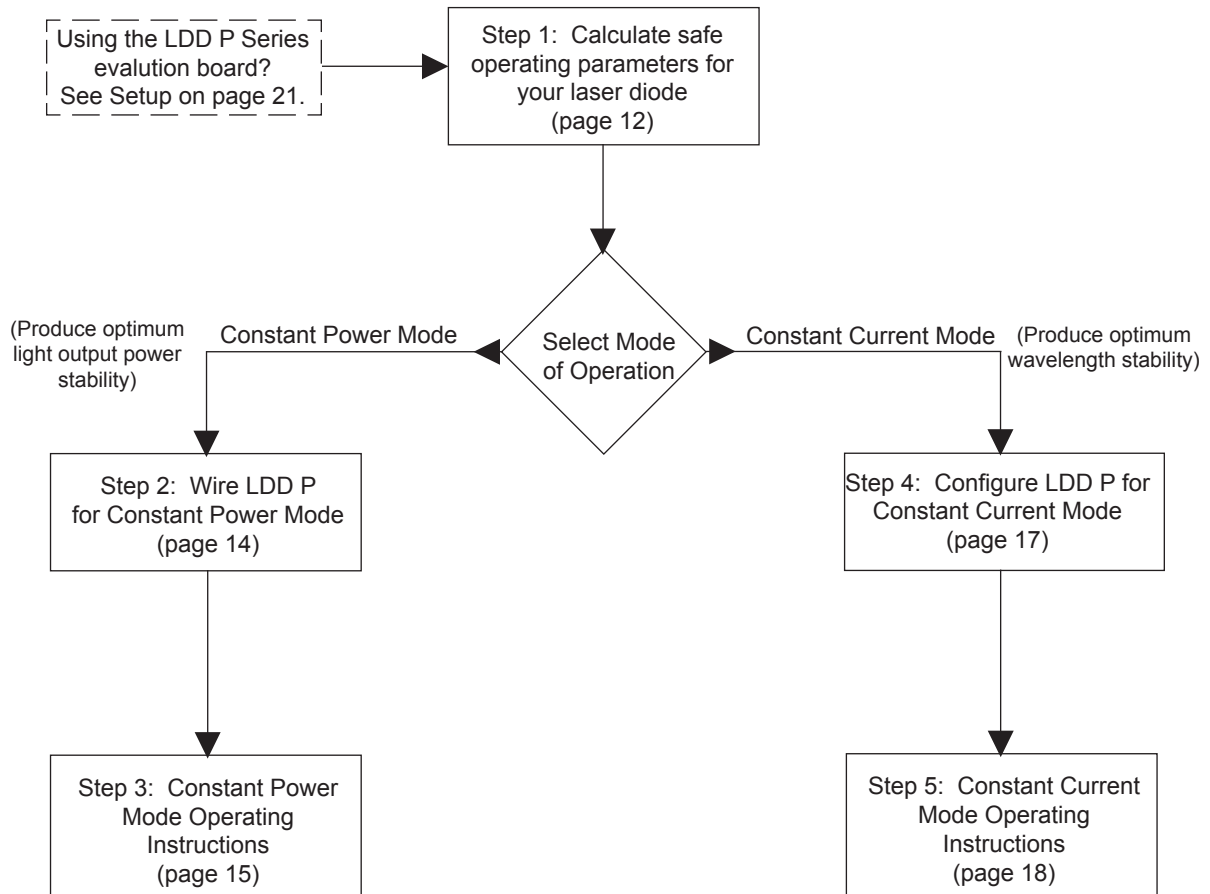
Unless Earth and Instrument Ground are connected via the power supply, Instrument Ground is floating with respect to Earth Ground

OPERATING GUIDE ORGANIZATION

Operating your LDD P Series laser diode driver is relatively simple. First, complete basic calculations about your laser diode. Then determine if you'll operate in Constant Power or Constant Current mode. Then follow the wiring and operating instructions for that mode.

If you're using an evaluation board, familiarize yourself with the components of the board then follow the regular steps.

To minimize the possibility of damage to your laser diode, follow these steps in order.



Step 1: Pre-Setup Calculations**1.1 Determine Maximum Laser Diode Operating Current**

- (1) Using the laser diode manufacturer's recommended operating specifications, determine the following four values:

- (a) Maximum laser diode light output power:
 $P_{MAX} = \underline{\hspace{2cm}}$ mW

(Note this value should be less than the laser diode's ABSOLUTE MAXIMUM RATINGS)

- (b) Typical Laser Diode threshold current:
 $I_{TH} = \underline{\hspace{2cm}}$ mA

- (c) Typical Laser Diode operating current:
 $I_{OP} = \underline{\hspace{2cm}}$ mA

- (d) Laser Diode slope efficiency:
 $\eta = \underline{\hspace{2cm}}$ mW / mA

- (2) Calculate the laser diode limit current using Equation 1.1:

$$\text{EQUATION 1.1: } I_{LIMIT} = I_{TH} + (P_{MAX}) / (\eta) \quad I_{LIMIT} = \underline{\hspace{2cm}} \text{ mA}$$

OR: If the laser diode's slope efficiency is unknown, then choose the laser diode limit current to be close to the operating current. Keep it well below the damage threshold of the laser diode.

$$I_{LIMIT} = (1.1) * I_{OP}$$

Example Calculations

Laser Diode Optical and Electrical Specifications used in this example are found on page 14.

Assume this laser diode application requires the laser diode to produce 25 mW of light output power and uses an LDD200-1P operating from +5 V.

$$[P_{OP} = 25 \text{ mW} \ \& \ V_{SUPPLY} = +5 \text{ V}]$$

$$P_{MAX} = 27.5 \text{ mW}$$

(P_{MAX} is conservatively estimated at 110% of P_{OP} , not the ABSOLUTE MAXIMUM RATING)

$$\begin{aligned} I_{TH} &= 40 \text{ mA} \\ I_{OP} &= 80 \text{ mA} \\ \eta &= 0.75 \text{ mW / mA} \end{aligned}$$

EQUATION 1.1:

$$I_{LIMIT} = I_{TH} + (P_{MAX}) / (\eta) =$$

$$40 + (27.5) / (0.75) = 76.66 \text{ mA}$$

1.2 Determine Laser Diode Operating Current for desired Output Power

- (1) Determine the following:

- (a) Desired laser diode light output power:
 $P_{OP} = \underline{\hspace{2cm}}$ mW

- (2) Calculate the laser diode operating current using Equation 1.2 [for I_{TH} & η , see Step 1.1]:

$$\text{EQUATION 1.2: } I_{OP} = I_{TH} + (P_{OP}) / (\eta) \quad I_{OP} = \underline{\hspace{2cm}} \text{ mA}$$

OR: If the laser diode's slope efficiency is unknown, then assume the laser diode operating current is:

$$I_{OP} = \text{Laser Diode Current at Rated Power}$$

$$P_{OP} = 25 \text{ mW}$$

EQUATION 1.2:

$$I_{OP} = I_{TH} + (P_{OP}) / (\eta) =$$

$$40 + (25) / (0.75) = 73.33 \text{ mA}$$

1.3 Determine Laser Diode Monitor Current (Photodiode Current)

- (1) Determine the following two values:

