User's Guide

6A Current Source Module
LDC-3926339

ILX Lightwave®
A Newport Corporation Brand

ILX Lightwave Corporation · 31950 Frontage Road · Bozeman, MT, U.S.A. 59715 · U.S. & Canada: 1-800-459-9459 · International Inquiries: 406-556-2481 · Fax 406-586-9405

ilx.custhelp.com · www.ilxlightwave.com

700358 February 2003

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SAFETY AND WARRANTY INFORMATION

The Safety and Warranty Information section provides details about cautionary symbols used in the manual, safety markings used on the instrument, and information about the Warranty including Customer Service contact information.

Safety Information and the Manual

Throughout this manual, you will see the words *Caution* and *Warning* indicating potentially dangerous or hazardous situations which, if not avoided, could result in death, serious or minor injury, or damage to the product. Specifically:

Caution indicates a potentially hazardous situation which can result in minor or moderate injury or damage to the product or equipment.

Warning indicates a potentially dangerous situation which can result in serious injury or death.

Visible and/or invisible laser radiation. Avoid direct exposure to the beam.

General Safety Considerations

If any of the following conditions exist, or are even suspected, do not use the instrument until safe operation can be verified by trained service personnel:

- Visible damage
- Severe transport stress
- Prolonged storage under adverse conditions
- Failure to perform intended measurements or functions

If necessary, return the instrument to ILX Lightwave, or authorized local ILX Lightwave distributor, for service or repair to ensure that safety features are maintained (see the contact information on page xiii).

All instruments returned to ILX Lightwave are required to have a Return Authorization Number assigned by an official representative of ILX Lightwave Corporation. See Returning an Instrument on page xi for more information.

SAFETY SYMBOLS

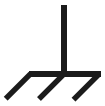
This section describes the safety symbols and classifications.

Technical specifications including electrical ratings and weight are included within the manual. See the Table of Contents to locate the specifications and other product information. The following classifications are standard across all ILX Lightwave products:

- Indoor use only
- Ordinary Protection: This product is NOT protected against the harmful ingress of moisture.
- Class I Equipment (grounded type)
- Mains supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage.
- Pollution Degree II
- Installation (overvoltage) Category II for transient overvoltages
- Maximum Relative Humidity: <80% RH, non-condensing
- Operating temperature range of 0 °C to 40 °C
- Storage and transportation temperature of –40 °C to 70 °C
- Maximum altitude: 3000 m (9843 ft)
- This equipment is suitable for continuous operation.

Safety Marking Symbols

This section provides a description of the safety marking symbols that appear on the instrument. These symbols provide information about potentially dangerous situations which can result in death, injury, or damage to the instrument and other components.

 Caution, refer to manual	 Earth ground Terminal	 Alternating current	 Visible and/or invisible laser radiation
 Caution, risk of electric shock	 Protective Conductor Terminal	 Caution, hot surface	 Frame or chassis Terminal
 **or (I)** On: In position of a bistable push control. The slash (I) only denotes that mains are on.		 **or (O)** Off: Out position of a bistable push control. The circle (O) only denotes that mains are off.	

WARRANTY

ILX LIGHTWAVE CORPORATION warrants this instrument to be free from defects in material and workmanship for a period of one year from date of shipment. During the warranty period, ILX will repair or replace the unit, at our option, without charge.

Limitations

This warranty does not apply to fuses, lamps, defects caused by abuse, modifications, or to use of the product for which it was not intended**.**

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for any particular purpose. ILX Lightwave Corporation shall not be liable for any incidental, special, or consequential damages**.**

If a problem occurs, please contact ILX Lightwave Corporation with the instrument's serial number, and thoroughly describe the nature of the problem.

Returning an Instrument

If an instrument is to be shipped to ILX Lightwave for repair or service, be sure to:

1. Obtain a Return Authorization number (RA) from ILX Customer Service.
2. Attach a tag to the instrument identifying the owner and indicating the required service or repair. Include the instrument serial number from the rear panel of the instrument.
3. Attach the anti-static protective caps that were shipped with the instrument and place the

instrument in a protective anti-static bag.

4. Place the instrument in the original packing container with at least 3 inches (7.5 cm) of compressible packaging material. **Shipping damage is not covered by this warranty.**
5. Secure the packing box with fiber reinforced strapping tape or metal bands.
6. Send the instrument, transportation pre-paid, to ILX Lightwave. Clearly write the return authorization number on the outside of the box and on the shipping paperwork. ILX Lightwave recommends you insure the shipment.

If the original shipping container is not available, place your instrument in a container with at least 3 inches (7.5 cm) of compressible packaging material on all sides.

Repairs are made and the instrument returned transportation pre-paid. Repairs are warranted for the remainder of the original warranty or for 90 days, whichever is greater.

Claims for Shipping Damage

When you receive the instrument, inspect it immediately for any damage or shortages on the packing list. If the instrument is damaged, file a claim with the carrier. The factory will supply you with a quotation for estimated costs of repair. You must negotiate and settle with the carrier for the amount of damage.

Comments, Suggestions, and Problems

To ensure that you get the most out of your ILX Lightwave product, we ask that you direct any product operation or service related questions or comments to ILX Lightwave Customer Support. You may contact us in whatever way is most convenient:

Phone . . . . . (800) 459-9459 or (406) 586-1244

Fax . . . . . (406) 586-9405

On the web at: . . . . . ilx.custhelp.com

Or mail to:

ILX Lightwave Corporation
P. O. Box 6310
Bozeman, Montana, U.S.A 59771
www.ilxlightwave.com

When you contact us, please have the following information:

Model Number: _____

Serial Number: _____

End-user Name: _____

Company: _____

Phone: _____

Fax: _____

Description of what is connected to the ILX Lightwave instrument: _____

Description of the problem: _____

If ILX Lightwave determines that a return to the factory is necessary, you are issued a Return Authorization (RA) number. Please mark this number on the outside of the shipping box.

You or your shipping service are responsible for any shipping damage when returning the instrument to ILX Lightwave; ILX recommends you insure the shipment. If the original shipping container is not available, place your instrument in a container with at least 3 inches (7.5 cm) of compressible packaging material on all sides.

CHAPTER 1

INTRODUCTION AND SPECIFICATIONS

This chapter is an introduction to the LDC-3926339 6-Amp Laser Diode Current Source module for the LDC-3926 mainframe. This chapter contains unpacking information, installation instructions, applying power, and safety considerations and instructions. It also contains maintenance information and specifications.

WARNING

If any of the following symptoms exist, or are even suspected, remove the LDC-3926339 Module from service. Do not use the module until trained service personnel can verify safe operation.

Visible damage

Severe transport stress

Prolonged storage under adverse conditions

Failure to perform intended measurements or functions

If necessary, return the LDC-3926339 to ILX Lightwave for service and repair to ensure that safety features are maintained.

Product Overview

The LDC-3926339 contains a laser diode current source. The current source provides high stability output up to 6 Amps, with fully redundant current limits and multiple laser protection features such as contact bounce detection, voltage limit adjust, and 4-wire voltage measurement for precise laser diode forward voltage measurement.

Initial Inspection

When you receive your LDC-3926339 module, check for shipping damage immediately. Shipping damage is not covered under warranty. Contact ILX Customer Service (see page *xii* for contact information) if the module appears to have shipping damage.

Verify that the module has an ESD protective hood on the combo-D connector and that it is enclosed in an ESD safe handling bag (when shipped separately from the mainframe). Remember to follow proper ESD safe handling procedures before handling the module.

Installing the Module into the Mainframe

These instructions are for installing the LDC-3926339 module into the LDC-3926 mainframe.

CAUTION

Static discharge can damage your new Laser Diode Controller Module. Be certain you use proper grounding procedures before unpacking and installing your module(s) into the LDC-3926 mainframe.

Inspect the module for any visible shipping damage that may have occurred before inserting the module into the mainframe. Pay special attention to the copper shielding material on the right edge of the rear panel of the module.

CAUTION

Be sure that the LDC-3926 mainframe power is off before inserting or removing any module. Inserting or removing a module while the mainframe power is on is known as hot-swapping.

Hot swapping may cause hardware, calibration data, and memory damage or loss. Module damage from hot-swapping is NOT covered under warranty.

Installing the Module

1. Unwrap the module from the anti-static bag.
2. Make sure the LDC-3926 mainframe is turned off.
3. Align the top and bottom edges of the module with the plastic guides in the desired slot on the mainframe. Make sure the copper shielding is facing the power entry side of the rear panel.
4. Carefully slide the module, 40-pin connector first, into the LDC-3926 mainframe until the connector is seated. Make sure to seat the module. The rear panel of the module is flush with the mainframe when properly inserted.

5 Secure the module to the mainframe with two screws located at the top and bottom of the module rear panel.

CAUTION

The LDC-3926339 module can be installed in only the LDC-3926 mainframe; it will *not* fit into the LDC-3900, LDC-3908, or LDC-3916 mainframes.

Specifications

Drive Current Output[1]	
Output Current Range:	0-6000 mA
Set-Point Resolution:	129 µA
Set-Point Accuracy:	±0.1% of full scale
Compliance Voltage:	7.0 V (adjustable voltage limit)
Temperature Coefficient:	≤75 ppm/°C
Short Term Stability (1 hr.): [2]	≤50 ppm
Long Term Stability (24 hr.): [3]	≤75 ppm
Noise and Ripple: [4] High Bandwidth Mode: Low Bandwidth Mode:	 <48 µA rms <32 µA rms
Transients: Operational: [5] 1 kV EFT/ Surge: [6]	 <5 mA <7 mA/<12 mA
Laser Drive Limit Settings	
Current Limit Range:	0-6025 mA
Current Limit Resolution:	2.05 mA
Current Limit Accuracy:	±18 mA
Voltage Limit Range:	0.0-7.5 V
Voltage Limit Resolution:	0.1 V
Voltage Limit Accuracy:	±0.2 V
Forward Voltage Limit Shut-off:	±200 mV
Photodiode Feedback	
Type:	Differential 10 Ω Input, Selectable Zero Bias or 5V Reverse Bias
PD Current Range:	0-5000 µA
Output Stability: [7]	±0.01%
Accuracy, set point (% of FS):	±0.1%
External Analog Modulation	
Input : [8]	0-8 V, 50 Ω
Transfer Function:	750 mA/V ±10%
High Bandwidth Mode, Large Signal Bandwidth: [9]	DC to 100 kHz
Low Bandwidth Mode:	DC to 27 kHz

Drive Current Measurement (Display)	
Output Current Range:	0.0-6000.0 mA
Output Current Resolution:	0.01 mA
Output Current Accuracy (@25 °C):	±0.07 % of Full Scale
Photodiode Current Range:	0-5000 μA
PD Current Resolution:	0.1 μA
PD Current Accuracy (@25°C):	±2 μA
PD Responsivity Range: [10]	0.00-1000.00 μA/mW
PD Responsivity Resolution:	0.01 μA/mW
Optical Power Range:	0.00-5000.00 mW
Optical Power Resolution:	100 μW
Forward Voltage Range:	0.00-7.50 V
Forward Voltage Resolution:	10 mV (1 mV through GPIB)
Forward Voltage Accuracy: [11]	±7 mV (±2 mV through GPIB)

1. All values are contingent upon a 60-minute warm-up period with the output turned-on.
2. Over any 1-hour period, half-scale output.
3. Over any 24-hour period, half-scale output.
4. Measured optically, evaluating noise intensity of a laser diode into a photodetector with 150 kHz bandwidth.
5. Maximum output current transient resulting from normal operational situations (e.g., power on-off, current on-off), as well as accidental situations (e.g., power line plug removal).
6. Maximum output current transient resulting from a 1000V power-line transient spike. Tested to ILX Lightwave Technical Standard #LDC-00196. Request ILX Application Note #3.
7. Maximum monitor photodiode current drift over any 30 minute period. Assumes zero drift in responsivity of photodiode.
8. Modulation input is 50 Ω terminated inside the mainframe.
9. 50% modulation at mid-scale output, 0.5 Ω load. High bandwidth mode.
10. Responsivity value is user-defined and is used to calculate the optical power.
11. Four wire voltage measurement. Voltage measurement accuracy while driving calibration load. Accuracy is dependent upon load and cable used.

CHAPTER 2

OPERATIONS

This chapter introduces the operation of the LDC-3926339 front panel control functions. It offers instructions for connecting your laser to the current source. This chapter also contains step-by-step procedures for operating your module in Constant Current Mode or Constant Power Mode. ILX Lightwave recommends you review the contents of this chapter before operating your Laser Diode Controller.

Connecting to the Laser Current Source

When connecting your laser diode or any other sensitive devices to the LDC-3926339, ILX recommends the instrument is powered up with the laser output turned off. In this condition, a low impedance shunt is active across the output terminals. When disconnecting devices, it is necessary to turn off only the laser outputs.

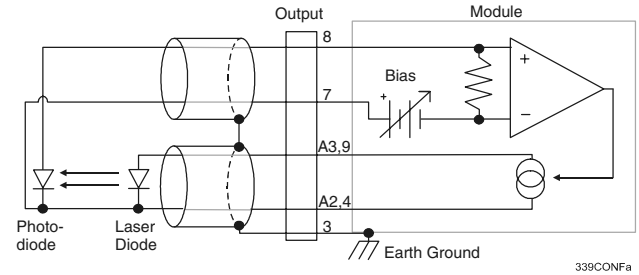
ILX recommends the connections to the LDC-3926339 output be made using twisted wire pairs with an earth-grounded shield (see Figure 2.1 on page *9*). ILX recommends using the CC-326H Current Source/Unterminated High Power Interconnect cable with a braided outer shield designed to provide the best possible rejection of most transient noise signals. The output terminals of the instrument are left floating, relative to earth ground, to suppress AC power-on/power-off transients that may occur through an earth-ground path. If the output circuit is earth-grounded at some point (such as through the laser package and mount), the user must avoid multiple earth grounds in the circuit. Multiple earth grounds may provide circuit paths that induce spurious currents in the photodiode feedback circuit and output leads.

If an inadvertent open circuit occurs during laser operation (while the laser is on), your laser may be damaged by a momentary circuit break-and-remake before the final circuit break. The LDC-3926339 has circuitry designed to detect open circuits and shut the output off under most conditions. However, ILX recommends that

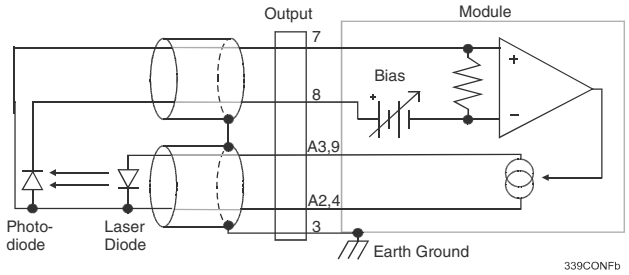
cable connections to the laser are secure enough to avoid intermittent open-circuit conditions should they be jostled or bumped.

CAUTION

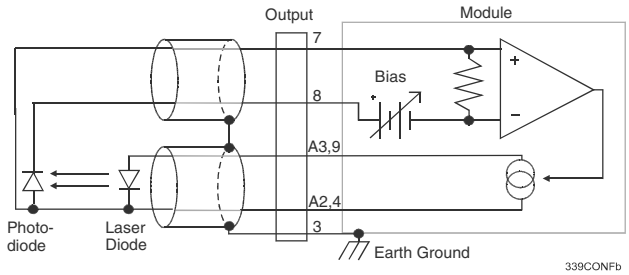
Use appropriately-shielded cabling to reduce coupling of potentially laser damaging transients. Do not bundle the current source cables with other cables in your system or laboratory.



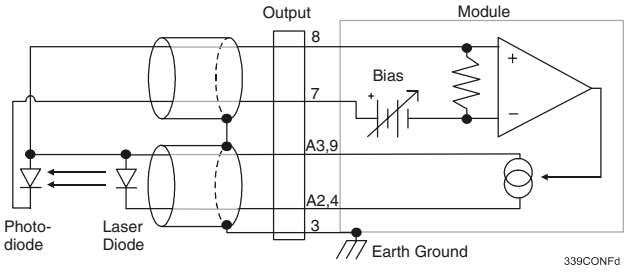
Common Laser Cathode
Photodiode Cathode



Common Laser Cathode
Photodiode Anode



Common Laser Anode
Photodiode Cathode



Common Laser Anode
Photodiode Anode

Figure 2.1 Laser Diode Connection Configurations

Laser Diode Connection

A Combo-D connector on the rear panel of the current source module is used to connect laser diodes to the module. There are connections provided for laser cathode and anode, photodiode cathode and anode, chassis ground, interlock, and laser forward voltage.

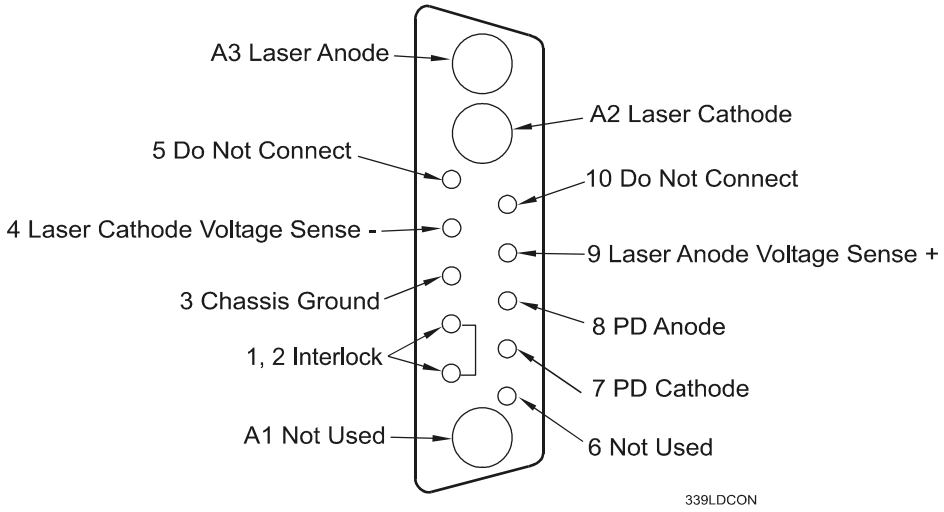


Figure 2.2 Back Panel Laser Diode Connector

Interlock Connections

To enable the laser output, a short must exist between the Interlock pins (pins 1 and 2) of the connector. The short can be a direct short across the pins or a switch to prevent laser operation until the switch is closed. If laser output is turned on without a short between pins 1 and 2, an error appears for the respective channel on any of the laser set-up pages or on the status screen. Furthermore, the output is turned off and error E501 (see *Front panel Error Indicators* on page *79*) appears if the interlock is disconnected.