- (a) Laser Diode Rated Power:
 $P_{RATED} = \underline{\hspace{2cm}}$ mW

- (b) Typical Monitor Current (Photodiode current):
 $I_{MON} = \underline{\hspace{2cm}}$ mA

- (2) Calculate the laser diode monitor current using Equation 1.3 [for P_{OP} see Step 1.2]:

$$\text{EQUATION 1.3: } I_{PD} = (P_{OP}) \left(\frac{I_{MON}}{P_{RATED}} \right) \quad I_{PD} = \underline{\hspace{2cm}} \text{ mA}$$

$$P_{RATED} = 30 \text{ mW}$$

$$I_{MON} = 0.3 \text{ mA}$$

[From specification sheet,
 I_{MON} typical at P_O]

EQUATION 1.3:

$$I_{PD} = (P_{OP}) \left(\frac{I_{MON}}{P_{RATED}} \right) =$$

$$(25)(0.3 / 30) = 0.25 \text{ mA}$$

Step 1: Pre-Setup Calculations, continued

1.4 Determine Laser Diode Operating Voltage (optional)

(1) Using the laser diode manufacturer's recommended operating specifications, determine the following four values:

(a) Typical Laser Diode operating voltage:

$$V_{OP} = \text{_____} \text{ V}$$

(b) Maximum Laser Diode operating voltage:

$$V_{MAX} = \text{_____} \text{ V}$$

(c) Typical Laser Diode operating current:

$$I_{OP} = \text{_____} \text{ mA}$$

(d) Maximum Laser Diode operating current:

$$I_{MAX} = \text{_____} \text{ mA}$$

(2) Calculate the laser diode forward voltage drop using Equation 1.4 [for I_{LIMIT} see Step 1.1]:

EQUATION 1.4:

$$V_{LD} = V_{OP} + (I_{LIMIT} - I_{OP}) \left(\frac{V_{MAX} - V_{OP}}{I_{MAX} - I_{OP}} \right) \quad V_{LD} = \text{_____} \text{ V}$$

If not enough data is available, assume $V_{LD} = 1.7 \text{ V}$

Example Calculations

$$V_{OP} = 2.4 \text{ V}$$

$$V_{MAX} = 3.0 \text{ V}$$

$$I_{OP} = 80 \text{ mA}$$

$$I_{MAX} = 120 \text{ mA}$$

EQUATION 1.4:

$$V_{LD} = V_{OP} + (I_{LIMIT} - I_{OP}) \left(\frac{V_{MAX} - V_{OP}}{I_{MAX} - I_{OP}} \right)$$

$$V_{LD} = 2.4 + (60.63 - 80) \left(\frac{3 - 2.4}{120 - 80} \right)$$

$$V_{LD} = 2.11 \text{ V}$$

1.5 Determine R_D Value for Dominant Resistor Protection (optional)

Resistor R_D is not required for proper operation of the LDD P Series Laser Diode Driver, but provides a very simple and inexpensive method for protecting the laser diode against various electrical and mechanical transients.

NOTE: R_{4a} is another optional safety component discussed on page 22. It is included on the evaluation board. The default value on the evaluation board is 1Ω .

(1) Determine the following:

(a) Power Supply Voltage applied between pin 8 & pin 4 (V+ & GND):

$$V_{SUPPLY} = \text{_____} \text{ V}$$

(2) Calculate R_D using I_{LIMIT} from Step 1.1, V_{LD} from Step 1.4, and Equation 1.5. [Note: use Equation 1.5A for LDD 200 models and Equation 1.5B for LDD 400 models]:

EQUATION 1.5A:

Use with LDD200-1P, LDD200-2P, and LDD200-3P laser diode drivers

$$R_D = \left(\frac{V_{SUPPLY} - V_{LD} - 0.2}{I_{LIMIT}} \right) - (6.2 \Omega + R_{4a}) \quad R_D = \text{_____} \Omega$$

EQUATION 1.5B:

Use with LDD400-1P, LDD400-2P, and LDD400-3P laser diode drivers

$$R_D = \left(\frac{V_{SUPPLY} - V_{LD} - 0.2}{I_{LIMIT}} \right) - (3.1 \Omega + R_{4a})$$

(3) Calculate the minimum power rating for R_D with Equation 1.6:

EQUATION 1.6:

$$P_{RD} = \text{Minimum power rating for } R_D \quad P_{RD} = \text{_____} \text{ W}$$

$$= (R_D)(I_{LIMIT})^2$$

$$V_{SUPPLY} = 5 \text{ V}$$

EQUATION 1.5A:

$$R_D = \left(\frac{V_{SUPPLY} - V_{LD} - 0.2}{I_{LIMIT}} \right) - (6.2 \Omega + R_{4a})$$

$$\left(\frac{5 - 2.11 - 0.2}{0.06063} \right) - (6.2 \Omega + 1 \Omega) = 37 \Omega$$

EQUATION 1.6:

$$P_{RD} = (R_D)(I_{LIMIT})^2 =$$

$$(37)(0.06063)^2 = 0.14 \text{ W}$$

Step 1: Pre-Setup Calculations, continued

EXAMPLE - Laser Diode Electrical and Optical Characteristics

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Ratings	Units
P_O	Laser Diode Light Output Power	35	mW
V_{RL}	Laser Diode Reverse Voltage	2	V
V_{RD}	Photodiode Reverse Voltage	30	V
I_{PD}	Photodiode Forward Current	10	mA

ELECTRICAL / OPTICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	Limits			Units
			Min	Typical	Max	
I_{TH}	Threshold Current	CW	-	40	65	mA
I_{OP}	Operating Current	CW, $P_O = 30$ mW	-	80	120	mA
η	Slope Efficiency	CW, $P_O = 30$ mW	-	0.75	-	mW / mA
V_{OP}	Operating Voltage	CW, $P_O = 30$ mW	2.0	2.4	3.0	V
I_{MON}	Monitor Current (photodiode)	CW, $P_O = 30$ mW, $V_{RD} = 1V$	-	0.3	0.5	mA

Step 2: Constant Power Operation: Wiring

Figure 1: LDD 1P or LDD 3P

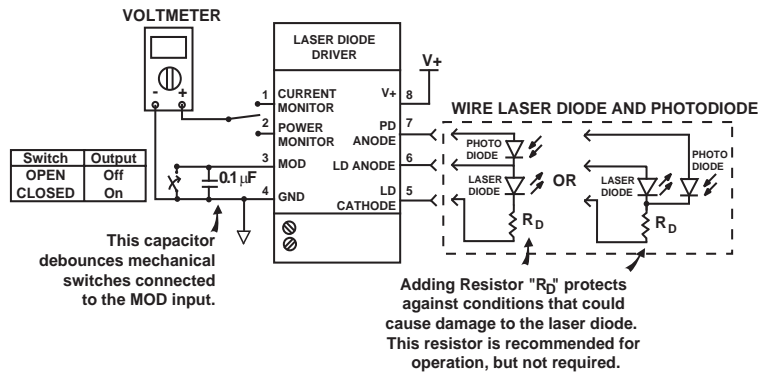


Figure 2: LDD 2P

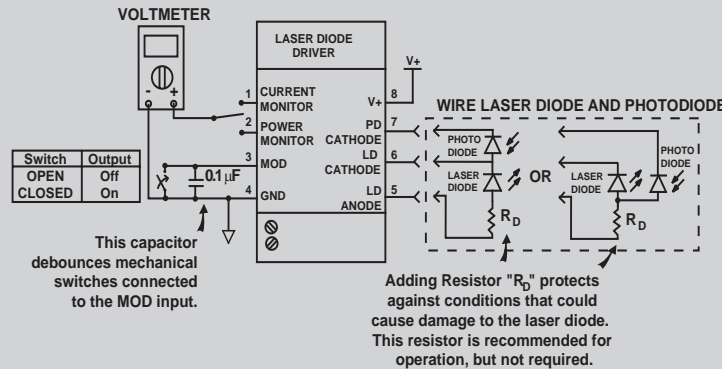


Figure 3

LDD 1P AND LDD 3P MODELS

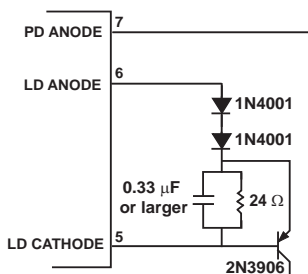
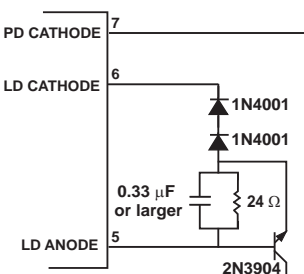


Figure 4

LDD 2P MODELS



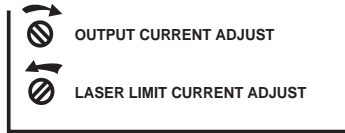
Using a Constant Power "Simulated" load

Figures 3 and 4 illustrate how to create constant power simulated loads for the Type A and Type C laser diodes, respectively. The simulated load allows the configuration of the LDD P laser diode driver without initially connecting a laser diode. Once the laser diode driver is adjusted to the correct output power and laser diode limit current, power it down before connecting a laser diode.

Step 3: Constant Power Operation

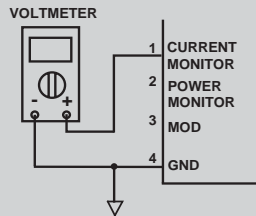
CAUTION: Do not power on the LDD P Series Laser Diode Driver until all wire connections are completely attached and the Output Current Adjust and Limit Current Adjust trimpots have been correctly configured.

CAUTION: Before connecting a power supply to the LDD P Series Laser Diode Driver, measure the supply's output voltage and ensure a reading between +5 and +12 Volts. Turn OFF the power supply before connecting to the LDD P.



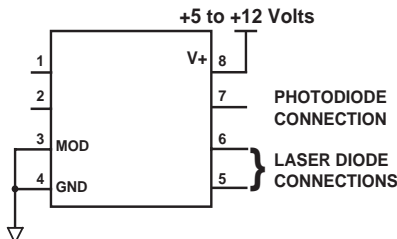
3.1 Locate and Adjust "on-board" trimpots

- (1) Adjust the OUTPUT CURRENT ADJUST TRIMPOT fully clockwise, at least 12 complete turns.
- (2) Adjust the LIMIT CURRENT ADJUST TRIMPOT fully counter-clockwise, at least 12 complete turns.



3.2 Measure Laser Current Monitor Output

- (1) Attach the positive input of a voltmeter to the current monitor output (pin 1) and the negative input of the voltmeter to ground (pin 4).



3.3 Turn on Voltage Source

- (1) Apply power to the LDD P only after all connections have been thoroughly reviewed. Notice the modulation input, pin 3, must be connected to ground, pin 4, to properly configure the limit current and photodiode current settings.

$$I_{LIMIT} = \frac{\text{_____}}{\text{(from Step 1.1)}} \text{ mA}$$

3.4 Adjust Laser Diode Limit Current

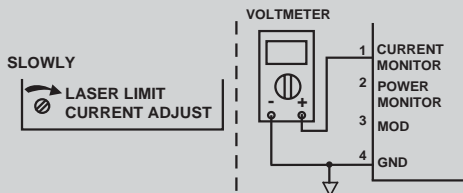
200 mA models:

$$V_{PIN 1} = (I_{LIMIT} \left(\frac{2.5 \text{ V}}{200 \text{ mA}} \right)) = \text{_____ V}$$

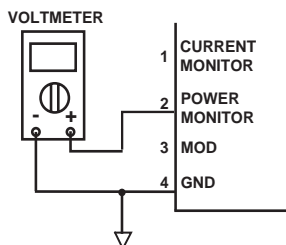
- (1) Calculate the current monitor voltage that corresponds to the proper limit current setting (determined in Step 1.1).

400 mA models:

$$V_{PIN 1} = (I_{LIMIT} \left(\frac{2.5 \text{ V}}{400 \text{ mA}} \right)) = \text{_____ V}$$



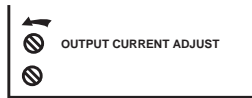
- (2) SLOWLY adjust the LIMIT CURRENT ADJUST TRIMPOT clockwise until the voltmeter attached to the current monitor (pin 1) reads V_{LIMIT} .



3.5 Measure Power Monitor Output

- (1) Attach the positive input of a voltmeter to the power monitor output (pin 2), and the negative input of a voltmeter to ground, (pin 4).

Step 3: Constant Power Operation, continued



$$I_{PD} = \text{_____ mA}$$

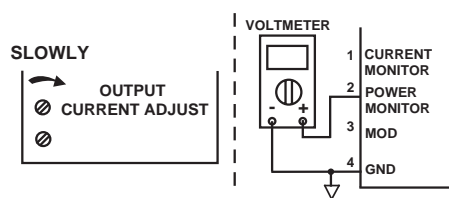
(from Step 1.3)

LDD 1P and LDD 2P models:

$$V_{PIN 2} = (I_{PD}) \left(\frac{2.5 \text{ V}}{2.5 \text{ mA}} \right) = \text{_____ V}$$

LDD 3P models:

$$V_{PIN 2} = (I_{PD}) \left(\frac{2.5 \text{ V}}{0.125 \text{ mA}} \right) = \text{_____ V}$$



3.6 Adjust Photodiode Current (light output power)

(1) Rotate the OUTPUT CURRENT ADJUST TRIMPOT fully counter clockwise, at least 12 turns.

(2) Calculate the power monitor voltage that corresponds to the proper photodiode current setting (determined in Step 1.3).

(3) SLOWLY adjust the OUTPUT CURRENT ADJUST TRIMPOT clockwise until the voltmeter attached to the power monitor (pin 2) reads V_{PD} .

$$I_{OP} = \text{_____ mA}$$

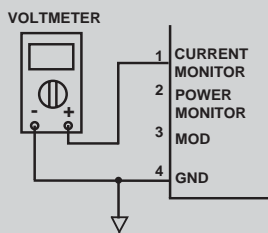
(from Step 1.2)

200 mA models:

$$V_{PIN 1} = (I_{OP}) \left(\frac{2.5 \text{ V}}{200 \text{ mA}} \right) = \text{_____ A}$$

400 mA models:

$$V_{PIN 1} = (I_{OP}) \left(\frac{2.5 \text{ V}}{400 \text{ mA}} \right) = \text{_____ A}$$

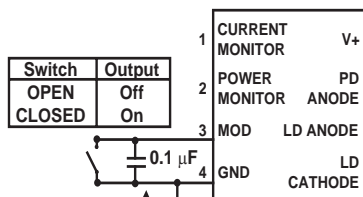


3.7. Verify Laser Diode Current level at Current Monitor Output

(1) Determine that the laser diode current measured on the current monitor output corresponds to the value calculated in Step 1.2. This value may vary from the calculated value depending on the temperature of the laser diode. A laser diode with a temperature above 25°C will require more laser diode current to produce the same power than one at or below 25°C.