CAUTION

The interlock terminals on the laser connector, pins 1 and 2, must be isolated from all other connections including earth ground.

Four-Wire Voltage Sense

The LDC-3926339 has a 4-wire voltage sense feature. The laser voltage is sensed through a pair of connections (pins 4 and 9) that are separate from the laser current drive connections (pins A2 and A3). This allows a more accurate laser voltage reading. All four of these pins (4, A2 , 9, A3) must be connected for the module to operate. For more information about 4-wire Voltage Sense, see Tech Note #TN3916-2. Contact ILX Lightwave Customer Service (see page *xii* for

contact information) for information about Tech Notes and other support information.

Photodiode Connections

Many laser diode modules contain an internal photodiode that monitors the back-facet emission of the laser. Usually, this photodiode is internally connected to either the laser anode or cathode.

The photodiode and laser connections to the LDC-3926339 are electrically isolated from ground and each other. If a 4-pin connection is made (no common connections) no additional jumpers are required. Figure 2.1 on page *9* shows the recommended connections and shielding for 3-pin lasers (where the common connection is internal to the device). A 4-pin laser must be connected with the same shielding as shown in Figure 2.1, but the common connection (between the photodiode and the laser) is optional.

Grounding Considerations

The laser output of the LDC-3926339 is isolated from chassis ground allowing either output terminal to be grounded at the user's option. Figure 2.1 shows the proper earth-ground shielding for laser diode/photodiode connections.

Front Panel Overview

This section describes how to operate the LDC-3926339 from the front panel of the LDC-3926 mainframe. For a more detailed explanation of the front panel keys, see the LDC-3926 User's Guide.

General Front Panel Operation

Figure 2.3 shows the front panel of the LDC-3926 mainframe. The key operating parameters for the LDC-3926339 can be set, adjusted, and displayed through established menus on the front panel. You control the menus on the display by using the keys (pushbuttons) to the right of the display. There are two kinds of

keys, the hard keys and soft keys. The hard keys have only one function, while the function of the soft keys varies with each menu on the display.

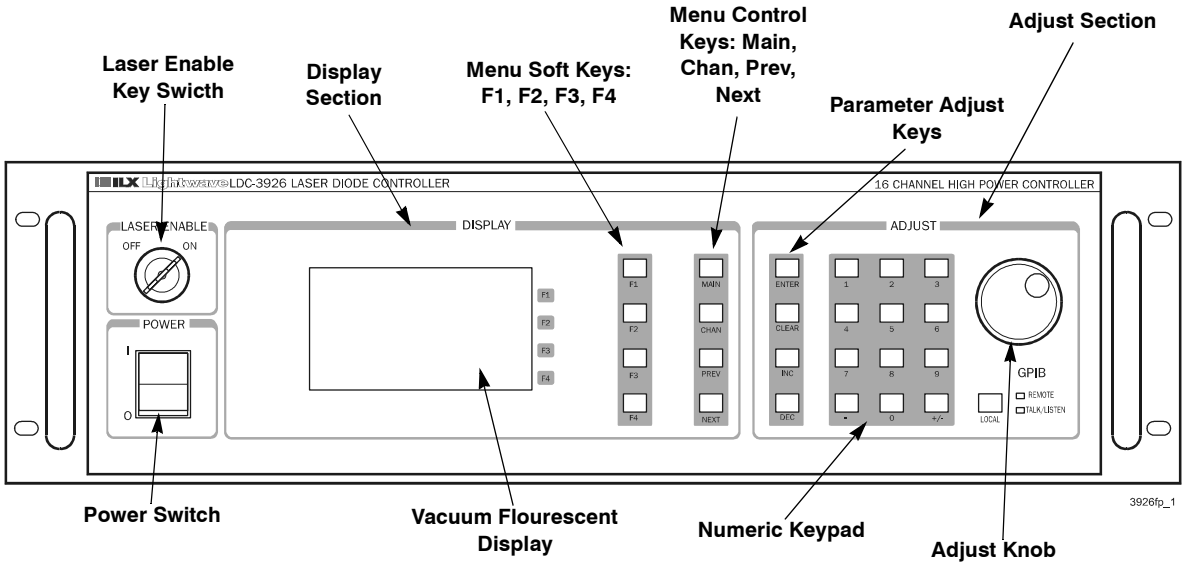


Figure 2.3 Front Panel

Laser Enable Key Switch

To enable laser output, a short must exist between the Interlock pins (pins 1 and 2) of the connector. The short can be a direct short across the pins or a switch to prevent laser operation until the switch is closed. If a short does not exist between these two pins, the laser output is disabled. See more information about interlock pins in the appropriate laser module User's Guide.

Display Section

Two important sections on the front panel are the Display and Adjust sections. The Display section contains the display screen and various keys that allow you to select a menu and parameters within that menu.

The keys labeled F1, F2, F3, and F4 (soft keys) have several functions depending which page is displayed. The boxed text on the right of the screen correspond with these softkeys. The MAIN, CHAN, and PREV/NEXT keys are the hard keys; their function is not dependent on what is on the display. Pressing the MAIN key provides direct access to the Main Instrument screen. The CHAN key provides direct access to the Channel screen, where the instrument displays channel

information on setpoints for the laser and TEC modules. The PREV and NEXT keys move the cursor around the screen to select operating parameters only..

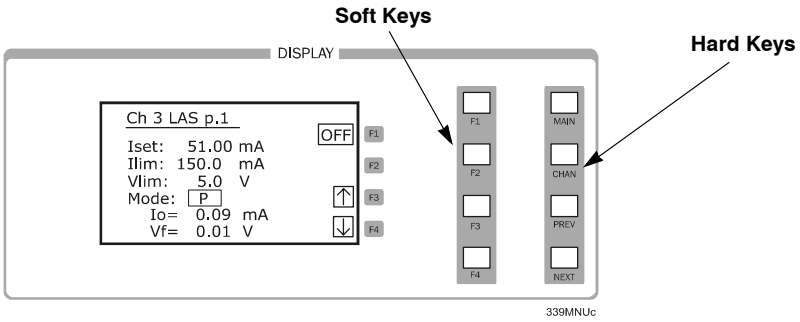


Figure 2.4 Display Section

Adjust Section

The Adjust section of the front panel provides various means of entering or modifying instrument parameters. These include a 10-key numeric keypad, a rotary knob (digital encoder), and increment and decrement keys..

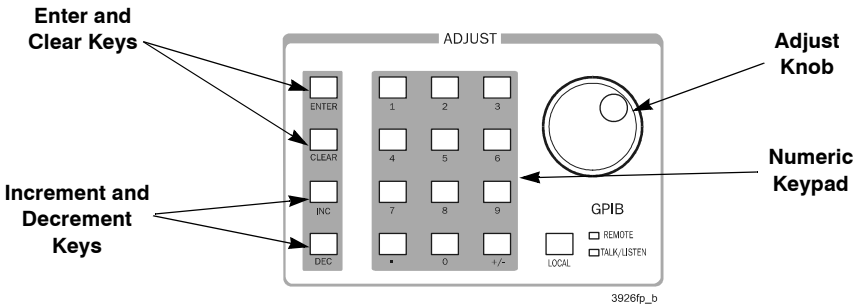


Figure 2.5 Adjust Section

Operating from the Front Panel

The current source in the module must be programmed before operation. If all the modules in the mainframe are the same model, configure the control parameters using the All Channel menu (see the LDC-3926 mainframe User's Guide). Alternatively, the control parameters for each individual channel can be set independently using the laser channel setup menus, which are accessed through the CHAN menu. Move between multiple pages of any setup menu by pushing the up and down arrow soft keys (F3 and F4) while in the setup menu. Use the Previous and Next keys (PREV/NEXT) to highlight different fields. Generally, adjust the highlighted parameter value with the numeric keypad, the Adjust knob, or the Increment and Decriment keys (INC/DEC).

Note: The ENTER key must be pressed within three seconds of entering a numeric value with the keypad, or the value reverts to the previous value.

Laser Current Controller Default Configuration:

- LASER output off
- I_{SET} = 50 mA
- I_{LIM} = 150 mA
- V_{LIM} = 5.0 V
- Constant I, low bandwidth mode
- I_{PD} Set Point = 100 µA
- Modulation off
- P_{PD} Set Point = 3.0 W
- P_{LIM} = 500 mW
- CAL PD = 0.0 µA/mW
- PD Bias off
- LASER STEP value = 0.1 mA
- LASER Tolerance values = 10 mA, 1.0 seconds

Operating in Constant Current Mode

There are two constant current modes: low bandwidth (ILBW) and high bandwidth (IHBW). The low bandwidth mode uses a low-pass filter on the laser drive current output to reduce noise, while the high bandwidth mode bypasses this filter. Use low bandwidth mode for CW operation or if the modulation frequency is below 27 kHz; use high bandwidth mode if the modulation frequency is above 27 kHz.

1 Press **CHAN** to display the channel menu. From this menu, you can see the measured parameters.

2 Use the INC/DEC keys or the Adjust knob to select the desired channel number highlighted at the top of the display.

3 Press the LAS soft key to enter page 1 of the laser channel setup menu.

From LAS page 1 menu, set the Current setpoint (Iset), the Current limit (Ilim), the Voltage limit (Vlim), and the control mode (Mode). This page also displays measured current output and laser forward voltage. You can also turn the controller on or off from this page.

4 Set the control mode.

4a Press **NEXT** until the Mode field is highlighted.

4b Select **`Ilbw`** or **`Ihbw`** using the INC/DEC keys or the Adjust knob.

Note: Repeatedly pressing the INC/DEC keys or turning the Adjust Knob cycles through the Constant Current low bandwidth (`Ilbw`), Constant Optical Power (`P`), Constant Current high bandwidth (`Ihbw`), and Photodiode Current (`Ipd`) control modes.

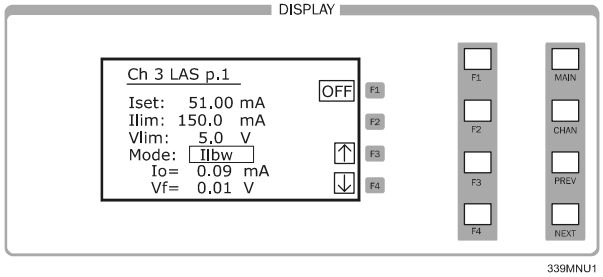


Figure 2.6 Constant Current Mode Setup, Laser Page 1

5 Select the voltage limit (Vlim) and current limit (Ilim).

5a Press **PREV** to select the voltage limit (`Vlim`) parameter.

5b Using the Adjust Knob or the numeric keypad, set the Vlim value and press **ENTER**. You must press Enter within three seconds of selecting the value.

Set the voltage limit slightly above the operating voltage of the laser diode to provide maximum protection. The voltage limit protects your laser by shutting off the source driver if the laser voltage exceeds the Vlim value.

5c Press **PREV** to select the current limit (`Ilim`) parameter.

5d Using the Adjust knob or the numeric keypad, set the Ilim value and press **ENTER**.

The current limit protects the laser by never allowing the drive current to exceed the Ilim value, independent of the current set point, modulation, or the controller mode (Constant Current or Constant Power).

⚠ CAUTION

Failure to set and ensure a proper Ilim value could result in laser damage.

6 Set the laser current setpoint (Iset).

6a Press **PREV** to select the current source setpoint (`Iset`) parameter.

6b Using the Adjust Knob or the numeric keypad, set the Iset value and press **ENTER**. This parameter sets the laser current source drive value when in Ilbw or Ihbw modes.

7 Enable the modulation and photodiode reverse bias.

7a Press the Down soft key (F4) until LAS page 3 is displayed.

7b To turn on Photodiode (PD) Bias parameter, press the INC/DEC keys or use the Adjust knob. This setting controls the 5 volt reverse voltage to the monitor photodiode.

7c Press **NEXT** to highlight Modulation. The Modulation parameter allows you to activate or deactivate the modulation input.

Note: If the modulation frequency is greater the 27 kHz, operate the module in high bandwidth mode (Ihbw).

7d Use the INC/DEC keys or the Adjust knob to turn on the modulation input. see *Specifications* on page *4* for modulation input specifications and limitations.

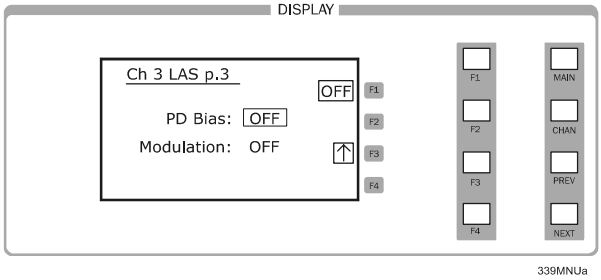


Figure 2.7 Modulation On/Off Screen, Laser Page 3

8 Press the F1 softkey on any of the three pages of the LAS setup menu to turn on or off the laser current source.

Also, you can turn on the current source with the F1 soft key from the CHAN menu. For safety, the ON toggle has a two-second delay before the current source is enabled.

Operating a Laser in Constant Power Mode (P)

The LDC-3926339 module allows you to operate the current source driver in Constant Optical Power (P) mode. In P mode, the module drives current to the laser to maintain a set power value (in mW).

The control loop feedback parameter is a monitor photodiode current. The controller converts the monitor photodiode current to optical power via a user defined photodiode responsivity, CalPD. If laser power changes due to internal or environmental conditions, the controller increases or decreases the current to the laser to maintain the power setpoint.

1 Calculate the photodiode responsivity (CalPD) value.

The photodiode responsivity, CalPD, is a transfer function that converts photodiode current to optical power of the laser diode.

1a Measure the output power of the laser with a calibrated detector.

1b Measure the corresponding monitor photodiode current (MPD).

1c Using the measured values for output power and MPD, calculate the responsivity (CalPD) by dividing the photodiode current by the optical power. The units required are mA/mW.

2 Press **CHAN** to display the channel menu.

3 Use the INC/DEC keys or the Adjust knob to select the desired channel number highlighted at the top of the display.

4 Press the LAS soft key to enter page 1 of the laser channel setup menu.

From LAS page 1 menu, set the Current setpoint (ISet), the Current limit (Ilim), the Voltage limit (Vlim), and the mode (Mode). This page also displays measured current output and laser forward voltage. You can also turn the controller on or off from this page.

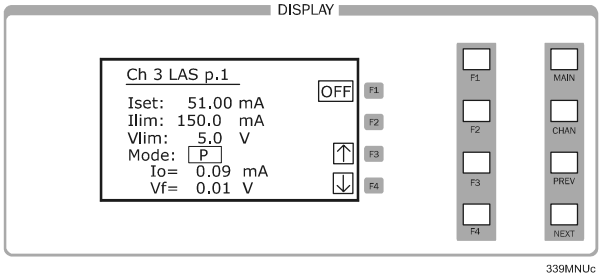


Figure 2.8 Laser Page 1

5 Set the current source mode to Constant Optical Power mode (P).

5a Press **NEXT** until the Mode field is highlighted.

5b Select `P` using the INC/DEC keys or the Adjust knob.

Note: Repeatedly pressing the INC/DEC keys or turning the Adjust Knob cycles through the Constant Current low bandwidth (`Ilbw`), Constant Optical Power (`P`), Constant Current high bandwidth (`Ihbw`), and Photodiode Current (`Ipd`) control modes.

6 Select the voltage limit (Vlim), current limit (Ilim), and current setpoint.

6a Press **PREV** to select the voltage limit (`Vlim`) parameter.

6b Using the Adjust Knob or the numeric keypad, set the Vlim value and press **ENTER**. You must press ENTER within three seconds of selecting the value.

Set the voltage limit slightly above the operating voltage of the laser diode to provide maximum protection. The voltage limit protects your laser by shutting off the source driver if the laser voltage exceeds the Vlim value.

6c Press **PREV** to select the current limit (`Ilim`) parameter.

6d Using the Adjust Knob or the numeric keypad, set the Ilim value and press **ENTER**.

The current limit protects the laser by never allowing the drive current to exceed the Ilim value, independent of the current set point and the controller mode (Constant Current or Constant Power).

⚠ CAUTION

Failure to set and ensure a proper Ilim value could result in laser damage.

7 Press **F4** continue to LAS page 2.

Note: There is no need to configure the current setpoint.

8 Press **NEXT** until the power limit (`Plim`) field is highlighted.

8a Using the INC/DEC keys, Adjust knob, or keypad, enter the optical power limit value.

The responsivity value (`CalPD`) must be set to the correct value for the power limit feature to function properly. This is a software limit only. For added security, the laser current output is turned off if this limit is reached.