(2) Confirm that the laser diode current is below the limit current setting.

CAUTION: If the current monitor indicates that the laser diode is operating in current limit, reduce the laser diode output power using the OUTPUT CURRENT ADJUST TRIMPOT. Turn the power supply OFF and verify calculations made in Step 1. Also inspect the laser diode mounting to insure proper heatsinking for the laser diode.



This capacitor debounces mechanical switches connected to the MOD input.

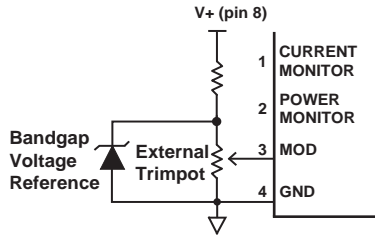
3.8 Disable Laser Diode Current

(1) To disable current, let pin 3 float or connect it to V+. As shown in the diagram, open the switch. NOTE: a residual current is present in the laser diode when disabled. DO NOT DISCONNECT THE LASER DIODE UNLESS POWER IS REMOVED FROM V+ AND GROUND.

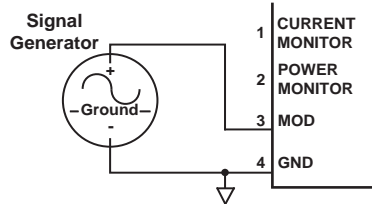
Step 3: Constant Power Operation, continued

3.9 Adjust Light Output Power using the Modulation Input (optional)

(1) An external trimpot or potentiometer can be attached to pin 3 to remotely control the light output power.



OR



Connect a signal generator to pin 3.

$$I_{PD} = \text{_____ mA}$$

(from Step 1.3)

(2) The modulation input adjusts the light output power by reducing the photodiode current from the setting determined by the OUTPUT CURRENT ADJUST TRIMPOT proportional to the voltage applied to pin 3.

LDD 1P and LDD 2P models:

$$I_{MOD} = (I_{PD}) - V_{PIN3} \left(\frac{2.5 \text{ mA}}{5 \text{ V}} \right) = \text{_____ A}$$

CAUTION: The modulation input voltage must always be maintained within the power supply voltage range between pin 8 & pin 4. A voltage on the modulation input below ground may produce excessive laser diode currents.

LDD 3P models:

$$I_{MOD} = (I_{PD}) - V_{PIN3} \left(\frac{0.125 \text{ mA}}{5 \text{ V}} \right) = \text{_____ A}$$

Step 4: Constant Current Operation: Wiring

Figure 5: LDD 1P or LDD 3P

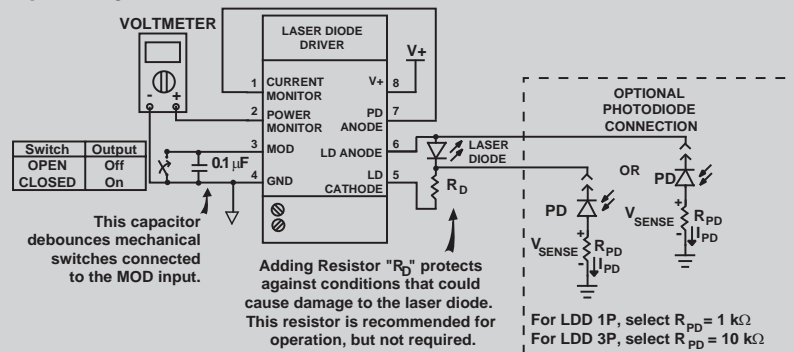
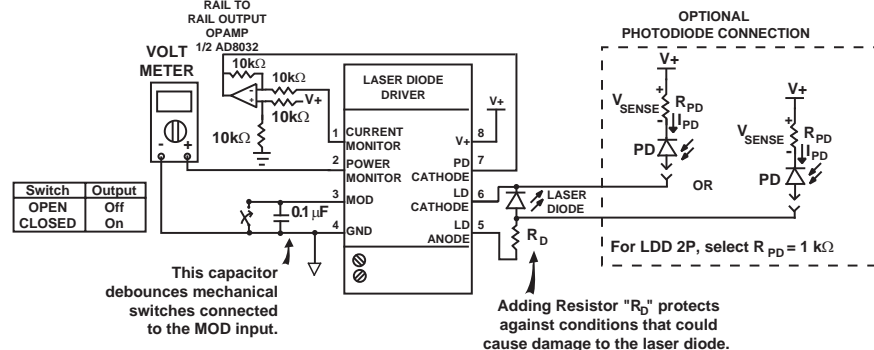


Figure 6: LDD 2P



Step 4: Constant Current Operation: Wiring, continued

Figure 7

LDD 1P AND LDD 3P MODELS

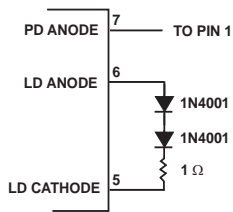
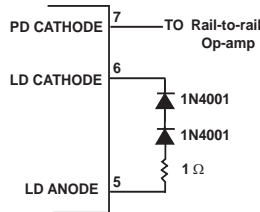


Figure 8

LDD 2P MODELS



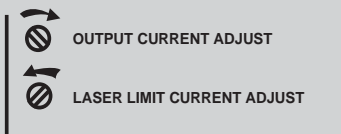
Using a Constant Current "Simulated" load

Figures 7 and 8 illustrate how to create constant current simulated loads for the LDD 1P, LDD 3P, or LDD 2P laser diode drivers, respectively. The simulated load allows the configuration of the LDD P laser diode driver without initially connecting the laser diode. Once the laser diode driver is adjusted to the correct output current and laser diode limit current, power it down before connecting a laser diode.

Step 5: Constant Current Operation

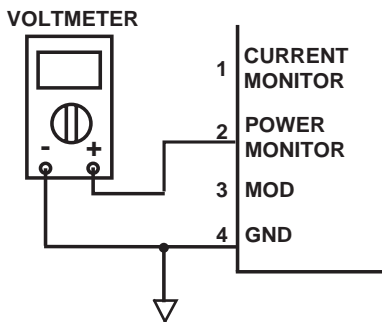
CAUTION: Do not power on the LDD P Series Laser Diode Driver until all wire connections are completely attached and the Output Current Adjust and Limit Current Adjust trimpots have been correctly configured.

CAUTION: Before connecting a power supply to the LDD P Series Laser Diode Driver, measure the supply's output voltage and ensure a reading between +5 and +12 Volts. Turn OFF the power supply before connecting to the LDD P.



5.1 Locate and Adjust "on-board" trimpots

- (1) Adjust the OUTPUT CURRENT ADJUST TRIMPOT fully clockwise, at least 12 complete turns.
- (2) Adjust the LIMIT CURRENT ADJUST TRIMPOT fully counter-clockwise, at least 12 complete turns.

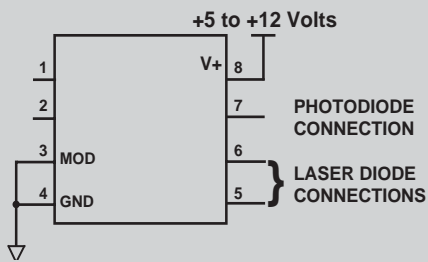


5.2 Measure Power Monitor Output

The current monitor and the power monitor outputs produce the same voltage output when the LDD P is configured for Constant Current Operation.

Since the current monitor is used to provide feedback in constant current mode, the power monitor is used to measure the laser diode current.

- (1) Attach the positive input of a voltmeter to the power monitor output (pin 2) and the negative input of the voltmeter to ground (pin 4).



5.3 Turn on Voltage Source

- (1) Apply power to the LDD P only after all connections have been thoroughly reviewed. Notice the modulation input, pin 3, must be connected to ground, pin 4, to properly configure the limit current and laser diode current settings.

Step 5: Constant Current Operation, continued

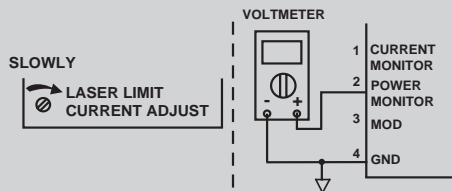
$$I_{LIMIT} = \frac{\text{_____}}{\text{(from Step 1.1)}} \text{ mA}$$

200 mA models:

$$V_{PIN 2} = (I_{LIMIT}) \left(\frac{2.5 \text{ V}}{200 \text{ mA}} \right) = \text{_____ V}$$

400 mA models:

$$V_{PIN 2} = (I_{LIMIT}) \left(\frac{2.5 \text{ V}}{400 \text{ mA}} \right) = \text{_____ V}$$



5.4 Adjust Laser Diode Limit Current

- (1) Calculate the current monitor voltage that corresponds to the proper limit current setting (determined in Step 1.1).

- (2) SLOWLY adjust the LIMIT CURRENT ADJUST TRIMPOT clockwise until the voltmeter attached to the power monitor (pin 2) reads V_{LIMIT}



5.5 Adjust Laser Diode Current

- (1) Rotate the OUTPUT CURRENT ADJUST TRIMPOT fully counter-clockwise, at least 12 turns.

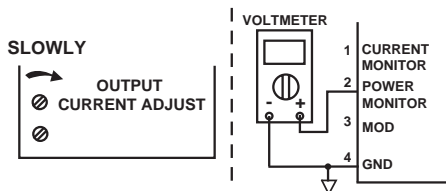
$$I_{OP} = \frac{\text{_____}}{\text{(from Step 1.2)}} \text{ mA}$$

200 mA models:

$$V_{PIN 2} = (I_{OP}) \left(\frac{2.5 \text{ V}}{200 \text{ mA}} \right) = \text{_____ V}$$

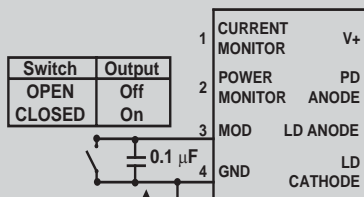
400 mA models:

$$V_{PIN 2} = (I_{OP}) \left(\frac{2.5 \text{ V}}{400 \text{ mA}} \right) = \text{_____ V}$$



- (2) Calculate the current monitor voltage that corresponds to the proper laser diode current setting (determined in Step 1.2).

- (3) SLOWLY adjust the OUTPUT CURRENT ADJUST TRIMPOT clockwise until the voltmeter attached to the current monitor (pin 2) reads V_{OP}

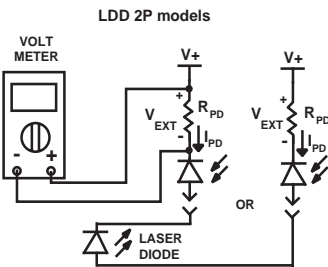
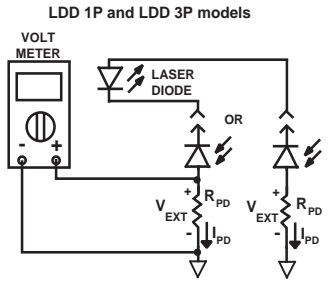


This capacitor debounces mechanical switches connected to the MOD input.

5.6 Disable Laser Diode Current

- (1) To disable current, let pin 3 float or connect it to V+. As shown in the diagram, open the switch. NOTE: a residual current is present in the laser diode when disabled. DO NOT DISCONNECT THE LASER DIODE UNLESS POWER IS REMOVED FROM V+ AND GROUND.

Step 5: Constant Current Operation, continued



$$I_{PD} = \frac{V_{EXT}}{R_{PD}} \text{ mA}$$

(from Step 1.3)

LDD 1P and LDD 2P models:

$$I_{PD} = \left(\frac{V_{EXT}}{1 \text{ k}\Omega} \right) = \text{_____ mA}$$

LDD 3P models:

$$I_{PD} = \left(\frac{V_{EXT}}{10 \text{ k}\Omega} \right) = \text{_____ mA}$$

5.7 Verify Photodiode Current level (optional)

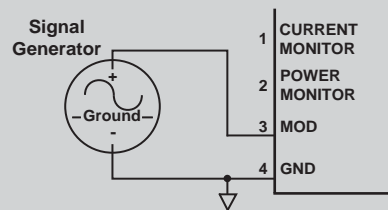
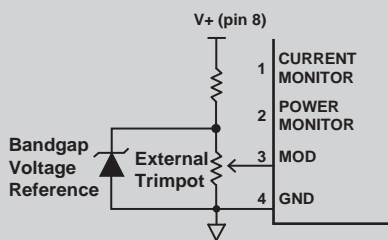
(1) If you wired an external photodiode in Step 4, attach the leads of a voltmeter across the external resistor as shown.

(2) Determine if the measured photodiode current corresponds to the value calculated in Step 1.3. This value may vary from the calculated value depending on the temperature of the laser diode. A laser diode with a temperature above 25°C will produce less photodiode current than one at or below 25°C.

(3) Confirm that the light output power does not exceed the rated output power for the laser diode.

CAUTION: If the photodiode current indicates that the laser diode is operating above the rated power, reduce the laser diode output power using the OUTPUT CURRENT ADJUST TRIMPOT. Turn the power supply OFF and verify calculations made in Step 1. Also inspect the laser diode mounting to insure proper heatsinking for the laser diode.

5.8 Adjust Laser Diode Current using the Modulation Input (optional)



$$I_{OP} = \text{_____ mA}$$

(from Step 1.2)

200 mA models:

$$I_{MOD} = (I_{OP}) - V_{PIN3} \left(\frac{200 \text{ mA}}{5 \text{ V}} \right) = \text{_____ mA}$$

400 mA models:

$$I_{MOD} = (I_{OP}) - V_{PIN3} \left(\frac{400 \text{ mA}}{5 \text{ V}} \right) = \text{_____ mA}$$

(1) An external trimpot or potentiometer can be attached to pin 3 to remotely control the laser diode current.