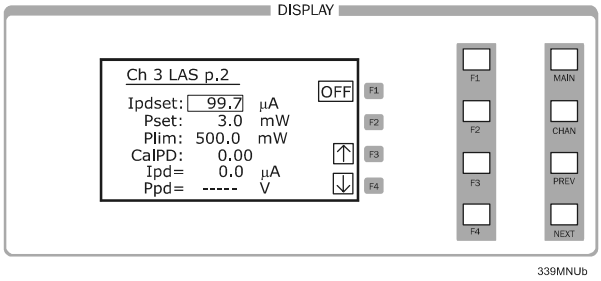


Figure 2.9 Power Limit Setup, Laser Page 2

9 Press **PREV** to select the power setpoint (`Pset`) parameter.

9a Using the INC/DEC keys, Adjust knob, or keypad, enter the optical power setpoint value.

The module divides the measured photodiode current by the CalPD value to calculate the laser optical power. The current source automatically adjusts the laser drive current to keep the calculated laser power at the Pset value.

9b Select CalPD and adjust it to the calculated value. If the correct CalPD is not known, see *Setting Constant Photodiode Current Mode (Ipd)* on page *20*.

The photodiode responsivity, CalPD, is used to convert photodiode current to optical power of the laser diode.The CalPD units are mA/mW. The correct responsivity value (CalPD) must be set for the constant power mode to properly operate.

10 Enable the photodiode bias.

10a Press the Down soft key (F4) until LAS page 3 is displayed.

10b To turn on Photodiode (PD) Bias parameter, press the INC/DEC keys or use the Adjust knob. The PD Bias parameter will toggle between on and off. This setting controls the 5 volt reverse voltage to the monitor photodiode.

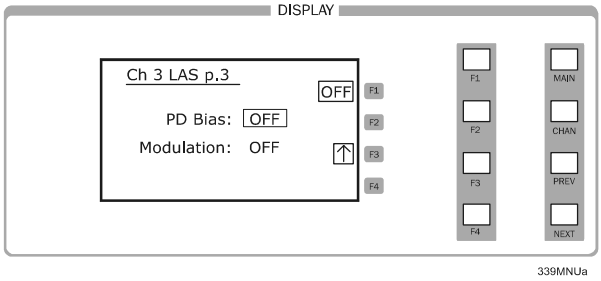


Figure 2.10 Laser Page Three

11 Press the F1 softkey on any of the three pages of the LAS setup menu to turn on or off the laser current source.

Also, you can turn on the current source with the F1 soft key from the CHAN menu. The ON toggle has a two-second delay before the current source is enabled.

Setting Constant Photodiode Current Mode (Ipd)

If the correct photodiode responsivity (CalPD) value is not known, the module can still drive the laser at a constant light power. The Constant Photodiode Current (Ipd) mode controls the laser drive current so the monitor photodiode current remains at a constant set point.

1 Press the LAS soft key to enter page 1 of the laser channel setup menu.

2 Set the current source mode to Photodiode Current mode (`Ipd`).

2a Press **NEXT** until the Mode field is highlighted.

2b Select **`Ipd`** using the INC/DEC keys or the Adjust knob.

Note: Repeatedly pressing the INC/DEC keys or turning the Adjust Knob cycles through the Constant Current low bandwidth (`Ilbw`), Constant Optical Power (`P`), Constant Current high bandwidth (`Ihbw`), and Photodiode Current (`Ipd`) control modes.

3 Set the voltage limit (Vlim) and current limit (Ilim).

3a Press **PREV** to select the voltage limit (`Vlim`) parameter.

3b Using the Adjust Knob or the numeric keypad, set the Vlim value and press **Enter**.

Set the voltage limit slightly above the operating voltage of the laser diode to provide maximum protection. The voltage limit protects your laser by shutting off the source driver if the laser voltage exceeds the Vlim value.

3c Press **PREV** to select the current limit (`Ilim`) parameter.

3d Using the Adjust Knob or the numeric keypad, set the Ilim value and press **Enter**.

The current limit protects the laser by never allowing the drive current to exceed the Ilim value, independent of the current set point and the controller mode (Constant Current or Constant Power).

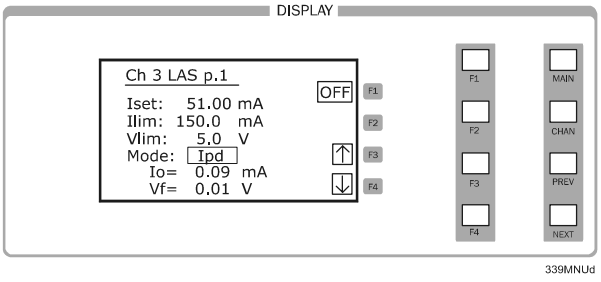


Figure 2.11 Laser Page 1

4 Press **F4** continue to LAS page 2.

5 Press the PREV/NEXT softkeys to highlight the photodiode current setpoint (`Ipdset`) field.

6 Using the INC/DEC keys, Adjust knob, or keypad, enter the photodiode current setpoint value.

Note: In this case, you may want to set the power limit (Plim) value high or set CalPD to zero which disables the power limit feature.

7 Press the F1 softkey on any of the three pages of the LAS setup menu to turn on or off the laser current source.

Also, you can turn on the current source with the F1 soft key from the CHAN menu. The ON toggle has a two-second delay before the current source is enabled.

Turning On the Laser Current Source

1 Press the F1 softkey on any of the three pages of the LAS setup menu to toggle the laser current source on and off.

Also, you can turn on the current source with the F1 soft key from the CHAN menu. The ON toggle has a two-second delay before the current source is enabled.

2 Each laser current source can be turned on or off independently, or you can turn on all channels of laser sources at the same time from the All Chnl menu. See the LDC-3926 mainframe manual for more information about all-channel operation.

CHAPTER 3

REMOTE OPERATIONS

GPIB (General Purpose Interface Bus) is the common name for *ANSI/IEEE Standard 488.2-1987*, an industry standard for interconnecting test instruments in a system. Everything you can do from the front panel can also be done remotely, and in some cases, with more flexibility. For instance, in remote mode you have access to commands for functions not found on the front panel. This chapter explains the fundamentals of operating the LDC-3926339 remotely through the General Purpose GPIB or RS-232 interfaces.

Remote Configuration

This section contains information about the command set, command syntax, as well as error and status registers. Refer to the Chapter 4, *Command Reference* for information about specific commands.

Command Syntax

This section describes command syntax and structure. You need this information to effectively write GPIB control programs. The syntax of GPIB commands follow the rules defined in the ANSI/IEEE 488.2-1987 standard.

Letters

Any GPIB command or query must contain all of the letters that are shown in upper case in the command definition, though they do not need to be typed in upper case. Some of the device dependent commands include optional letters shown in lower case in the command reference (Chapter 4, *Command Reference*). Letter case does not matter. Lower case characters are used in this

manual to identify optional letters; although, the optional letters must be in the correct sequence. Some examples of what does, and does not, work:

Okay	Not Okay
DIS	DS
Disp	dsp
Displ	dply
Displa	DSPLY
Display	disply

White Space

White space is normally the space character (space bar). A single white space must separate a command from its parameters or data. For example:

Okay	Not Okay
DELAY 500	DELAY500

To enhance readability, you can use one or more white spaces before a comma, semicolon, or terminator. Since a computer normally puts the terminator at the end of each command string (line), an extra space character at the end of the command line does not affect the command string.

A query has no space between the mnemonic and the question mark. For example:

Okay	Not Okay
TIMER?	TIMER ?

Note: Too many consecutive white spaces can overflow the 80-byte data I/O buffer.

Terminators

A program message terminator identifies the end of a command string. These are the valid terminator sequences:

- <NL>
- <^END>
- <NL><^END>

Many computers terminate with <CR><NL><^END> (Carriage Return - New Line - EOI). A carriage return (<CR>) is read as a white space.

The LDC-3926 terminates its responses with <CR><NL><^END>, unless you use the TERM command to change it. See

If you encounter problems with GPIB communications, the terminator string can sometimes be the cause.

Command Separators

You can put more than one command on the same line (same command string) if you separate them with a semicolon.

Note: The semicolon can be preceded by one or more spaces. Examples:

```
TEC:DIS 1; tec:set:t?;
TEC:MODE:t ; TEC:T 25 ; TEC:Const 1, 2, 3.5 ; TEC:OUT 1g1
```

Parameters

Some commands require a parameter. The parameter must be separated from the command by at least one space.

The syntax symbol `<nrf value>` refers to the flexible numeric representation defined by the GPIB standard. It means that you can represent numbers in integer or floating point form, or in engineering/scientific notation. The IEEE-488.2 standard uses the names NR1, NR2, and NR3 respectively to denote "integer", "floating point", and "scientific notation". For example the number *twenty* may be represented by any of the following ASCII strings:

Integer	20	+20	NR1
Floating point	20.0	+20.0	NR2
Scientific notation	2.0E+1 2.0e+1	+2.0E+1 +2.0e+1	NR3

There are no default values for omitted parameters. If a command is expecting a parameter and none is entered, an error is generated.

For further clarity in programming, the (Boolean) values of one (1) and zero (0) may be used or their names as indicated in the following table.

Table 3.1 Substitute Parameter Names

SUBSTITUTE NAME	VALUE
ON	1
OFF	0
OLD	1
NEW	0
TRUE	1
FALSE	0
SET	1
RESET	0

If multiple parameters are expected, they must be separated with commas. For example, to set the Steinhart-Hart constants (C1, C2, and C3) on a TEC module, the following command may be sent:

```
TEC:CONST 1.111, 2.004, 0.456
```

The LDC-3926 uses a terminator of <NL><^END> (new line EOI). For users whose GPIB driver defaults expect a carriage return in the terminator, <CR><NL><^END>, the "TERM" command may be used for convenience (see *TERM* on page *50*).

Laser Diode Current Source Command Set

The LDC-3926339 Series modules have their own module-specific command sets, separate from the commands for the mainframe (see the mainframe Instruction Manual). Figure 3.1 shows all of the commands that are usable by the LDC-3926339 Series modules in conjunction with the mainframe.

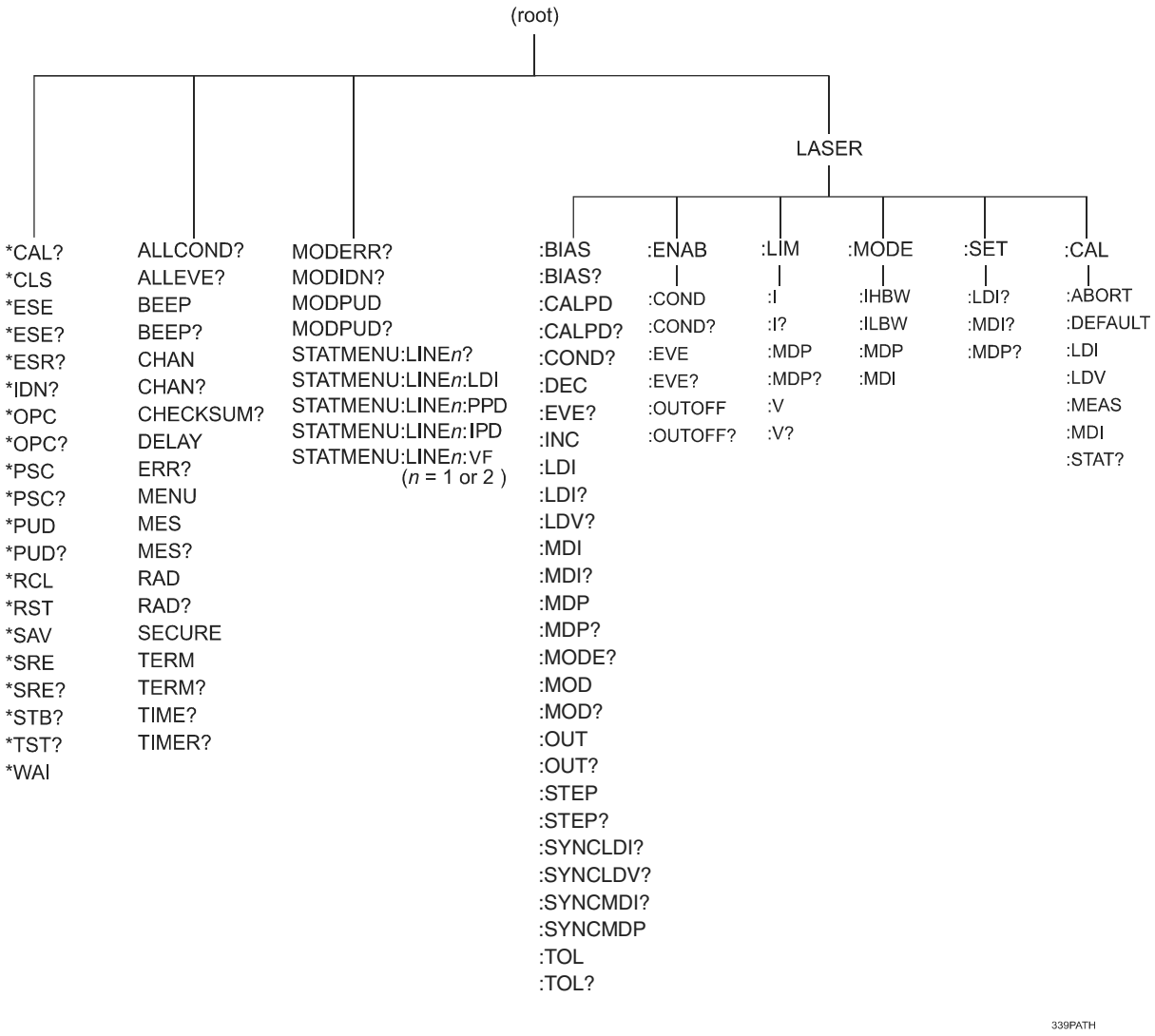


Figure 3.1 Command Path Structure

Syntax Summary

GPIB commands must contain all of the letters shown in upper case in the command definition. Optional letters shown in lower case for some device dependent commands in the command reference are useful for clarity, but must be in the correct sequence.

A single white space must separate a command from its parameters or data. White space is normally the space character (space bar). Other control characters are also interpreted as white space.

Note: Do not use white space before the question mark in a query command.

If you encounter problems with GPIB communications, the terminator string can be the cause. The instrument accepts <NL>, or <^END>, or <NL><^END> as a command line terminator. Many computers terminate with <CR> <NL> <^END> (Carriage Return - New Line - EOI). The instrument ignores the <CR> (Carriage Return) and treats it as white space. The LDC-3926 terminates its responses with <CR><NL><^END>, unless you use the TERM command to change it.

You can put more than one command on the same line (same command string) if you separate them with a semicolon.

GPIB uses a flexible representation for numeric parameters: integer, floating point, or engineering/scientific notation. There are no default values for omitted parameters.

Some device-dependent GPIB commands are compound commands, in which the first mnemonic opens a path to a set of commands relating to that path. The second mnemonic then defines the actual command.

Table 3.2 shows examples of invalid syntax command strings that produce errors:

Table 3.2 Invalid Syntax Command Strings

COMMAND	COMMENT
`TEC:MODE T`	Missing colon, MODE? expected.
`TEC:MODE:R DEC`	Missing semicolon, DEC command generates an error.
`LAS:DIS ?`	Space not allowed before question mark, DIS command expected.
`Las:LDI33;dis?`	Space missing between LDI command and the parameter value, 33.

IEEE 488.2 Common Commands

IEEE 488.2 Common Commands and Queries are distinguished by the "*" which begins each mnemonic. The diagrams below show the syntax structure for common commands, common command queries, and common commands with numeric data required.

Numeric data is required with *PSC (1 = on, 0 = off), *RCL (0 to 10, see *Save and Recall* on page *15*), *SAV (1 to 10, see *Save and Recall* on page *15*), *ESE (0 to 255, see page *40*), *SRE (0 to 255, see page *62*), and *PUD (used at factory only).

The *CAL? query returns "1" if all LDC-3926 modules' self-calibration routines are completed properly, otherwise "0" is returned.

The *TST? query returns "1" if all LDC-3926 modules that were working at power-up (or at the time of the last *TST? query) have responded to the LDC-3926339 within the past 15 seconds. If any modules fail to respond to the mainframe, *TST? returns "0", and those modules are no longer recognized by the system.

A list of all of the IEEE 488.2 Common Commands supported by the LDC-3926339 follows.

*CAL?	*CLS	*ESE
*ESE?	*ESR?	*IDN?
*OPC	*OPC?	*PSC
*PSC?	*PUD	*PUD?
*RCL	*RST	*SAV
*SRE?	*SRE	*STB?
*TST?	*WAI	

Command Timing

This section describes, for each command, whether the command is performed in an overlapped or sequential manner. Command timing states whether the next command can begin while another command is being executed, or if the next command must wait until this command is completed before its execution begins. See *Operation Complete Definition* on page *34* for information about the operation complete flag.

Sequential/Overlapped Commands

All common commands for the LDC-3926339 module are sequential and most device-dependent commands are executed before the previous command is complete.

All device-dependent commands are executed in an overlapped manner (except the DELAY command); subsequent commands begin before the current command is completed. The common commands are sequential; the next command must wait until the previous command is completed. The operation complete flag (OPC) is set after the conditions outlined in the Operation Complete Definition are satisfied.

The *WAI (common command) is an example of a sequential command which forces the next command to wait until the no-operation-pending flag is true. This is essentially the same as waiting for the OPC flag to become true, because the no-operations-pending flag is used to set the OPC flag (bit 0 of the Standard Event Status Register).

Commands that change the status of the instrument limits, or change its mode or current range, step value, or status enable registers, do not have their OPC flag set until all current writing to non-volatile memory has been completed. This ensures the OPC flag is never set prematurely.

Query Response Timing

Query responses are evaluated at the time the query request is parsed, and not at the time the response message is sent. In most cases this does not create a problem since the time between parsing a query and sending its response is small.