OR

Connect a signal generator to pin 3.

(2) The modulation input adjusts the laser diode current by reducing the laser diode current from the setting determined by the OUTPUT CURRENT ADJUST TRIMPOT proportional to the voltage applied to pin 3.

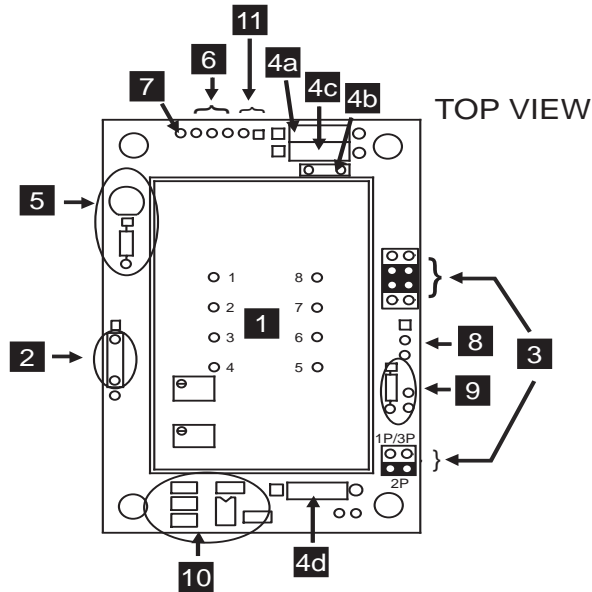
CAUTION: The modulation input voltage must always be maintained within the power supply voltage range between pin 8 & pin 4. A voltage on the modulation input below ground may produce excessive laser diode currents.

Using the LDD Evaluation Board

The LDD P is designed to be soldered to a circuit board. The LDDPCB evaluation board integrates with any LDD P laser diode driver.

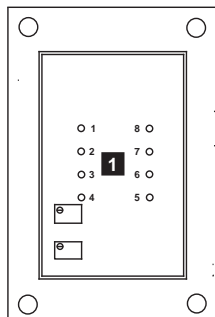
Instructions for using the LDDPCB are on the next four pages. **Once you are familiar with the board, follow the operating instructions for the LDD P, starting on page 11.**

Model LDDPCB P Series: Component Diagram
 For more detail refer to sections on the following pages.



Typical Component Functions

No.	Component	Function
1	LDD Module	Laser Diode Driver Component location
2	Enable/ Disable wire pads	Enable / Disable laser current
3	Jumpers	Select LDD P model and operating mode
4a	Decoupling Resistor	Decouple power supply
4b	Decoupling Capacitor	Decouple power supply
4c	Transzorb	Over-voltage protection
4d	Dominant Impedance	Laser diode over-current and transient protection
5	LED and bias resistor	Power ON indicator
6	Measurement wire pads	Measure laser diode or photodiode current
7	MOD INPUT wire pads	Connections to optional signal generator
8	Laser diode wire pads	Solder laser diode cable to these pads
9	External photodiode wire pads	Monitor photodiode current while in constant laser diode current mode
10	Op-amp, 4 resistors, one capacitor	For operating LDD 2P in constant current mode
11	Power supply wire pads	Connections to power supply

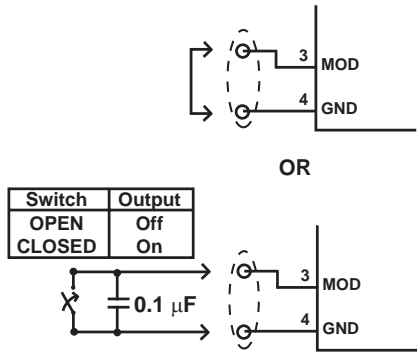


Component #1: Solder LDD P module to accessory board

- (1) The silkscreen on the top of the board shows the orientation of the two trimpots when the LDD P module is properly positioned. Solder the LDD P to the circuit board. Do not exceed solder tip temperature of 260°C or apply heat to any lead for more than 10 seconds.

Using the LDD Evaluation Board, continued

Component #2: Enable laser diode current



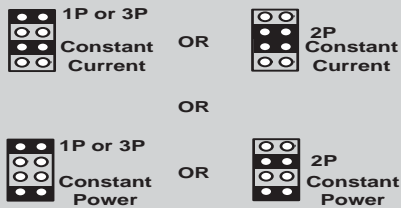
(1) Solder a jumper between the two round solder pads

OR

(2) Use a switch to enable and disable the laser diode current. Connect it across the round solder pads. Place a capacitor across the switch to debounce the connection.

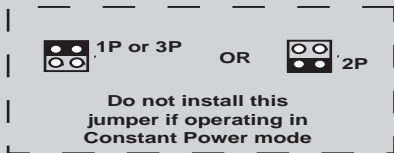
Component #3: Configure for LDD 1P / LDD 3P or LDD 2P models & Mode of operation

Use one of these four jumper diagrams to configure the LDDPCB to the model LDD P you are using and the appropriate mode of operation



(1) The top two jumpers configure the evaluation board for the model of LDD P.

(2) The second set of jumpers determine the operating mode- Constant Light Output Power, or Constant Laser Diode Current.

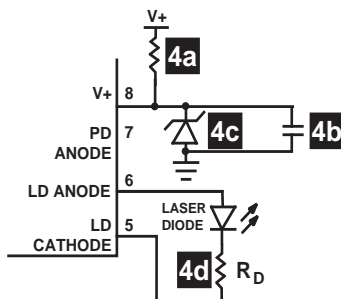


(3) A second set of jumpers, lower on the LDDPCB are used only if you operate in Constant Current mode. **CAUTION:** Do not load this jumper when operating in Constant Power Mode.

Component #4: Determine which safety components to install

Component #4a: Power Supply Decoupling Resistor

A 1 to 10 ohm resistor can be used to decouple the power supply from the LDD P laser diode driver. This series resistor forms a low pass single pole filter with the capacitance seen from pin 8 to ground. This component is not recommended for V+ operation below 6 V. A one ohm resistor is installed on the LDDPCB. **If you do not install the decoupling resistor, install a jumper between the two solder pads.**



Component #4b: Power Supply Decoupling Capacitor

A 1 to 10 μF tantalum or low ESR electrolytic capacitor can be used to shunt regulate the power supply around the LDD P laser diode driver. Note the polarity marked on the silkscreen. A 10 μF capacitor is installed on the LDDPCB.

Component #4c: Over-voltage protection - Transzorb

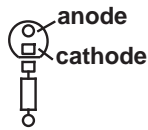
This zener diode limits the voltage differential across the LDD P. A typical transzorb for a +12 V supply would be the Motorola P6KE15A. Solder the cathode of the transzorb in the square solder pad. A P6KE15A is installed on the LDDPCB.

Component #4d: Dominant Impedance

This resistor limits the voltage that can develop across the laser diode in the case of a power supply transient or if the connections to the laser diode are broken and reconnected. Select either a metal film power resistor or a non-inductive wire wound resistor. Carbon based resistors add a significant amount of noise and inductive wire wound resistors can damage the laser diode. **If you do not install the dominant impedance resistor, install a jumper between the two solder pads. A value for R_D is calculated in Step 1.5 of the operating instructions (starting on page 13).**

A 1 Ω, 2 W resistor is installed on the LDDPCB.

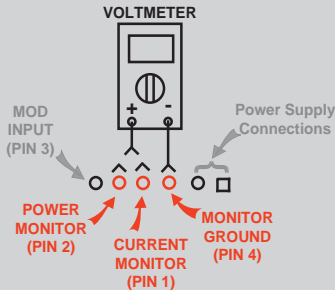
Using the LDD Evaluation Board, continued



Component #5: Power ON indicator LED (optional)

When power is applied to the LDD P evaluation board, this LED will light. A 1 kΩ resistor in series with the LED establishes a bias current

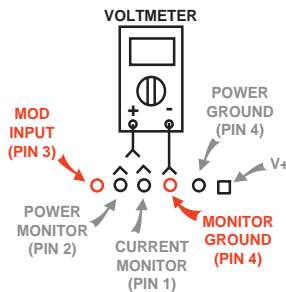
A 1kΩ resistor and a green indicator LED are installed on the LDDPCB.



Component #6: Connect Voltmeter to monitor laser diode power or current

Pin 1 (current monitor) and pin 2 (power monitor) are used to monitor laser diode current and power during setup and operation. These pins are brought out to solder pads on the edge of the accessory board.

- (1) Attach the positive input of a voltmeter to either solder pad and the negative input of the voltmeter to ground. NOTE: For noise reduction, use the Monitor Ground solder pad, not the Power Supply ground solder pad.



Component #7: Connect signal generator to MOD INPUT (optional)

Pin 3 is a modulation input. This pin is brought out to a solder pad on the edge of the board.

- (1) Attach the positive input of a signal generator to the far left solder pad and the negative input of the signal generator to the monitor ground.

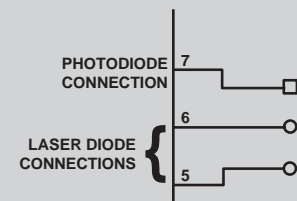
Component #8: Connect Laser Diode to accessory board

These three pins correspond to pins 5, 6, and 7 of the LDD P module.

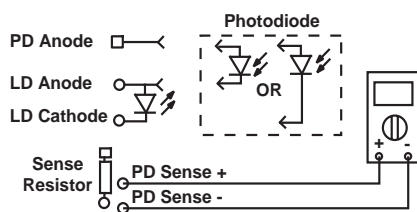
Refer to Step 2 for Wiring Instructions for Constant Power mode (page 14).

Refer to Step 4 for Wiring Instructions for Constant Current mode (page 17).

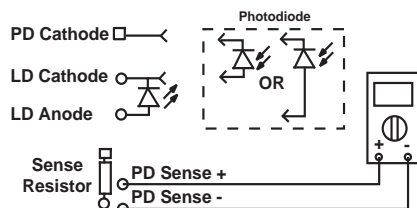
If you are operating in constant laser diode current mode and want to monitor the photodiode current, the next section details how to wire the photodiode.



LDD 1P and LDD 3P



LDD 2P



Component #9: Monitor Photodiode Current in Constant Laser Diode Current Mode

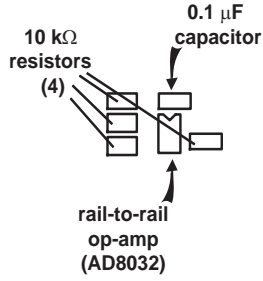
- (1a) If you are operating an LDD 1P or LDD 3P laser diode driver, connect the anode of the photodiode to pin 7. Connect the photodiode cathode to the laser diode (in most laser diodes, this connection is made inside the laser diode case).

- (1b) If you are operating an LDD 2P laser diode driver, connect the cathode of the photodiode to pin 7. The photodiode anode should already be connected to the laser diode inside the laser diode case.

- (2) Install the sense resistor across the two wire pads indicated in the diagram. Use a 1kΩ resistor for the LDD 1P and LDD 2P models. Use a 10 kΩ resistor for the LDD 3P models.

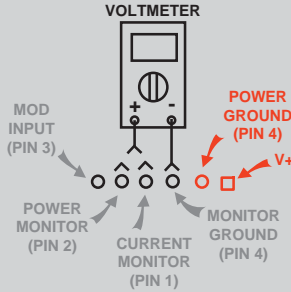
- (3) During operation, monitor the voltage across the PD Sense + and PD Sense - solder pads with a voltmeter.

Two resistors are included (loose) in the LDDPCB package. One is 1 kΩ and the other is 10 kΩ.



Component #10: LDD 2P in Constant Laser Diode Current Operation

To operate an LDD 2P in constant laser diode current mode, an external op-amp and components are required. These are installed on the LDDPCB.

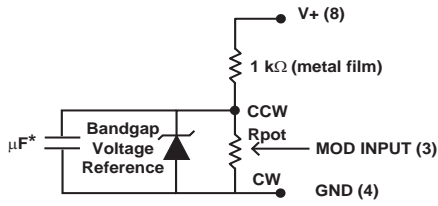


Component #11: Connect Power Supply

(1) Connect V+ and Ground to the solder pads indicated. NOTE: To minimize noise, use the Power Ground solder pad, not the Monitor Ground solder pad.

To complete setup, follow the operating instructions starting on page 11.

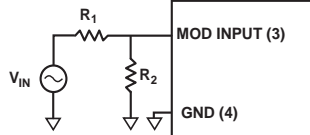
External Trimpot Circuit



Rpot = 10 to 200 kΩ

* Add capacitor to reduce noise

Change the Modulation Transfer Function



Keep R₁ and R₂ below 100 kΩ for maximum accuracy.

$$\text{New Transfer Function} = \left(\frac{R_2}{R_2 + R_1} \right) \text{Original Transfer Function}$$

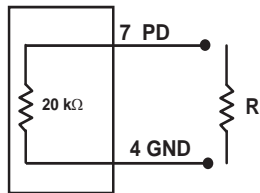
Example:
(for LDD200-1P,
Constant Current Mode)

R₁ = 1 kΩ
R₂ = 9 kΩ

$$\text{New Transfer Function} = \left(\frac{9}{1 + 9} \right) (-40 \text{ mA/V}) = -36 \text{ mA/V}$$

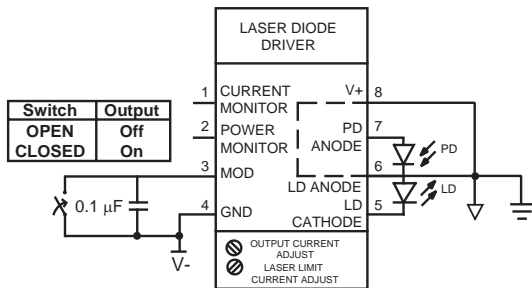
Change LDD 3P Photodiode Range

Put a resistor across pins 7 (PD) and 4 (GND) to modify the PD range.