Status Reporting

The following sections discuss the LDC-3926339 module-dependent aspects of status reporting, including the OUTOFF commands and queries. The Output Off Register section also contains information on enabling the conditions that disable one of the laser current sources.

Refer to the LDC-3926 User's Guide, Chapter 3 Remote Operations for more detailed information about standard status structures and mainframe-related commands.

Status Registers

The LDC-3926339 module provides status registers which are summarized in the mainframe. These summaries are accessed using the ALLCOND? and ALLEVE? remote queries. Refer to the LDC-3926 User's Guide for details about remote status reporting.

Each channel of the mainframe may contribute to the ALLCOND and ALLEVE registers. For the LDC-3926339 module, the enabled conditions of both laser current sources are logically ORed, and the summary is passed to the appropriate bit of the ALLCOND register (see Figure 3.2). Likewise, the enabled events of both current sources are logically ORed, and the summary is passed to the appropriate bit of the ALLEVE register (see Figure 3.3). An *appropriate bit* is the bit corresponding to the channel number; bits 0-15 correspond to channels 1-16.

For example, you may wish to have the mainframe generate an interrupt to the host PC in the event of the laser current source going into Power Limit. As Figure 3.3 shows, bit 3 of the laser Event register is set when the laser goes in or out of Power Limit. Enable the event by setting bit 3 in the laser Enable Event register using the command `LASER:ENAB:EVE 8`. This allows the event to be passed to the ALLEVE register in the mainframe. You can monitor the ALLEVE status by using the ALLEVE? query, and you can monitor the summary using the *STB? query. To generate the SRQ (interrupt) for our example, you must also set the Service Request Enable Register. For example, *SRE 1 allows the ALLEVE

summary to generate the interrupt. See the mainframe Instruction Manual for details about status structures.

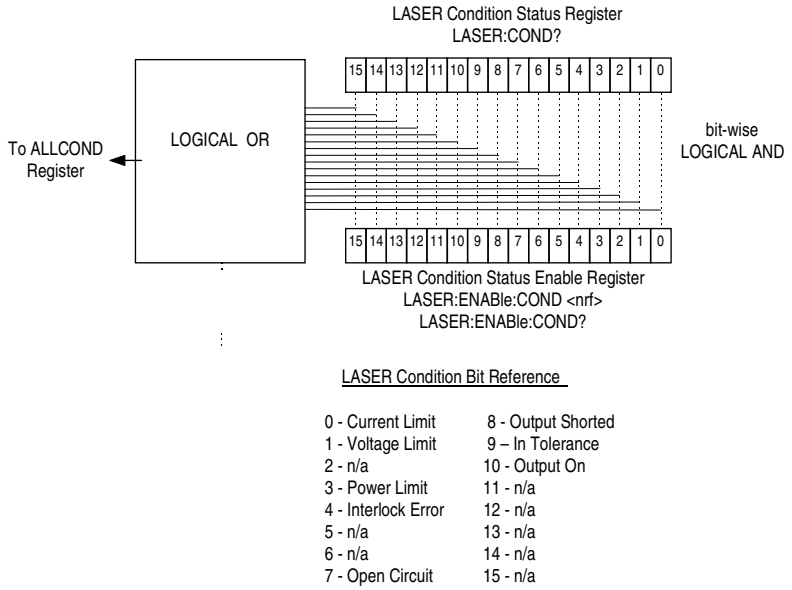


Figure 3.2 Condition Registers

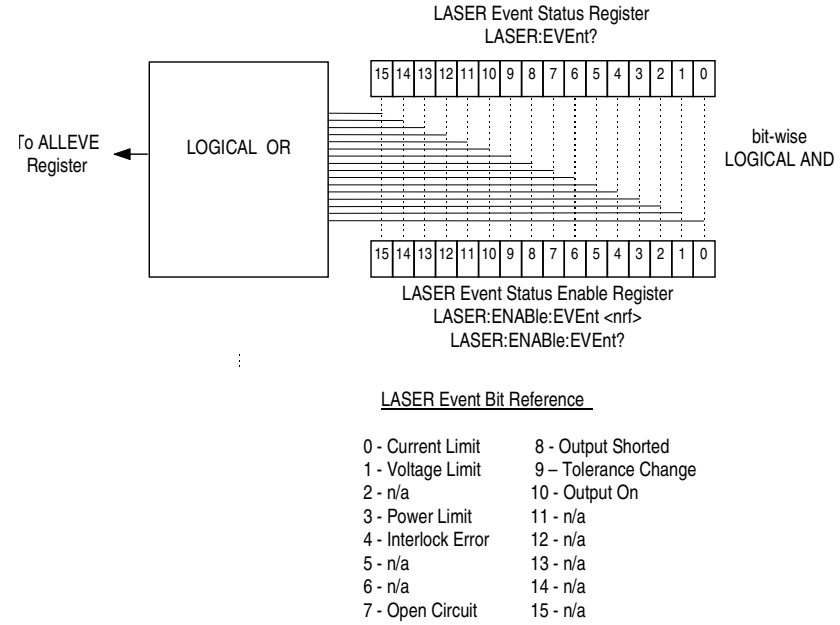


Figure 3.3 Event Registers

If bit 1 of the condition register is set, the laser's forward voltage is near the user's Voltage Limit (VLim) setpoint. The Laser Voltage Limit condition occurs when the voltage is about 0.25 volts less than the VLim setting. When the VLim set voltage is reached, the hardware is triggered to shut the Laser output off and bit 7, Open Circuit, is set.

Output Off Registers

The Output Off Enable Registers allow you to determine which conditions and events in the current sources can cause their outputs to be turned off. These registers are configured in a manner which is similar to the status reporting registers. However, their outputs are not reported in the Status Byte Register. Rather, they go to the hardware which controls the output switching for that current source. The events and conditions which may be set to cause the outputs to be turned off are shown in Figure 3.4.

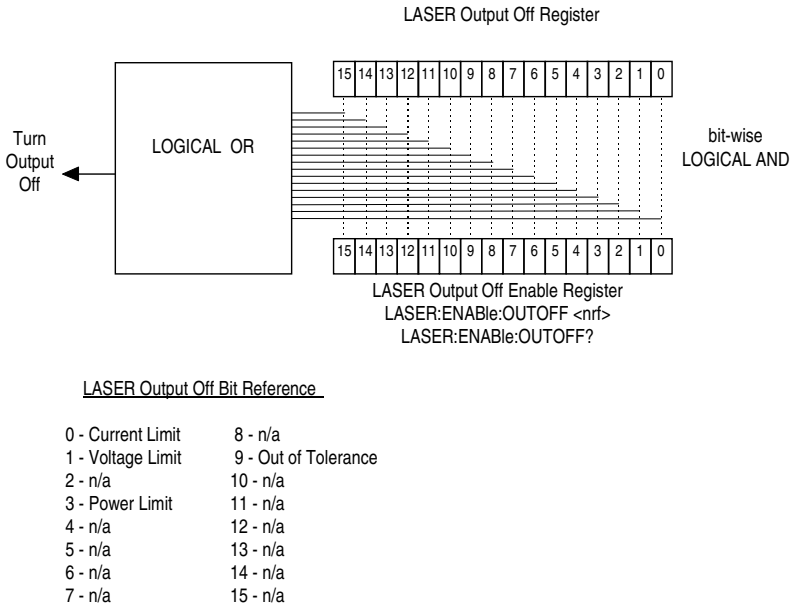


Figure 3.4 LDC-3926339 Output Off Register

The default settings for the Output Off registers are shown in Table 3.3. These settings are not affected by the *PSC (Power-On Status Clear) command.

Table 3.3 Default Settings for Output Off Registers

LASER1 Output Off Register	
0- disabled	8- n/a
1- disabled	9- disabled
2- n/a	10- n/a
3- enabled	11- n/a
4- n/a	12- n/a
5- n/a	13- n/a
6- n/a	14- n/a
7- n/a	15- n/a

Operation Complete Definition

Bit 0 of the Standard Event Status register contains the status of the Operation Complete flag. Enabling this bit via the *ESE command allows you to update Bit 5 of the status byte. Then, if the SRE mask has bit 5 set, and you issue an *OPC command, the SRQ signal is generated upon completion of the currently processed commands. This is used to initiate service request routines that depend on the completion of all previous commands.

The LDC-3926339 defines Operation Completeness as the state when all sequential and overlapped commands are completed. Most commands are sequential; only a few are overlapped. See *Sequential/Overlapped Commands* on page *29* and refer to your module instruction manual for a list of overlapped commands.

Error Messages

This section contains descriptions of the errors that are specific to the LDC-3926339 module. These are the error codes that are returned via the "MODERR?" query. Refer to the mainframe manual for a list of mainframe error codes and descriptions (the codes returned via the "ERR?" query).

Testing for Errors in Remote Operation

For more information about specific GPIB commands, see Chapter 4, *Command Reference*.

1. Send the query `ERR?` to read the system errors and module error summary.

   This allows you to error-check the LDC-3926 as a whole. If any module errors are present, the corresponding bit of the module error summary is set. For example, suppose the mainframe responds to an ERR? query with the string 0,0000000001100000. The zero to the left of the comma indicates that there are no mainframe errors, and the binary representation to the right of the comma indicates that there are errors on channels 7 and 6.

2. Send the query `MODERR?` to read the module errors.

   For example, type `CHAN 7;MODERR?` to return the errors in module 7, and `CHAN 6;MODERR?` returns any errors in module 6. For more information about mainframe errors, refer to the LDC-3926 Manual.

Note: Error codes not listed are reserved for future design use.

Table 3.4 Error Message Codes

Error Code	Explanation
E-103	Length of arbitrary block is different from expected length.
E-104	Parameter is an undefined numeric type.
E-105	Parameter has an invalid exponent.
E-106	A digit was expected in the parameter but was not found.
E-114	Specified arbitrary block length is invalid.
E-123	Command is not found.
E-126	Wrong number of parameters for command.
E-201	Parameter value out of range.
E-202	Error in conversion of parameter type.
E-203	Command is a "secure" command, but secure commands are disabled.
E-204	Suffix is invalid.
E-205	Expected Boolean parameter is invalid.
E-206	Error in conversion to signed 16-bit integer.
E-207	Error in conversion to unsigned 16-bit integer.
E-208	Error in conversion to signed 32-bit integer.
E-209	Error in conversion to unsigned 32-bit integer.
E-210	Error in conversion to floating-point number.

Table 3.4 Error Message Codes

Error Code	Explanation
E-211	Error in conversion to character pointer.
E-212	Error in conversion to byte pointer.
E-214	Response is too long to output.
E-222	Set value is over range.
E-223	Set value is under range.
E-226	Error in arbitrary block specification.
E-501	Interlock Open forces Laser output off.
E-503	Laser Voltage limit forces output off. "Open Circuit" error.
E-504	Laser Current Limit forces output off.
E-505	Laser Voltage Limit forces output off.
E-507	Laser Monitor Diode Power Limit forces output off.
E-508	External TEC Output Off Status forces LAS output off.
E-509	External TEC Temperature Limit forces LAS output off.
E-510	Out of Tolerance status forced LAS output off.
E-511	Laser Hardware Error forces output off. (e.g. low power line voltage).
E-529	Laser Output is off, but Laser status thought it was on.
E-535	Laser Mode changed while output on.
E-601	Internal error: recalled bin has incorrect checksum. (Settings do not match bin).
E-602	Internal error: task synchronization error.
E-620	Internal error: resource unavailable.
E-621	Internal error: message undeliverable to task.
E-622	Internal error: could not send message to mainframe.
E-710	AC Power Low Error detected
E-711	AC Power Low Error detected
E-713	Power Brown-Out Error detected
E-802	Calibration error: measurement entered before calibration was ready.

CHAPTER 4

COMMAND REFERENCE

This chapter is a guide to all of the commands for the LDC-3926339 6-Amp module. It contains an overview of the remote commands used by the module, shown in Table 4.1, as well as detailed command descriptions, listed in alphabetical order.

GPIB Commands

Table 4.1 Command Summary

NAME	PARAMETERS	FUNCTION
*CAL?	none	Used for the A/D calibration procedure.
*CLS	1	Resets the Standard Event Register, Status Byte and Error Queue to zero.
*ESE	1	Used to load the Standard Event Status Enable register.
*ESE?	none	Sets the summary bit (bit 5) in the Status Byte.
*ESR?	none	Returns the value of the **Standard Event Register**.
*IDN?	none	Returns the **DEVICE IDENTIFICATION** string.
LASER:BIAS	1	Enables or disables the 5 V reverse photodiode bias.
LASER:BIAS?	NONE	Returns the status of the photodiode bias control.
LASER:CALPD	1	Used to set the CAL PD (monitor responsivity) constant.
LASER:CALPD?	NONE	Returns the CAL PD (monitor responsivity) constant.
LASER:CAL:ABORT	NONE	Aborts a calibration.
LASER:CAL:DEFAULT	NONE	Restores calibration values to their defaults.
LASER:CAL:LDI	NONE	Starts the constant current source calibration mode.
LASER:CAL:LDV	NONE	Starts the voltage measurement calibration mode.
LASER:CAL:MDI	NONE	Starts the monitor photodiode current calibration mode.
LASER:CAL:MEAS	1	Enters a calibration value.
LASER:CAL:STAT?	NONE	Returns a value which represents the calibration status.
LASER:COND?	NONE	Returns the value of the condition register.
LASER:DEC	2	Decreases the set point value by one or more steps with user-programmable delay between steps.

Table 4.1 Command Summary

NAME	PARAMETERS	FUNCTION
LASER:ENAB:COND	1	Sets the conditions that will affect the All Condition register.
LASER:ENAB:COND?	NONE	Returns the value of the Condition Enable register.
LASER:ENAB:EVE	1	Sets the events that will affect the All Event register.
LASER:ENAB:EVE?	NONE	Returns the value of the Event Enable register.
LASER:ENAB:OUTOFF	1	Sets the enable register with conditions that will turn off the output.
LASER:ENAB:OUTOFF?	NONE	Returns the value of the Outoff Enable register.
LASER:EVE?	NONE	Returns the value of the Event register.
LASER:LDI	1	Sets the constant current source set point value.
LASER:LDI?	NONE	Returns the constant current source measured value.
LASER:INC	2	Increases the current source set point value by one or more steps with user-programmable delay between steps.
LASER:LDV?	NONE	Returns the measured laser voltage value.
LASER:LIM:I	1	Sets the laser current source limit.
LASER:LIM:I?	NONE	Returns the laser current source limit.
LASER:LIM:MDP	1	Sets the constant optical power (from monitor PD) limit value.
LASER:LIM:MDP?	NONE	Returns the optical power (from monitor PD) limit value.
LASER:LIM:V	1	Sets the current source's adjustable compliance voltage.
LASER:LIM:V?	NONE	Returns the value of the adjustable compliance voltage setting.
LASER:MDI	1	Sets the monitor current set point.
LASER:MDI?	NONE	Returns the monitor PD current measured value.
LASER:MDP	1	Sets the constant optical power set point
LASER:MDP?	NONE	Returns the actual monitor PD power value
LASER:MODE?	NONE	Returns the mode: ILBW (constant current, low bandwidth), IHBW (constant current, high bandwidth), MDP (constant optical power) or MDI (constant monitor current).
LASER:MODE:IHBW	NONE	Sets the mode to constant current, high bandwidth.
LASER:MODE:ILBW	NONE	Sets the mode to constant current low bandwidth mode.
LASER:MODE:MDI	NONE	Sets the mode to constant monitor current mode (regardless of CALPD value).
LASER:MODE:MDP	NONE	Sets the mode to constant optical power mode.
LASER:MOD	1	Enables or disables the channel's modulation input.
LASER:MOD?	NONE	Returns the status of the channel's modulation input.
LASER:OUT	1	Turns the current source output on or off.
LASER:OUT?	NONE	Returns the current source output status.
LASER:SET:LDI?	NONE	Returns the constant I (current) set point.
LASER:SET:MDI?	NONE	Returns the constant optical power set point.
LASER:SET:MDP?	NONE	Returns the constant P (optical power) set point.

Table 4.1 Command Summary

NAME	PARAMETERS	FUNCTION
LASER:SYNCLDI?	NONE	Synchronized measurement. Returns the laser current in mA.
LASER:SYNCLDV?	NONE	Synchronized measurement. Returns the laser voltage in volts.
LASER:SYNCMDI?	NONE	Synchronized measurement. Returns the monitor photodiode current in μA.
LASER:SYNCMDP?	NONE	Synchronized measurement. Returns the optical power.
LASER:STEP	1	Sets the current source set point step value.
LASER:STEP?	NONE	Returns the current source set point step value.
LASER:TOL	2	Sets the laser set point tolerance value and time period.
LASER:TOL?	NONE	Returns the laser set point tolerance value and time period.
MODERR?	NONE	Returns the error codes (up to 10) from the module.
MODIDN?	NONE	Returns identification data from the module.
MODPUD	1	Used at factory to set product information.
MODPUD?	NONE	Returns factory-set product information.
*OPC	none	Generates the **OPERATION COMPLETE** message in the Standard Event Status Register .
*OPC?	none	Places an ASCII character 1 into the Output Queue.
*PSC	1	Used to avoid any undesirable service requests.
*PSC?	none	Queries the power-on-status-clear flag.
*PUD	none	Stores data unique to the instrument.
*PUD?	none	Retrieves the contents of the *PUD storage area.
*RCL	1	Recall a stored setup configuration
*RST	none	Performs a device reset.
*SAV	1	Save the current setup configuration
*SRE	1	Sets the Service Request Enable register bits to allow generation of the user-selectable service requests.
*SRE?	none	Determines the current contents of the Service Request Enable register.
STATMENU:LINEn?	NONE	Returns the name of the measurement that is displayed on line *n* of the status menu. (*n* can be either 1 or 2).
STATMENU:LINEn:IPD	NONE	Sets line *n* of the status menu to display photodiode current.
STATMENU:LINEn:LDI	NONE	Sets line *n* of the status menu to display laser current
STATMENU:LINEn:PPD	NONE	Sets line *n* of the status menu to display optical power.
STATMENU:LINEn:VF	NONE	Sets line *n* of the status menu to display laser forward voltage.
*STB?	none	Reads the Status Byte.
*TST?		Initiates an internal self-test and returns a response when complete.
*WAI		Prevents executing any further commands until the No-Operation-Pending flag is true.

GPIB Command Reference

This section presents the module commands for both local and remote operation of the LDC-3926339, listed in alphabetical order. Sub-sections for each path are presented, listing the commands which are legal for that path.

---

*CAL?

Action	Adjusts the internal analog to digital (A/D) converter to reference points, then reports results.
Results	Zero = OK
	Non-zero = calibration error
Note	A/D referencing is performed each 10 minutes of inactive time.
Example	*CAL?

---

*CLS

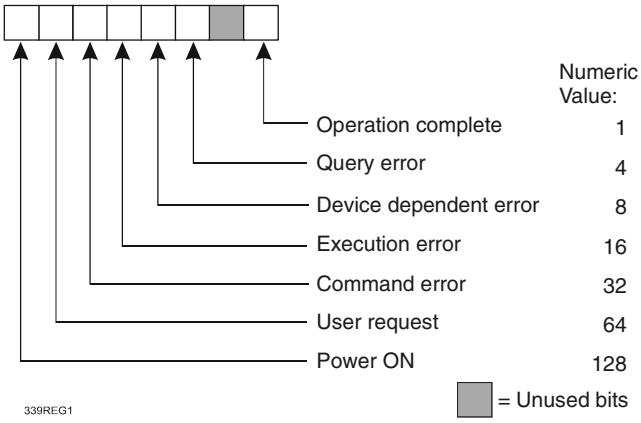
Action	Clears status event registers: Event Status, Event Status Enable, and Error Queue.
Note	Useful to clear registers before enabling service requests (SRQ).
Example	***CLS**

---

*ESE <nrf value>

Event Status Enable

Action	Enables bits in the standard event status enable register.
Response	The value must be between 0 and 255.



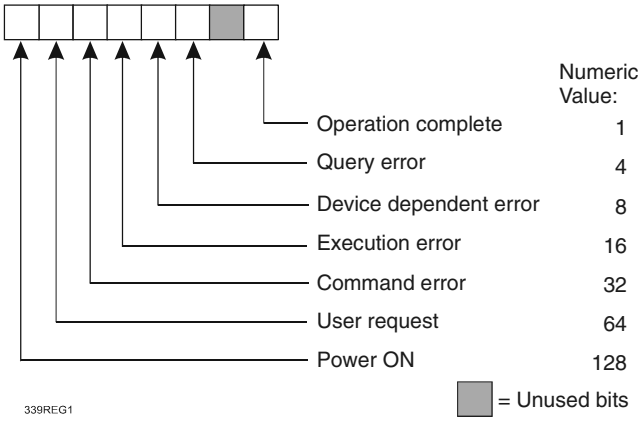
Notes	Bit 5 of the status byte register is set if any enabled conditions are true.
	Setting bit 0 allows you to generate service requests from overlapped commands as previous operations complete. This may be useful for ensuring that an operation is complete before starting a measurement.

*ESE?

Event Status Enable?

Action Requests the value in the standard event status enable register.

Response The value must be between 0 and 255.



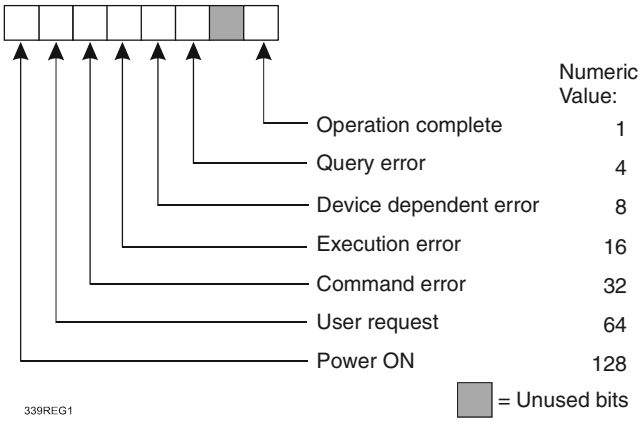
Notes Bit 5 of the status byte register is set if any enabled conditions are true.
Response is the sum of the enabled bits.

*ESR?

Standard Event Status Register?

Action Requests the value in the standard event status register.

Response The value must be between 0 and 255.



Notes Response is the sum of the enabled bits.
This command allows you to determine which type of error has occurred.

*IDN?

Action	Requests the instrument to identify itself.
Response	Returns a comma delimited standard format ASCII identification string, from information stored in the instrument during manufacture.

LASER:

The LASER: command path is used to access the LDC-3926339 current source commands. The following command paths may be reached from the LASER: command path:
LASER:CAL:
LASER:ENABle:
LASER:LIMit:
LASER:MODE:
LASER:SET:
The following commands may be reached directly from the LASER: command path.

LASER:BIAS	LASER:LDI	LASER:MDP?	LASER:SYNCLDV?
LASER:BIAS?	LASER:LDI?	LASER:MODE?	LASER:SYNCMDI?
LASER:CALPD	LASER:INC	LASER:MODulation	LASER:SYNCMDP?
LASER:CALPD?	LASER:LDV?	LASER:MODulation?	LASER:STEP
LASER:COND?	LASER:MDI	LASER:OUTput	LASER:STEP?
LASER:DEC	LASER:MDI?	LASER:OUTput?	LASER:TOL
LASER:EVEnt?	LASER:MDP	LASER:SYNCLDI?	LASER:TOL?

LASER:BIAS

The LASER:BIAS command turns the laser photodiode bias on or off.

Parameters	An <nrf value>; 1 = on, 0 = off.
Notes	When the BIAS is on, a bias of ñ5 V is placed across the photodiode terminals.
Examples	LASER:BIAS ON-action: sets LASER photodiode bias output on.

LASER:BIAS?

The LASER:BIAS? query returns the status of the photodiode bias selection.

Parameters	None. The response is an <nrf value>.
Notes	Photodiode bias is turned off when a *RST command is issued.
Examples	LASER:BIAS?-response: 0, means that the laser photodiode bias is off.

LASER:CALPD

The LASER:CALPD command sets the laser photodiode feedback responsivity (the CAL PD parameter).

Parameters	An <nrf value>, in microamps/milliwatt (µA/mW).
Notes	The module calculates optical power by dividing the monitor feedback current by its CalPD value. Photodiode (PD) responsivity is frequently provided by manufacturers of packaged lasers with built-

in power monitors, and is typically called "Monitor Detector Responsivity." The monitor produces a current when the laser illuminates it, and this current will increase with increasing laser optical power. Manufacturers of laser modules with integrated monitors may specify the responsivity of the monitor in terms of the laser optical power and the resulting monitor current. For example, a responsivity may be specified as 5 μA/mW, meaning that to produce a monitor current of 5 μA, the laser optical power must be 1 mW. Typically, the specified responsivity is entered into the current source as CalPD, using the Laser:CalPD command.

If this parameter is set to 0, the module will not calculate the optical power. It will display "-----" on the front panel, and GPIB queries of the optical power, using the "Laser:mdp?" query, will return -1.0.

Examples LASER:CALPD 0-action: sets the CAL PD parameter to 0.

Laser:Calpd 10.0-action: sets the CAL PD parameter to 10 microamp/milliwatt. A photodiode feedback current of 10 μA will cause the measured optical power to be 1 mW.

LASER:CALPD?

The LASER:CALPD? query returns the value of the laser photodiode feedback responsivity (CalPD parameter) setting.

Parameters None. The response is an <nrf value>.

Notes If this value is 0, the front panel Ppd will display "-----", and measured optical power (read with GPIB using the "Laser:mdp?" query) will be -1.0.

Examples Laser:CALPD?-response: 1.1, means the laser CalPD is set to 1.10 μA/mW: a photodiode feedback current of 2.2 μA represents 2 mW of optical power.

LASER:CAL

The LASER:CAL: command path is used to access the laser calibration commands.

The following commands may be reached directly from the LASER:CAL: command path.

- `LASER:CAL:ABORT`
- `LASER:CAL:DEFAULT`
- `LASER:CAL:LDI`
- `LASER:CAL:LDV`
- `LASER:CAL:MDI`
- `LASER:CAL:MEAS`
- `LASER:CAL:STATUS?`
- `LASER:CAL:VALUE?`

LASER:CAL:ABORT

The LASER:CAL:ABORT command is used to exit the laser calibration procedure without changing the calibration values.

Parameters None.

Notes If this command is issued while the LDC-3926339 Series Laser Diode Current Source is in a Laser calibration, the calibration will be terminated and the module will operate with the same calibration values as before the calibration mode was started.

This command is intended for use after a false or invalid calibration value is entered, or to exit calibration mode before any values have been entered.

Examples Laser:CAL:ABORT-action: the module exits calibration mode.

LASER:CAL:DEFAULT

The LASER:CAL:DEFAULT command sets all of the laser calibration constants to default values.

Parameters None.

Notes This command should only be used in the case in which the calibration has become corrupted and circumstances make calibration impossible. Measurements and setpoints on the laser current source are not guaranteed to meet accuracy specifications after this command is issued. Accuracy will remain unspecified until calibration is performed on the module.

Examples Laser:CAL:Default-action: sets all of its laser calibration constants to their default values.

LASER:CAL:LDI

The LASER:CAL:LDI command is used to initiate the calibration procedure for the laser current setpoint, measurement, and current limit.

Parameters None.

Notes Both low and high bandwidth modes, along with current limit, are calibrated during this procedure. See the Service Reference portion of this manual for complete calibration instructions.

Examples Laser:CAL:LdI-action: enters calibration mode for laser current.

LASER:CAL:LDV

The LASER:CAL:LDV command is used to initiate the calibration procedure for the laser voltage measurement.

Parameters None.

Notes See the Service Reference portion of this manual for complete calibration instructions.

Examples Laser:CAL:Ldv-action: enters calibration mode for laser voltage measurement.

LASER:CAL:MDI

The LASER:CAL:MDI command is used to initiate the calibration procedure for the laser photodiode current setpoint and measurement system.

Parameters None.

Notes See the Service Reference portion of this manual for complete calibration instructions.

Examples Laser:CAL:MDI-action: enters the laser photodiode current calibration mode.

LASER:CAL:MEAS

The LASER:CAL:MEAS command is used to enter measured values during the laser calibration procedure.

Parameters An <nrf value> which represents the measured value expected for the present Laser calibration state.

Notes See the Service Reference portion of this manual for complete calibration instructions.

Examples Laser:CAL:MEAS 4.95-action: the module uses the value 4.95 for the required measurement value.

LASER:CAL:STATus?

The LASER:CAL:STATus? query is to determine whether the unit is ready for a calibration value and whether it is in a Laser calibration mode.

Parameters: None. The response will be an <nrf value>; 0 = Not Ready for Measurement, 1 = Ready for Measurement, 2 = Calibration Completed, and 3 = Calibration Aborted.

Notes: If the calibration is aborted, the status value will remain "3" until the calibration is started again.

Examples: LASER:CAL:STAT?-response: 1, means the module is ready for a calibration measurement to be entered using the "LASER:CAL:MEAS" command.

LASER:CAL:STAT?-response: 2, means the module has completed calibration.

LASER:Cal:Stat?-response: 0, means the module is not yet ready for the LASER calibration measurement value to be entered.

LASER:COND?

The LASER:COND? query returns the contents of the Laser Condition Status register.

Parameters: None. The response is the sum of the following:

1 -	Current Limit	256 -	Output is Shorted
2 -	Voltage Limit	512 -	Output In Tolerance
4 -	n/a	1024 -	Output On
8 -	Power Limit	2048 -	n/a
16 -	Interlock Disabled	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit	32768 -	n/a

Notes: The conditions which are reported to the LDC-3926 Status Byte are set using the LASER:ENABle:COND command (for each channel). See the Status Reporting section of the LDC-3926 manual for more complete information.

The Open Circuit condition can only be present while a LASER output is on; when the hardware detects this condition, it will turn that LASER output off. Therefore, the Open Circuit condition is fleeting and may be missed with the LASER:COND? query. The user should test for the Open Circuit Event using the LASER:EVEnt? query.

The condition status is constantly changing, while the event status is only cleared when the event status is read or the *CLS or *RST command is issued.

The voltage limit condition occurs as a warning when the laser diode voltage is about 0.25 volts below the VLim setting. The Open Circuit condition occurs when the laser diode voltage is equal to or exceeds the VLim setting.

Examples: LASER:COND?-response: 1027, means that the Laser Output is On (1024), it is in Voltage Limit (2), and it is in Current Limit (1).

LASER:COND?-response: 272, means that the Laser Output is shorted (turned off - 256) and its Interlock pins are not connected (16).

LASER:DEC <nrf value>

The LASER:DEC command decrements the laser constant-current set point by one or more steps. Parameters allow multiple steps to be decremented and the time (in milliseconds) between decrements to be set, respectively.

Parameters — Two values (see *Parameters* on page *25* for information about <nrf values>) are required. The first one represents the number of steps to decrement, and the second is the number of milliseconds between steps.

Notes — The step size is set with the LASER:STEP command; its default value is 1.0 mA.

The first parameter, the number of steps to decrement, must be an integer between 1 and 50000.

The minimum time to complete one decrement is about 10 to 20 msec. Therefore, values for the second parameter (time between decrements) have a practical minimum of 20. The maximum number of msec is 65535.

Only the LASER:LDI set point is decremented using this command, regardless of mode setting or output status (on or off).

Examples — LASER:STEP 0.3; LASER:DEC 1,100-action: the Laser constant-current setpoint is decremented by 0.3 mA.

LASER:STEP 0.5; LASER:DEC 4,100-action: the step size is set to 0.5 mA, the setpoint is decremented by 4 steps of 0.5 mA, separated in time by 100 msec, for a total decrement of 2.0 mA.

laser:step 1.0; laser:dec 10,1000-action: the step size is set to 1.0 mA, the setpoint is decremented by 1.0 mA, 10 times, with 1 second between decrement steps. The Laser output is decremented a total of 10 mA over a period of 10 seconds.

LASER:ENABle:

The LASER:ENABle: command path is used to access the laser status enable commands and queries.

The following commands may be reached directly from the LASER:ENABle: command path.

- LASER:ENABle:COND
- LASER:ENABle:COND?
- LASER:ENABle:EVEnt
- LASER:ENABle:EVEnt?
- LASER:ENABle:OUTOFF
- LASER:ENABle:OUTOFF?

LASER:ENABle:COND

The LASER:ENABle:COND command sets the Laser Condition Status Enable register. The bits in this register determine which bits in the Laser Condition Status register are summarized in the LDC-3926 Status Byte.

Parameters An <nrf value> whose sum represents the enabled bits:

1 -	Current Limit	256 -	Output Shorted
2 -	Voltage Limit	512 -	Output In Tolerance
4 -	n/a	1024 -	Output On
8 -	Power Limit	2048 -	n/a
16 -	Interlock Disabled	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit	32768 -	n/a

Notes This register can be read using the LASER:ENABle:COND? query.

See the Status Reporting section of the LDC-3926 manual for more information regarding condition reporting.

Examples LASER:ENAB:COND 9-action: the only conditions from the selected module that will be reported to the LDC-3926 Status Byte are the Power Limit (8) and Current Limit (1) conditions.

LASER:ENABle:COND?

The LASER:ENABle:COND? query returns the value of the Laser Condition Status Enable register.

Parameters None. The response is the sum of the following:

1 -	Current Limit	256 -	Output Shorted
2 -	Voltage Limit	512 -	Output In Tolerance
4 -	n/a	1024 -	Output On
8 -	Power Limit	2048 -	n/a
16 -	Interlock Disabled	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit	32768 -	n/a

Notes The enabled laser conditions can be set by using the LASER:ENABle:COND command.

The LASER condition status can be monitored by the LASER:COND? query.

Examples LASER:ENAB:COND?-response: 258, means that only the following two conditions will be reported (in summarized form) to the LDC-3926's Status Byte: Output Shorted (256) and Voltage Limit (2). Note that the "Output Shorted" condition is the same as "Output Off".

LASER:ENABle:EVEnt

The LASER:ENABle:EVEnt command sets the Laser Event Status Enable register. The bits in this register determine which bits in the Laser Event Status register are summarized in the LDC-3926 Status Byte.

Parameters: An <nrf value> whose sum represents the bits which are enabled:

1 -	Current Limit changed state	256 -	Output Shorted changed state
2 -	Voltage Limit changed state	512 -	Output Changed Tolerance State
4 -	n/a	1024 -	Output On changed state
8 -	Power Limit changed state	2048 -	n/a
16 -	Interlock changed state	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit changed state	32768 -	n/a

Notes: This register is read with the LASER:ENABle:EVEnt? query. The laser event status is monitored by the LASER:EVEnt? query.

See the Status Reporting section of the LDC-3926 manual for more information regarding condition reporting.

Examples: LASER:ENAB:EVENT 136-action: only the "Open Circuit Changed State" (128) and "Power Limit Changed State" (8) events will be reported (in summarized form) to the LDC-3926's Status Byte.

LASER:ENABle:EVEnt?

The LASER:ENABle:EVEnt? query returns the contents of the Laser Event Status Enable register.