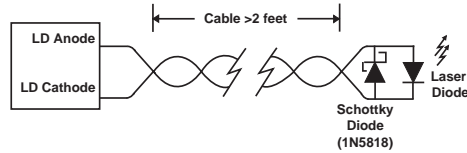
$$\text{Maximum Photodiode Current} = \frac{(2.5 \text{ V})}{R \parallel 20 \text{ k}\Omega} [\text{Amps}] \quad R \parallel 20 \text{ k}\Omega = \frac{(R)(20000)}{R + 20000}$$

Using the LDD 1P and LDD 3P with a Negative Power Supply to earth ground the laser diode anode

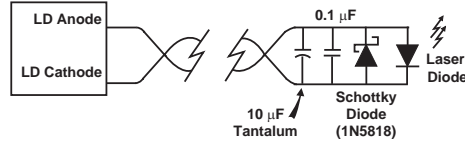


Laser Diode Protection when using a long cable

With a cable longer than two feet, add a Schottky diode across the laser diode.

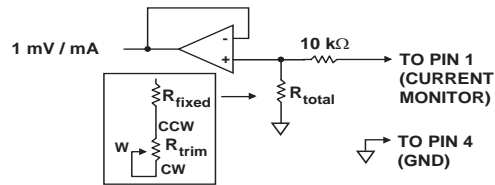


Filter the LDD P Output If you are not modulating the laser diode, add capacitors to reduce the noise by filtering the output current.



Convert Current Monitor to 1 mV / mA

Op-amp can be 1/2 of:
National Semiconductor LM358 or
Analog Devices AD8032

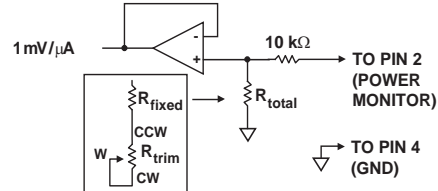


	LDD200	LDD400
R _{total}	869 Ω	1905 Ω
R _{fixed}	750 Ω	1820 Ω
R _{trim}	200 Ω	200 Ω

All resistors are metal film

Convert Power Monitor to 1mV / ∞A (LDD 3P only)

1/2 LM358 or LMC662

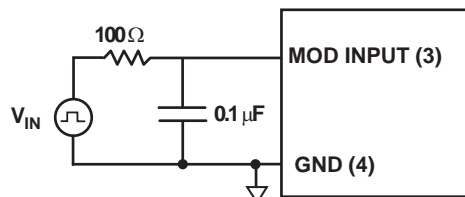


LDD 3P	
R _{total}	526 Ω
R _{fixed}	475 Ω
R _{trim}	200 Ω

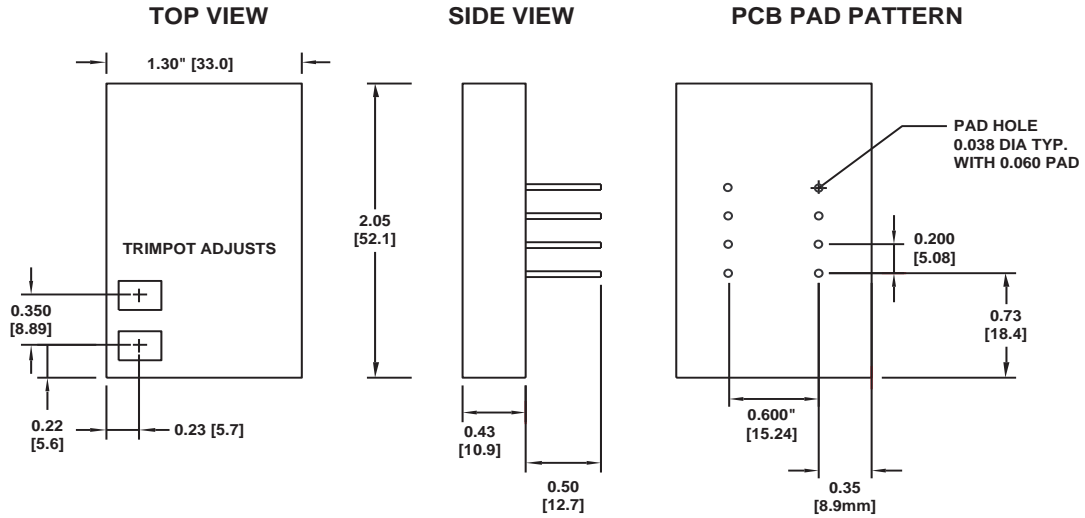
All resistors are metal film

To use a TTL signal at the MOD INPUT

TTL signals require pre-conditioning. The following circuit filters the TTL signal appropriately (low pass with a corner frequency of 15 kHz). Note: With +5 V applied at the MOD INPUT, a residual output current will still flow through the laser diode.

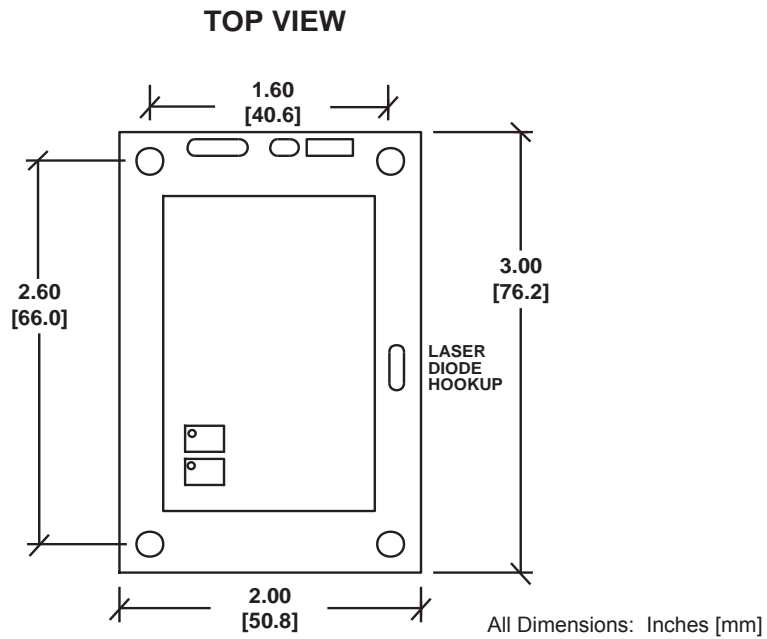


LDD P Series Laser Diode Driver



All Dimensions: Inches [mm]

LDD P Series Laser Diode Driver Evaluation Board



All Dimensions: Inches [mm]

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WARRANTY:

This Wavelength product is warranted against defects in materials and workmanship for a period of 90 days from date of shipment. During the warranty period, Wavelength will, at its option, either repair or replace products which prove to be defective.

WARRANTY SERVICE:

For warranty service or repair, this product must be returned to the factory. An RMA is required for products returned to Wavelength for warranty service. The Buyer shall prepay shipping charges to Wavelength and Wavelength shall pay shipping charges to return the product to the Buyer upon determination of defective materials or workmanship. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Wavelength from another country.

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REVISION HISTORY

REVISION	DATE	NOTES
REV. D	Aug-05	Initial release
REV. E	5-Oct-09	Updated to reflect RoHS compliance
REV. F	17-May-11	Updated to include R _{4a} and ModInput Safe Range
REV. G	22-Dec-11	Updated Type C Laser Quick Connect Diagram
REV. H	25-Jan-13	Updated Type C Laser Quick Connect