Parameters: None. The response is the sum of the following:

1 -	Current Limit changed state	256 -	Output Shorted changed state
2 -	Voltage Limit changed state	512 -	Output Changed Tolerance state
4 -	n/a	1024 -	Output On changed state
8 -	Power Limit changed state	2048 -	n/a
16 -	Interlock changed state	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit changed state	32768 -	n/a

Notes: This register is set using the LASER:ENABle:EVEnt command. The laser event status can be monitored by the LASER:EVEnt? query.

Examples: "LASER:ENAB:EVE?" -response: 256, means that the laser "Output Shorted Changed State" event is the only event that will be reported to the LDC-3926 Status Byte.

LASER:ENABle:OUTOFF

The LASER:ENABle:OUTOFF command sets the Laser Output Off Enable register. The bits in this register specify the conditions that will cause the Laser current source to automatically turn off.

Parameters: An <nrf value> whose sum represents the enabled bits:

1 -	Current limit	256 -	n/a
2 -	Voltage limit	512 -	Output Out of Tolerance
4 -	n/a	1024 -	n/a
8 -	Power limit	2048 -	n/a
16 -	n/a	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	n/a	32768 -	n/a

Notes: This register is read using the LASER:ENABle:OUTOFF? query.

The factory default value for this register is 8: only Power Limit will shut off the output.

Enabling voltage limit will cause the output to shut off when the laser diode voltage reaches a level that is about 0.25 volts below the VLim setpoint. Regardless of how this register is set, the current source will shut off when the laser diode voltage exceeds the VLim setpoint: this is an Open Circuit error.

Examples: LASER:ENAB:OUTOFF 9-action: sets the LASER Output-Off enable register so that either a Power Limit or a Current Limit condition will cause the LASER output to be turned off.

Open Circuit or Interlock Open conditions will always turn off the current source. They are not included in the Output Off Enable Register because they cannot be disabled.

LASER:ENABle:OUTOFF?

The LASER:ENABle:OUTOFF? query returns the contents of the Laser Output Off Enable register.

Parameters: None. The response is the sum of the following:

1 -	Current limit	256 -	n/a
2 -	Voltage limit	512 -	Output Out of Tolerance
4 -	n/a	1024 -	n/a
8 -	Power limit	2048 -	n/a
16 -	n/a	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	n/a	32768 -	n/a

Notes: This register can be set by using the LASER:ENABle:OUTOFF command. The laser output status can be monitored by the LASER:EVEnt? query.

Examples: LASER:ENAB:OUTOFF?-response: 8, means that the Power Limit condition will cause the laser output to be turned off.

LASER:EVEnt?

The LASER:EVEnt? query returns the contents of the Laser Event Status register.

Parameters: None. The response is the sum of the following:

1 -	Current Limit changed state	256 -	Output Shorted changed state
2 -	Voltage Limit changed state	512 -	Output Changed Tolerance state
4 -	n/a	1024 -	Output On changed state
8 -	Power Limit changed state	2048 -	n/a
16 -	Interlock changed state	4096 -	n/a
32 -	n/a	8192 -	n/a
64 -	n/a	16384 -	n/a
128 -	Open Circuit changed state	32768 -	n/a

Notes: The events in this register will not be reported to the LDC-3926's Status Byte unless they are selected using the LASER:ENABle:EVEnt command.

The event status register is only cleared when it is read or by the *CLS command; the condition status, however, is constantly changing.

Examples: LASER:EVE?-response: 131, means that an "Open Circuit Changed State" event (128), a "Voltage Limit Changed State" event (2), and a "Current Limit Changed State" event (1) have occurred since the last LASER:EVEnt? query.

LASER:LDI

The LASER:LDI command sets the laser constant-current setpoint.

Parameters: An <nrf value> which represents the setpoint, in mA.

Notes: The setpoint is the same for both low and high bandwidth output modes.

The setpoint is read using the LASER:SET:LDI? query.

Examples: Laser:LDI 400-action: sets the laser output current to 400.00 mA.

LASER:ldi 100-action: sets the laser output current to 100.00 mA.

LASER:LDI?

The LASER:LDI? query returns the value of the measured Laser current.

Parameters: None. The response is an <nrf value>.

Notes: Response is the measured laser output current, regardless of control mode.

This measurement is updated approximately once every 600 msec.

Examples: LASER:ldi?-response: 30.0, means the measured laser output current is 30.0 mA.

Laser:LDI?-response: 149.6, means the measured laser output current is 149.6 mA.

LASER:INC

	The LASER:INC command increments the laser constant-current set point by one or more steps. A second parameter allows the time (in milliseconds) between increments to be set.
Parameters	Two values are required. The first represents the number of steps, and the second is the time in milliseconds between steps.
Notes	The step size can be set using the LASER:STEP command. Its default value is 1.0 mA.
	The first parameter (number of steps) must be an integer between 1 and 50000.
	The minimum time to complete one increment is about 10 to 20 msec. Therefore, values for the second parameter (time between increments) have a practical minimum of 20. The maximum number of msec is 65535.
Examples	LASER:STEP 0.5; LASER:INC 10,50-action: the step size is set to 0.5 mA, and the set point is incremented by 0.5 mA ten times, each increment being separated by 50 msec.

LASER:LDV?

	The LASER:LDV? query returns the value of the measured laser voltage.
Parameters	None. The response is an <nrf value>.
Notes	Response is the measured Laser output voltage in Volts, regardless of control mode.
	This measurement is updated approximately once every 600 msec.
Examples	LASER:ldv?-response: 3.03, means the measured Laser output voltage is 3.03 volts.
	Laser:LDV?-response: 1.0, means the measured Laser output voltage is 1.00 volts.

LASER:LIMit:

The LASER:LIMit: command path is used to access the laser limit commands.

The following commands may be reached directly from the LASER:LIMit: command path

.

- LASER:LIMit:I
- LASER:LIMit:I?
- LASER:LIMit:MDP
- LASER:LIMit:MDP?
- LASER:LIMit:V
- LASER:LIMit:V?

LASER:LIMit:I

	The LASER:LIMit:I command sets the laser current limit value.
Parameters	An <nrf value> which represents the laser limit current, in mA.
Notes	The current limit is in effect in all modes of operation.
Examples	LASER:LIM:I 80-action: the laser current limit is set to 80 mA.
	:Laser:Limit:I 160-action: the laser current limit is set to 160 mA.

LASER:LIMit:I?

The LASER:LIMit:I? query returns the value of the laser current limit.

Parameters: None. The response is an <nrf value>.

Notes: The current limit is valid for all modes of operation.

Examples: LASER:LIM:I?-response: 40, means the laser current limit is 40 mA.

Laser:LIM:I?-response: 300, means the laser current limit is 300 mA.

LASER:LIMit:MDP

The LASER:LIMit:MDP command sets the Laser optical power limit. If the measured optical power exceeds this value, the current source output will be shut off, and a Power Limit error will be generated.

Parameters: An <nrf value> which represents the laser monitor photodiode power limit, in mW.

Notes: The monitor photodiode power limit condition normally shuts the output off, but this can be disabled using the LASER:ENABle:OUTOFF command.

The laser optical power is a calculated value. The module derives the optical power by dividing the monitor diode current (MDI) by CalPD.

The optical power limit is in effect for all operating modes with the following exceptions: if CalPD is set to 0.0, the power is not calculated and the limit test is not performed. The limit test is also not performed during calibration.

Examples: LASER:LIM:MDP 200-action: sets the laser monitor photodiode power (optical power) limit to 200 mW.

LASER:LIMit:MDP?

The LASER:LIMit:MDP? query returns the value of the laser optical power limit setpoint.

Parameters: None. The response is an <nrf value>.

Examples: LASER:LIM:MDP?-response: 300.0, means the monitor PD power limit is set to 300.0 mW.

LASER:LIMit:V

The LASER:LIMit:V command sets the laser voltage limit (VLim) value. If the laser diode voltage exceeds this value, the output will automatically turn off, and an Open Circuit error will be generated.

Parameters: An <nrf value> which represents the laser limit voltage, in volts.

Notes: Voltage limit is in effect in all modes of operation. If the laser diode voltage exceeds this value, the current source will automatically turn off and generate an Open Circuit error.

The range for the voltage limit is 0.1 to 7.5 volts.

Examples: LASER:LIM:V 4.6-action: the laser voltage limit is set to 4.6 volts.

:Laser:Limit:v 6.1-action: the laser voltage limit is set to 6.1 volts.

LASER:LIMit:V?

The LASER:LIMit:V? query returns the value of the laser voltage limit setpoint.

Parameters: None. The response is an <nrf value>.

Notes: The voltage limit is valid for all modes of operation.

Examples: LASER:LIM:V?-response: 4.0, means the laser voltage limit is 4.0 volts.

LASER:MDI

The LASER:MDI command sets the laser monitor photodiode current (MDI) setpoint.

Parameters An <nrf value> which represents the photodiode current setpoint, in μA.

Notes In constant monitor diode current ("MDI") mode, the output current is controlled so that the monitor diode current remains constant at the MDI setpoint. See the "Laser:Mode" command for more information.

Monitor diode current is sometimes referred to as "photodiode feedback current". On the front panel, monitor diode current is referred to as IPD.

Examples Laser:Mdi 40-action: The laser monitor photodiode current setpoint is set to 40 μA.

Laser:MDI 200.5-action: The laser constant-monitor photodiode current setpoint is set to 200.5 μA.

LASER:MDI?

The LASER:MDI? query returns the value of the laser photodetector (monitor photodiode) current measurement, in μA.

Parameters None. The response is an <nrf value>.

Notes The response is in μA, and is valid even when the unit is not in MDI mode.

This measurement is updated approximately once every 600 msec.

Examples Laser:MDi?-response: 57.3, means 57.3 μA of photodetector current was measured in the laser monitor photodiode circuit.

LASER:MDP

The LASER:MDP command sets the value of the laser optical power set point, in mW.

Parameters An <nrf value> which represents the optical power setpoint, in mW.

Notes In constant optical power ("MDP") mode, the output current is controlled so that the optical power remains constant at the MDP setpoint. See the "Laser:Mode" command for more information.

If CALPD is 0, the actual MDP set point will be approximately 0.

On the front panel, the monitor photodector power is referred to as PPD.

Examples Laser:Mdp 40-action: The laser power setpoint is set to 40 mW.

LASER:MDP?

The LASER:MDP? query returns the value of the laser photodetector power measurement, in mW.

Parameters None. The response is an <nrf value>.

Notes The response is in mW. The response is valid, even when the unit is not in constant power mode.

This measurement is derived from the monitor photodiode current (MDI): it is calculated by dividing MDI by CalPD. If CalPD is 0, this query returns a -1.0. This measurement is updated approximately once every 600 msec.

Examples Laser:MDp?-response: 100.0, means Laser's optical power is calculated to be 100 mW.

LASER:MODE?

The LASER:MODE? query returns the laser control mode.

Parameters: None. The response is character data (which represents the operating mode).

Notes: IHBW mode is the same as ILBW mode (low bandwidth), except that the output low bandpass filter is disabled in IHBW mode.

Examples: LASER:MODE?-response: ILBW, means that constant current, low bandwidth mode is in effect for the laser output.

:Laser:Mode?-response: MDP, means that constant optical power mode is in effect for the laser output.

Laser:Mode?-response: MDI, means that constant monitor current mode is in effect for the laser output.

:Laser:MODE?-response: IHBW, means that constant current, high bandwidth mode is in effect for the laser output.

LASER:MODE:

The LASER:MODE: command path is used to access the laser mode selection commands.

The following commands may be reached directly from the LASER:MODE: command path.

LASER:MODE:IHBW

LASER:MODE:ILBW

LASER:MODE:MDI

LASER:MODE:MDP

LASER:MODE:IHBW

The LASER:MODE:IHBW command selects high-bandwidth constant current mode for the laser current source.

Parameters: None.

Notes: In high bandwidth mode the modulation bandwidth is increased.

Examples: Laser:mode:ihbw-action: enables the high bandwidth constant current mode for the laser current source.

LASER:MODE:ILBW

The LASER:MODE:ILBW command selects low-bandwidth constant current mode for the laser current source.

Parameters: None.

Notes: Constant ILBW mode (low bandwidth) enables the output low bandpass filter.

Examples: Laser:mode:ilbw-action: enables the low bandwidth constant current mode for the laser current source.

LASER:MODE:MDI

The LASER:MODE:MDI command selects constant monitor diode current ("MDI") mode for the laser current source.

Parameters: None.

Notes: On the front panel, constant monitor diode current mode is referred to as IPD mode.

In this mode, the control set point is entered with the LAS:MDI command.

Examples: Laser:Mode:MDI-action: sets the laser operating mode to constant monitor diode current mode.

LASER:MODE:MDP

The LASER:MODE:MDP command selects constant optical power mode ("MDP") for the laser current source.

Parameters: None.

Notes: On the front panel, photodetector power mode is referred to as P mode.

This mode of operation uses the monitor photodiode feedback to maintain constant laser optical power. The actual set point will be a monitor photodiode current value calculated with the CALPD conversion factor. Therefore, in this mode the set point is only as accurate as the user's CALPD value.

Examples: LASER:MODE:MDP-action: sets the laser operating mode to constant optical power mode.

LASER:MODulation

The LASER:MODulation command turns the laser modulation switch on or off.

Parameters: An <nrf value>; 1 = on (enabled), 0 = off (disabled).

Notes: When the modulation switch is enabled for a channel, the laser current may be modulated by connecting a modulation signal onto the back panel "MODULATION" connector (BNC).

The modulation bandwidth depends on the operating mode and the module used. Refer to Chapter 1, Specifications, for more information on bandwidth specifications.

Examples: LASER:LDI 20; LASER:MOD ON-action: sets the laser output current to 20 mA and then turns the laser modulation switch on.

Laser:Mod 0-action: disables modulation of the laser current source.

LASER:MODulation?

The LASER:MODulation? query returns the status of the laser modulation switch.

Parameters None. The response is an <nrf value>, 1 = on (enabled), 0 = off (disabled).

Notes More than one channel at a time may be modulated by the modulation signal, if desired.

Examples Laser:MODULATION?-response: 0, means that the laser modulation switch is disabled.

LASER:MOD?-response: 1, means that the aser modulation switch is enabled. A signal applied to the back panel modulation connector will modulate the laser current.

LASER:OUTput

The LASER:OUTput command turns the laser output on or off.

Parameters An <nrf value>; 1 = on, 0 = off.

Notes After the laser output is turned on, it may be useful to wait until the output is fully on before performing further operations, but it is not necessary. When the output is turned on, there is a two second delay before the output is actually enabled. This delay is a safety requirement.

When a current source output is off, an internal short is placed across the output terminals.

Examples LASER:LDI 20; Laser:out on-action: sets the laser output current to 20 mA and then turns the laser output on.

Laser:Out 0-action: turns off the laser current source.

LASER:OUTput?

The LASER:OUTput? query returns the status of the laser output switch.

Parameters None. The response is an <nrf value>.

Notes Although the status of the switch is on, the output may not have reached the set point value.

Examples Laser:OUT?-response: 0, means that the laser output switch is disabled; devices may be safely disconnected or connected at the laser output terminal.

LASER:OUT?-response: 1, means that the laser output switch is enabled.

LASER:SET:

The LASER:SET: command path is used to access the laser set point queries.

The following commands may be reached directly from the LASER:SET: command path.

- LASER:SET:LDI?
- LASER:SET:MDI?
- LASER:SET:MDP?

LASER:SET:LDI?

The LASER:SET:LDI? query returns the laser constant-current setpoint. This value is used for both bandwidth modes (IHBW and ILBW).

Parameters None. The response is an <nrf value> which represents the constant I set point value, in mA.

Notes The LDI set point is only in effect when the operating mode is IHBW or ILBW.

Examples "LASER:SET:LDI?" -response: 50.0, means the laser output current set point value is 50.0 mA.

LASER:SET:MDI?

The LASER:SET:MDI? query returns the monitor photodiode current setpoint value.

Parameters: None. The response is an <nrf value> which represents the constant MDI set point value, in μA.

Notes: The monitor photodiode current is dependent on the laser optical output power. Therefore, the MDI set point may be used to control optical output of the laser.

Examples: Laser:set:mdi?-response: 30.0, means the laser monitor photodiode current setpoint is 30 μA, for use in constant MDI mode.

LASER:SET:MDP?

The LASER:SET:MDP? query returns the laser monitor PD power set point value.

Parameters: None. The response is an <nrf value> which represents the constant power set point, in mW.

Notes: This set point is used in constant MDP (P) mode only.

Examples: LASER:Set:MDP?-response: 10.0, means the laser monitor PD feedback set point is 10.0 mW.

LASER:SYNCLDI?

The LASER:SYNCLDI? query returns the value of the selected channel's measured laser current, in mA.

Parameters: None. The response is an <nrf value> representing current in mA.

Notes: This is a "synchronized" measurement: the measurement system is connected to the current-measure signal when this query is received. A current measurement is made, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal function, switching between the various signals and measuring them.

The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the laser:ldi? query returns immediately, but the measurement can be up to 600 msec old.

Examples: LASER:syncldi?-response: 54.1, means the measured laser current is 54.1 mA.

LASER:SYNCLDV?

The LASER:SYNCLDV? query returns the value of the selected channel's measured laser voltage, in volts.

Parameters: None. The response is an <nrf value> representing voltage in Volts.

Notes: This is a "synchronized" measurement: the measurement system is connected to the voltage-measure signal when this query is received. A voltage measurement is made, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal function, switching between the various signals and measuring them.

The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the laser:ldv? query returns immediately, but the measurement can be up to 600 msec old.

Examples: LASER:syncldv?-response: 3.03, means the measured laser output voltage is 3.03 volts.

LASER:SYNCMDI?

The LASER:SYNCMDI? query returns the value of the selected channel's measured monitor photodiode current in μA.

Parameters: None. The response is an <nrf value> representing current in μA.

Notes: This is a "synchronized" measurement: the measurement system is connected to the monitor current-measure signal when this query is received. The photodiode current measurement is made, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal function, switching between the various signals and measuring them.

The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the laser:mdi? query returns immediately, but the measurement can be up to 600 msec old.

Examples: LASER:syncmdi?-response: 145.5, means the measured photodiode current is 145.5 μA.

LASER:SYNCMDP?

The LASER:SYNCMDP? query returns the value of the selected channel's measured optical power, in mW.

Parameters: None. The response is an <nrf value> representing optical power in mW.

Notes: Optical power is derived from photodiode current. Optical power is defined as photodiode current divided by CalPD, the photodiode responsivity.

This is a "synchronized" measurement: the measurement system is connected to the monitor current-measure signal when this query is received. The photodiode current measurement is made, optical power is calculated, and the result is returned as the response. After the measurement is made, the measurement system returns to its normal function, switching between the various signals and measuring them.

The response time to this query is from 200 msec to 250 msec, but the measurement is made as soon as the query is received. In contrast, the laser:mdp? query returns immediately, but the mea-

LASER:syncmdp?-response: 5.5, means the calculated optical power is 5.5 mW.

LASER:STEP

The LASER:STEP command specifies the amount the laser constant current setpoint will change when the Laser:Inc or Laser:Dec command is issued.

Parameters: An <nrf value> representing the step amount in mA, in the range 0.1 to 100.0.

Notes: The step applies to the constant-current (ILBW or IHBW mode) setpoint.

Examples: LASER:STEP 10-action: sets the laser step size to 10.0 mA.

Laser:Idi 20; Laser:Step 10.0; Laser:Inc 2,50-action: sets the Laser setpoint to 20 mA, sets the step size to 10 mA, and performs two increments, separated by 50 mSec. After the increments, the setpoint is 40 mA.

LASER:STEP?

The LASER:STEP? query is used to read back the laser setpoint step size. This value is the amount the setpoint will change in response to a Laser:Inc or Laser:Dec command.

Parameters — None. The response is an <nrf value> of the step amount.

Notes — The step of 1 corresponds to 1.0 mA.

Examples — Laser:Step?-response: 1.0 means the laser step size is 1.0 mA.

LASER:TOLerance

The LASER:TOLerance command sets the selected module's laser control tolerance parameters.

Parameters — Two <nrf values>; the first represents the measurement window, in mA, µA, or mW, depending on the laser control mode. The second parameter represents the time window, in seconds.

Notes — The range of the first parameter, the tolderance window, is 0.01 to 500.0. The units of this parameter depend on the control mode. In current mode, the units are mA, in IPD mode the units are µA. If the mode is constant power (P), the first parameter is in mW. The range of the second parameter, the time window, is 0.1 to 50.

Examples — "LAS:LDI 750; LAS:TOL 0.5,1; LAS:OUT ON" - action: the laser current will be in tolerance when it is within 0.5 mA of 750.00 mA for a period of 1.0 second, at which point the In Tolerance bit in the Laser Condition Status register will be set.

LASER:TOLerance?

The LASER:TOLerance? query returns the selected module's laser control tolerance parameters.

Parameters — None. The response is two <nrf values> representing the tolerance parameters. The first represents the tolerance window, in mA, µA, or mW, (depending on the mode). The second represents the tolerance duration, in seconds.

Notes — The laser tolerance specification is also used in the laser status event and condition registers, and may be tested by using the appropriate query.

Examples — "LAS:TOL?" - response: "0.2,1.0", means the selected module has a laser tolerance window of 0.2 mA, 0.2 µA or 0.2 mW (depending on the mode) with a duration of 1.0 seconds.

MODERR?

The MODERR? query returns a list of "module" device and command errors. The "module" errors are those which have occurred since the last "MODERR?" query. The errors are notated by a

	number (code) which corresponds to the type of error which occurred. See the appropriate module instruction manual for information regarding error handling for each specific module.
Parameters	None. The response consists of one or more “module” error code values, separated by commas.
Notes	A response of “0” indicates that no errors were reported. The response data is sent as character data.
Examples	“MODERR?” - response: 0, means no “module” errors reported.
	“MODERR?” - response: 501, means that the module has a LASER interlock error which prevented the LAS output from being turned on.

.

MODIDN?

	The MODIDN? query returns the module’s model name and serial number.
Parameters	None. The response consists of the module’s model number, serial number, and version number, separated by commas.
Notes	The serial number may also be found by removing the module from the mainframe and viewing the serial number information on the side of the module.
Examples	“MODIDN?” - response: “3926339,03740001,v1.00”, for example.

MODPUD

The MODPUD command allows the service technician to enter the protected user data. This data is normally changed only at the factory, and therefore MODPUD command is not needed by the user.

MODPUD?

	The MODPUD? query returns protected user data from a module. This data is entered by factory personnel when the module is calibrated.
Parameters	None. The response consists of serial number, hardware version, option information, calibration date, and initials of the calibrating technician. The response is in the form of <arbitrary block data> with the header, #221, indicating twenty-one characters.
Notes	The serial number may also be found by removing the module from the mainframe and viewing the serial number information on the side of the module.
Examples	“MODPUD?” - response: #2210372000200111204 98grb

*OPC

Operation Complete

Action	Sets the operation complete bit in the Event Status Register when all pending overlapped commands have been completed.
Response	None.
Example	*OPC

*OPC

Operation Complete

Action	Places an ASCII character 1 into the instrument's Output Queue when all pending operations have been finished.
Response	1 - when all overlapped commands are complete.
Example	*OPC?

*PSC <nrf value>

Power-on Status Clear

Action Sets automatic power-on clearing of the enable registers.

Values 0 = disable power-on clearing
1 = enable power-on clearing

Notes Any non-zero value is interpreted as 1.

Registers affected:
Condition Status Enable Service Request Enable
Event Status Enable: Standard Event Status Enable
Factory default condition: disabled.

In the disabled state, the values of the enable registers are saved through power OFF/ON. The power-on status clear flag (see PSC?) is set false, disallowing service request interrupts after power-on.

In the enabled state, the enable registers are cleared during power ON. The power-on status clear flag (see PSC?) is set true, allowing service request interrupts after power-on.

Examples *PSC 0-Disable automatic power-on clearing of the enable registers.

*PSC 1-Enable automatic power-on clearing of the enable registers.

*PSC?

Power-on Status Clear?

Action Requests the state of the power-on status clear flag.

Response 0-The enable registers are saved through power OFF/ON.
1-The enable registers are cleared during power ON.

Registers affected:
Condition Status Enable: Service Request Enable
Event Status Enable: Standard Event Status Enable

See Chapter Three for more information on register structure.

Example *PSC?-Request state of power-on status clear flag.

*PUD

Action Stores data unique to the instrument, such as calibration date and serial number. This data is protected from change by the "SECURE <nrf>" command and is usually entered by the factory.

Notes The arbitrary block program data is exactly 25 bytes long.

*PUD?

Action Requests the factory-stored identification string.

*RCL <nrf value>

Recall

Action Recalls a stored setup configuration from memory.

Value range 0 through 10

Notes Setup **0** has a factory-set default configuration.

If you use GPIB to recall setup 0 (*RCL 0), GPIB mode is set to REMOTE. If you recall setup "0" by the front panel, GPIB mode is set to LOCAL.

Same function as RECALL on the front panel.

Use *SAV to store various setup configurations for convenient recall.

The current setup is automatically stored and recalled at next power-ON, unless you use ***PSC** to tell the instrument not to do so.

Examples ***RCL 0**-Recall the factory default setup.

*RST

Reset

Action Performs a device reset and the following:

Sets OCIS state

Sets OQIS state

Notes **OCIS** = Operation-complete Command Idle State. This is the same state as after ***OPC**: no further operations to complete.

OQIS = Operation-complete Query Idle State. This is the same state as after ***OPC?**: no further operations to complete.

These idle states allow the 8033 to complete its reset process (no operations pending) before continuing with other operations.

Example *RST

*SAV <nrf value>

Save

Action Saves the current setup configuration in memory.

Value range 1 through 10

Notes Configuration **0** is reserved for a factory-set default configuration. See ***RCL**.

It is normally not necessary to save the current setup for next power-ON. The current setup is automatically stored for recall at next power-ON unless you use ***PSC** not to do so.

Example ***SAV 2**—Save the current setup configuration as #2.

*SRE <nrf value>

Service Request Enable

Action Enables bits in the service request enable register.

Notes Response is the sum of the enabled bits.

Example *SRE 136-Enable the service request enable register condition summary and error message bits (8 + 128 = 136).

*SRE?

Service Request Enabled?

Action Requests the value in the service request enable register.

Notes Response is the sum of the enabled bits.

See Chapter Three for more information about register structure.

Example *SRE?-Response 136 means the service request enable register condition summary and error message bits are enabled (8 + 128 = 136).

STATMENU:LINE*n*:

The STATMENU:LINE*n*: command path is used to access the selected channel's status menu display selection commands. (*n* can be either 1 or 2). Line 1 only displays measurement from laser source 1 and line 2 displays measurements from laser source 2. The letter *n* is either 1 or 2, to indicate lines on the Status menu.

The following commands may be reached directly from the STATMENU:LINE*n*: command path.

STATMENU:LINE*n*:IPD
STATMENU:LINE*n*:LDI
STATMENU:LINE*n*:PPD
STATMENU:LINE*n*:VF

STATMENU:LINE*n*?:

The STATMENU:LINE*n*? query returns name of the measurement that is currently being displayed on line *n* of the status menu. (*n* can be either 1 or 2).

Parameters None. The response is character data which represents the measurement that is currently being displayed on line 1 of the selected channel's portion of the status menu.

Notes The possible responses are 1. "LDI" laser diode current.
2. "IPD" photodiode current.
3. "PPD" optical power.
4. "VF" laser diode forward voltage.

The default condition of the status menu displays laser diode current 1 (LDI) on line 1 and laser diode current 2 (LDI) on line 2.

The letter *n* is either 1 or 2, to indicate lines on the Status menu.

Examples STATMENU:LINE1?-response: "PPD", means that optical power from laser 1 is selected to be displayed on line 1.

STATMENU:LINE2?-response: "PPD", means that optical power from laser 2 is selected to be displayed on line 2.

STATMENU:LINE*n*:IPD

The STATMENU:LINE*n*:IPD command sets the measurement that is to be displayed on line *n* of the status menu to photodiode current (IPD).

Parameters None. The letter *n* is either 1 or 2, to indicate lines on the Status menu.

Notes The default condition of the status menu displays laser diode current 1 (LDI) on line 1 and laser diode current 2 (LDI) on line 2.

Examples STATMENU:LINE1:IPD-response: photodiode current of laser 1 is displayed on line 1 of the STATMENU:LINE2:IPD-response: photodiode current of laser 2 is displayed on line 2 of the sta-tus menu.

STATMENU:LINE*n*:LDI

The STATMENU:LINE*n*:LDI command sets the measurement that is to be displayed on line *n* of the status menu to laser diode current (LDI).

Parameters: None. The letter *n* is either 1 or 2, to indicate lines on the Status menu.

Notes: The default condition of the status menu displays laser diode current 1 (LDI) on line 1 and laser diode current 2 (LDI) on line 2.

Examples: STATMENU:LINE1:LDI-response: laser diode current of laser 1 is displayed on line 1 of the status menu.

STATMENU:LINE2:LDI-response: laser diode current of laser 2 is displayed on line 2 of the status menu.

STATMENU:LINE*n*:PPD

The STATMENU:LINE*n*:PPD command sets the measurement that is to be displayed on line *n* of the status menu to optical power (PPD).

Parameters: None. The letter *n* is either 1 or 2, to indicate lines on the Status menu.

Notes: Photodetector power is calculated via the CALPD conversion factor. The measurement is only as accurate as the user's CALPD value.

Examples: STATMENU:LINE1:PPD-response: optical power is displayed on line 1 of the status menu.

STATMENU:LINE2:PPD-response: optical power is displayed on line 2 of the status menu.

STATMENU:LINE*n*:VF

The STATMENU:LINE*n*:VF command sets the measurement that is to be displayed on line *n* of the status menu to laser diode forward voltage (VF).

Parameters: None. The letter *n* is either 1 or 2, to indicate lines on the Status menu.

Examples: STATMENU:LINE1:VF-response: laser diode forward voltage of laser 1 is displayed on line 1 of the status menu.

STATMENU:LINE2:VF-response: laser diode forward voltage of laser 2 is displayed on line 2 of the status menu.

*STB?

Status Byte?

Action Requests the value in the status byte register.

Notes Response is the sum of the enabled bits.

See Chapter Three for more information about register structure.

Example *STB?-Response 200 means the status byte condition and master status summary bits, and error message bits, are enabled. (8 + 64 + 128 = 200)

*TST?

Test?

Action Performs internal self-test, then reports results.

Response 0 = test completed with no errors.
Non-zero = test not completed, or was completed with errors.

Example TST?

*WAI

Wait to Continue

Action Prevents the instrument from executing any further commands until OPC (operation complete) status is true.

Note This command can be used to make the instrument wait until an operation is complete before continuing.

Care should be taken to set the GPIB time-out appropriately for use with the *WAI command. After this command (or the Delay) command is sent, the controller may receive up to 20 more commands before the wait period is over. If more than 20 commands are sent before the delay or wait period is over, the additional commands will be ignored and an error E220 will be generated.

Example *WAI-Wait until OPC status is true.

CHAPTER 5

CALIBRATION AND TROUBLESHOOTING

This chapter describes calibration of the LDC-3926339 module. Descriptions of the required test instruments, calibration conditions, and detailed procedures for calibrating the current sources are included. A troubleshooting guide is also offered for some of the more common failure symptoms.

ILX Lightwave Corporation provides in-house and on-site calibration services for ILX instruments. Most ILX instruments require yearly calibration to ensure performance to published specifications. ILX factory calibrations employ NIST traceable measurement instrumentation, and our calibration engineers and technicians use automated test equipment to accurately and efficiently capture and record calibration data. An original certificate of calibration authenticity is provided with all instrument calibrations, and a detailed report showing any pre-calibration out-of-tolerance conditions is available upon request. Calibration turn-times are normally five business days or less. On-site calibrations can be performed around your production schedule, night or day, seven days a week. Please contact ILX Customer Support (see page *xii* for contact information) for additional calibration information.

For further assistance with technical solutions and troubleshooting, visit the www.ilxlightwave.com Support page (ilx.custhelp.com), and the Library page (www.ilxlightwave.com/library/index.html) for Application Notes and Technical Notes.

Calibration

There are several calibrations required to completely calibrate the module. The calibration consists of calibrating the current source, the photodiode monitor feedback ammeter, and the forward voltage measurement. The current limits are calibrated internally by the instrument, using measurements supplied by the user, as part of the calibration process.

The LDC-3926339 must be calibrated while installed in a mainframe. Calibrate the module every 12 months or whenever performance verification indicates that calibration is necessary, such as differences between set point and measurement display values which exceed the accuracy specification. Calibrate the modules under laboratory conditions; typically, 23.0 °C (±3.0 °C). If possible, calibrate the LDC-3926339 at its intended use temperature if this is within the specified operating temperature range of 0-40 °C.

Note: Turn on and warm-up the LDC-3926339 for at least one hour before calibration.

Recommended Equipment

The recommended test equipment specifications for calibrating the module are shown in Table 5.2. Equipment other than that shown in the table can be used if the specifications meet or exceed those listed.

Table 5.2 Recommended Test Equipment

DMM	DC Amps (@ 6.0 A): ±0.02 % DC Volts (@10 V range): ±0.005 % 0.1 µA or 0.1 mV resolution

You must connect various loads and circuits to the outputs of the module for the calibration procedure. The devices required for most of the calibration loads are listed in Table 5.4. A schematic is shown in Figure 5.1 for the photodiode calibration circuit, with the required components listed in Table 5.3.

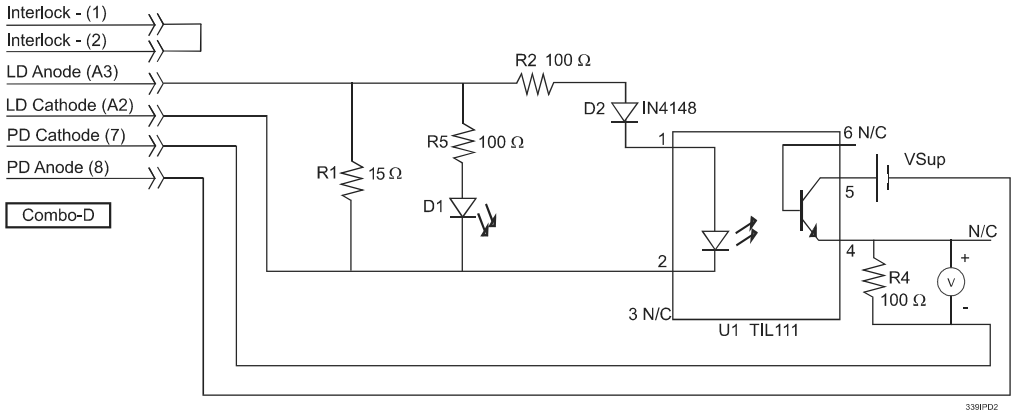


Figure 5.1 I_{PD} Calibration Circuit

Table 5.3 Required Photodiode Current Source Calibration (I_{PD}) Circuit Components

R1	15 Ω resistor, 5% 3 W
R2	100 Ω resistor, 1%, 1/4 W
R4	100 Ω resistor, 1% 1/4 W
R5	100 Ω resistor, 1% 1/4 W[1]

Table 5.3 Required Photodiode Current Source Calibration (I_{PD}) Circuit Components

U1	TIL 111 opto isolator
D1	LED: Lumex SSL-LX5093HD or similar[1]
D2	IN4148
VSup	3-9 V DC
Connector	Combo-D

1. R5 and D1 are optional components to indicate if LD current is working properly.

Table 5.4 Required Laser Current Source Calibration Components

Current Source Calibration:	1 Ω 50 W resistor, low TCR
Voltage Measurement Calibration:	1 Ω 50 W resistor, low TCR

Local Calibration

There are three calibration adjustments for the current source module: calibration of the constant current (LDI) source, calibration of the constant light power (I_{PD}) feedback circuit, and calibration of the laser forward voltage (LDV) measurement.

Current Source Calibration

This procedure is for calibrating the laser current sources. The internal calibration procedure sets the current to two values; you must enter the exact laser diode current measured at both of these points.

1 With the output off, connect a 1 Ω, 50 W resistor across the LASER output terminals (Laser Anode, pin A3, and Laser Cathode, pin A2).

Current flows from the anode to the cathode.

2 Connect a calibrated DMM across the load resistor.

3 Calculate laser current (LDI) using Ohm's Law:

I = E / R

Where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance (a 4-point probe resistance measurement is recommended). I is the calculated current in Amps.

Note: ILX recommends that the load resistor be temperature-controlled during the calibration. Alternatively, the current may be measured directly using an ammeter with a range of at least 6 A, and accurate to ±0.001 mA. If you use the ammeter approach, connect the ammeter in series with a load resistor, with a nominal value of 1 Ω. Note that auto-ranging ammeters may cause calibration errors.

4 Press **MAIN** to enter the LDI calibration mode.

4a Press the **Sys. Config** softkey, then the **Cal.** softkey.

4b Press the **Cal LAS** softkey.

4c Press the **LDI Cal** softkey. The LDI calibration screen appears.

5 Press **Start**. The internal calibration procedure turns on the output and drives the LD current to approximately 10% of full range. Allow the current to settle for at least 10 seconds.

6 Calculate or measure the actual current through the load resistor and enter the value (in mA) into the IReal adjust field and press **ENTER.**

Do not enter more than eight characters, including the decimal point. The internal calibration procedure sets the LD current to approximately 90% of full range. Allow the current to settle for at least 10 seconds.

7 Measure the actual current and enter the value into the IREAL adjust field.

After you have entered the second value, the internal calibrations procedure calibrates the LD current measurement circuit, the LD current source for both low and high bandwidths, and the LD current limit circuit.

IPD Current Calibration

This procedure is for calibrating the laser I_{PD} (photodiode monitor) measurement circuits. The internal calibration procedure sets the current to two values; you must enter the resulting I_{PD} current at both of these points.

1. With the output off, connect the IPD calibration circuit, Figure 5.1 on page *68*, to the laser connector.
2. Determine R4 resistance with 4-wire resistance measurement. Connect DMM across R4.
3. Press **MAIN** to enter the IPD calibration mode.
   - **3a** Press the **Sys. Config** softkey, then the **Cal.** softkey.
   - **3b** Press the **Cal LAS** softkey.
   - **3c** Press the **IPD Cal** softkey. The IPD calibration screen appears.
4. Press the **Start** softkey. The internal calibration procedure turns on the output and drives the LD current until the PD current is approximately 20% of full range. Allow the current to settle for at least 10 seconds.
5. Using a DMM, measure the voltage across R4. Calculate actual photo diode current (I=E/R) and enter the value (in μA) into the IPDReal field on the screen and press **ENTER.**

   Do not enter more than seven characters, including the decimal point. The internal calibration procedure drives the LD current until the PD current is approximately 60% of full range. Allow the current to settle for at least 10 seconds.
6. Using a DMM, measure the voltage across R4. Calcualte the actual photodiode current (I=E/R) and enter the value (in μA) into the highlighted IPDReal field on the screen and press **ENTER.**

   The internal calibration procedure calibrates the I_{PD} current measurement circuit. The screen then displays a message indicating that the calibration has finished.

Laser Forward Voltage Measurement Calibration

This procedure is for calibrating the laser forward voltage (LDV) measurement circuits. The internal calibration procedure sets the current to two values; you must enter the resulting forward voltage at both of these points.

1. With the output off, connect a 1 Ω load resistor to the LASER output terminals (Laser Anode, pin 9, and Laser Cathode, pin 5).
2. Connect a voltmeter with at least 15V range and accuracy of ±0.01 V across the load resistor.
3. Press **MAIN** to enter the LDV calibration mode.
   - **3a** Press the **Sys. Config** soft key, then the **Cal.** soft key.
   - **3b** Press **Cal LAS**.
   - **3c** Press the **LDI Cal** softkey. The LDV calibration screen appears.
4. Press the **Start** softkey. The internal calibration procedure turns on the output and drives the LD current to approximately 25% of full range. Allow the current to settle for at least 10 seconds.
5. Measure the voltage across the load resistor and enter the value in Volts (V) into the VReal field and press **ENTER.**

   Do not enter more than seven characters, including the decimal point. The internal calibration procedure then drives the LD current to approximately 75% of full range. Allow the current to settle for at least 10 seconds.
6. Measure the actual voltage across the load resistor, enter that value (in Volts) into the highlighted "VReal" adjust field on the screen, and press **ENTER.**

   After you have entered the second value, the internal calibration procedure calibrates the laser forward voltage measurement circuit. The screen then displays a message indicating that the calibration has finished.

Remote Calibration

The LDC-3926339 Modules can be calibrated remotely via the GPIB Interface. All of the required calibration commands are listed in Table 4.1 on page *37*. The remote calibration procedures are general guidelines for writing a program to calibrate the module.

There are three calibration adjustments for the current sourcemodule: calibration of the constant current (LDI) source, calibration of the constant light power (I_{PD}) feedback circuit, and calibration of the laser forward voltage (LDV) measurement.

LDI Calibration

This procedure is for remotely calibrating the laser current source. The internal calibration procedure sets the current to two values; you must enter the exact laser diode current measured at both of these points.

1. With the output off, connect a 1 Ω, 50 W resistor across the laser output terminals (Laser Anode, pin A3, and Laser Cathode, pin A2).

2. Connect a calibrated DMM across the load resistor and calculate laser current (LDI) in the following manner using Ohm's Law:

   I = E/R

   Where E is the accurately measured voltage across the resistor, and R is the accurately measured load resistance (a 4-point probe resistance measurement is recommended). I is the calculated current in Amps.

   Note: ILX recommends the load resistor be temperature-controlled during the calibration. Alternatively, the current can be measured directly using an ammeter with a range of at least 6 A, and accurate to ± 0.001 mA. If you use the ammeter, you must connect the ammeter in series with a load resistor with a nominal value of 1 Ω. Note that auto-ranging ammeters may cause calibration errors.

3. Send the command `LASER:CAL:LDI` to begin the LDI calibration.

   The internal calibration procedure begins by setting the laser output current to approximately 10% of its full range. Allow the current to settle for at least 10 seconds.

   Note: If the calibration value is measured and entered remotely via a GPIB controlled DMM, the actual value of the current cannot be entered until the calibration procedure is ready to receive it.

4. Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

   The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the value that is returned is 1.

5. Enter the measured current in Amps by sending the command `LASER:CAL:MEAS`

(current in Amps).

For example: `LASER:CAL:MEAS 513.9`

The internal calibration procedure stores the actual measured value and briefly changes its measurement status to 0 to indicate that it is not yet ready for another measurement. This occurs each time a new measurement is entered.

The cal procedure sets the output current to approximately 90% of its output range. Allow the current to settle for at least 10 seconds.

6 Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the 1 value is returned.

7 Enter the second measured current by sending the command `LASER:CAL:MEAS` (current in Amps).

For example: `LASER:CAL:MEAS 5350.7`

After you have entered the second measured current, the internal calibration procedure performs the calibration for the laser current setpoint, current measurement, and current limit circuits. The calibration procedure sets the status to 2, indicating the calibration is finished.

IPD Current Calibration

This procedure is for remotely calibrating the laser I_{PD} (photodiode monitor) measurement circuits. The internal calibration procedure sets the current to two values; you must enter the resulting I_{PD} current measured at both of these points. The GPIB commands use the nomenclature MDI, which means "Monitor Diode Current", and is synonymous with "IPD".

1 With the output off, connect the IPD calibration circuit, Figure 5.1 on page *68*, to the laser connector.

2 Determine R4 resistance with 4-wire resistance measurement. Connect DMM across R4.

3 Send the command `LASER:CAL:MDI` to begin the IPD current calibration.

The internal calibration procedure turns on the output and drives the laser current until the PD current is approximately 20% of full range. Allow the current to settle for at least 10 seconds.

Note: If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, the actual value of the current cannot be entered until the cal procedure is ready to receive it.

4 Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the value that is returned is 1.

5 Enter the measured current in µA by sending the command `LASER:CAL:MEAS` (current

in μAmps).

For example: `LASER:CAL:MEAS 981.234`

The internal calibration procedure stores the actual measured value and briefly changes its measurement status to 0 to indicate that it is not yet ready for another measurement. This occurs each time a new measurement is entered.

The controller drives the laser current until the PD current is approximately 60% of full range. Allow the current to settle for at least 10 seconds.

6 Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the value that is returned is 1.

7 Enter the measured current in μA by sending the command `LASER:CAL:MEAS` (current in μAmps).

For example: `LASER:CAL:MEAS 2986.123`

After you have entered the second measured photodiode current, the internal calibration procedure performs the calibration for the photodiode current measurement circuit. The calibration procedure sets the status to 2, indicating the calibration is finished.

Laser Forward Voltage Measurement Calibration

This procedure is for remotely calibrating the laser forward voltage (LDV) measurement circuit. The internal calibration procedure sets the current to two values; you must measure and enter the forward voltage at both of these points.

1 With the output off, connect a 1 Ω, 50 W resistor across the laser output terminals (Laser Anode, pin A3, and Laser Cathode, pin A2).

2 Connect a calibrated voltmeter across the load resistor.

3 Send the command `LASER:CAL:LDV` to begin the LDV measurement calibration.

The internal calibration procedure begins by setting the laser output current to approximately 25% of its full range. Allow the current to settle for at least 10 seconds.

Note: If this calibration value is to be measured and entered remotely via a GPIB controlled DMM, for example, the actual value of the current should not be entered until the cal procedure is ready to receive it.

4 Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the value that is returned is 1.

5 Enter the measured voltage in Volts (V) by sending the command `LASER:CAL:MEAS` <voltage in V>.

For example: `LASER1:CAL:MEAS 1.40`

The calibration procedure sets the output current to approximately 75% of its output range. Allow the current to settle for at least 10 seconds.

6 Send the query `LASER:CAL:STATUS?` to make sure the internal calibration procedure is ready for a measurement.

The calibration procedure is ready for a measurement if it returns the value 1. Query the status until the value that is returned is 1.

7 Enter the measured voltage in Volts (V) by sending the command `LASER:CAL:MEAS` <voltage in V>.

For example: `LASER1:CAL:MEAS 4.429`

After you have entered the second voltage measurement, the internal calibration procedure performs the calibration. The calibration procedure sets the status to 2, indicating the calibration is finished.

Troubleshooting Guide

This section is a guide to troubleshooting the LDC-3926339. Some of the more common symptoms are listed here, and the appropriate troubleshooting actions are given. If problems persist, contact ILX Customer Service (see page *xii* for contact information). Also check the www.ilxlightwave.com Support page, and the Library page for Application Notes and Technical Notes.

Table 5.5 Troubleshooting

Symptom	Corrective Action
LDC-3926 Series unit will not power up	• Check AC Power line voltage and power cord connection.
Power on, but outputs have been shut off. Instrument may be locked up or instrument resets itself.	• This may occur if the instrument loses power (AC line) briefly or line voltage drops below specification. If instrument is "locked up", power it off and then on to restart.
Power on, but no current output	• Check Interlock pins on LASER input connector on instrument rear panel. These pins must be shorted either directly or through a switch. The front-panel Laser Enable key switch should also be on. • If OPEN CIRCUIT is indicated (E403 or E503), check the load connections and cable and then try again. Be sure the cable connector is securely fastened to the back of the module(s). Also check that the Voltage Limit setting is above the laser's operating voltage.
Unable to adjust output	• Check the OUTPUT ON soft key. It should read ON. Check the instrument mode, the channel number, and the laser current limit.
Output current is at limit and cannot be lowered	• If IPD or PPD mode is used, check the monitor diode (feedback) connections. Check the monitor photodiode connections. Also check if the photodiode bias is off.
Output goes off intermittently	• Check the interlock circuit. An intermittent interlock will turn the output off. • Make sure the AC power cord connection is secure. Power-line drop-outs may reset the unit and when power is restored, the output will be off. • Check the output cabling. A laser open circuit will disable output.
Unable to adjust output	• Make sure that the ISET adjust parameter is highlighted. • Check the I LIMIT parameter; it should be set above the laser operating current. • Check the VLIMIT parameter, the voltage limit should be set above the voltage condition of your laser load.
Power Mode operation has high output current, but little or no power is measured	• Check the photodiode bias. If it is off, the circuit may act as an open feedback loop. Set the bias to on (5V).

Table 5.5 Troubleshooting

Symptom	Corrective Action
Output exceeds Power Limit	• Make sure the output-off feature is not disabled. When the power limit is exceeded the output is turned off, but this feature can be disabled through the GPIB. At power-up, the instrument defaults to this safety feature. • The "Power Limit" is not a hardware limit. It only serves as a warning that the power measurement has exceeded the limit set point.
Open Circuit Error occurs during calibration	• Check load connections. Check that measuring meter does not auto-range (use non-auto-ranging modes).
Calibration is aborted unintentionally	• Calibration modes will be aborted if an open circuit is detected or if entered measurements are invalid.

Automatic Shut Off Conditions

When the laser output is off, an internal short is placed across the laser output (pins A2 and A3). By default, the current source output is turned off when when you power up the mainframe. With the laser output enabled, the Channel or Status screens indicate the measured laser current. If the output is not functioning or an error code appears, check the following conditions or Table 5.7 on page *80*.

These conditions automatically force the laser current source to turn off:

- Laser High Power Limit (Plim)
- Laser High Voltage Limit (Vlim)
- Laser Enable Interlock
- Laser Enable Key Lock turned off on the front panel
- Laser Open Circuit

In addition, the laser current limit setting (Ilim) clips the laser drive current at the Ilim setpoint when the signal is being modulated or the current limit setting is exceeded. When the laser current limit (Ilim) is reached, a current limit warning appears on the CHAN menu. The current limit setting is independent of the voltage drop of the device connected to the laser output. Since the current limit circuitry is fully independent of the main current control, the current limit is safely adjustable, even while the laser output is active.

The module's response to sensing the various limits is controlled through the GPIB interface. Most high limit responses are set to turn off the source or give a limit warning through the GPIB interface. See the LASER:ENAB:OUTOFF command on page *49* for more information.

Error Codes

The LDC-3926339 indicates general operational error conditions on the display or through the GPIB. This section contains descriptions of the errors that are specific to the LDC-3926339 module. Refer to the LDC-3926 Manual, for a list of mainframe error codes and descriptions.

Front panel Error Indicators

When an error occurs, the error code appears on the Status page, the Chan page, or the respective channel's setup pages on the front panel display.

The error code clears when you exit any page where it appears. Error indicator codes are summarized in Table 5.6. These are the only error codes that appear on the display. See *Remote Accessible Error Codes* on page *80* for a complete list of all possible error codes.

The output drive shuts off when any error in Table 5.6 occurs.

Table 5.6 Front Panel Error Codes

Error Condition	Explanation
E501 Interlock	Pins 1 and 2 (interlock pins) are not connected properly or the LASER ENABLE key lock is turned off on the front panel.
E503 Voltage limit or open circuit	The laser current source pins are open, or some condition caused the laser voltage to exceed the voltage limit (Vlim) setting.
E504 Current limit	The current limit (Ilim) was reached. This condition causes error code E504 and shut down the source only when enabled through the GPIB interface; otherwise, a current limit will only clip the drive current at the Ilim value and indicate ILIM on the display.
E505 Voltage limit warning	The voltage on the laser current source is approaching the Vlim value. This condition will cause Error Indicator Code E405 or E505 and shut down the source only when enabled through the GPIB interface.
E507 Output power limit	Software calculated optical output power limit (Plim) was detected.
E511 Hardware error	Hardware has detected an error.
E529 Output off when controller thinks it is on	Laser source is off without hardware or software indicating a reason.
E535 Mode changed while output on	Operating mode was changed while the laser current source was on.

Remote Accessible Error Codes

This section contains error codes that the module reports in response to the "MODERR?" query. Refer to the LDC-3926 Manual, for a list of mainframe error codes and descriptions (the codes returned in response to the ERR? query).

Testing for Errors in Remote Operation

For more information about specific GPIB commands, see Chapter 4, *Command Reference*.

1. Send the query `ERR?` to read the system errors and module error summary.

   This allows you to error-check the LDC-3926 as a whole. If any module errors are present, the corresponding bit of the module error summary is set. For example, suppose the mainframe responds to an ERR? query with the string 0,0000000001100000. The zero to the left of the comma indicates that there are no mainframe errors, and the binary representation to the right of the comma indicates that there are errors on channels 7 and 6. (Module 16 is on the left, module 1 is on the right).

2. Send the query `MODERR?` to read the module errors.

For example, type `CHAN 7;MODERR?` to return the errors in module 7, and `CHAN 6;MODERR?` returns any errors in module 6. For more information about mainframe errors, refer to the LDC-3926 Manual.

Table 5.7 Error Codes

Error Code	Explanation
E-103	Length of arbitrary block is different from expected length.
E-104	Parameter is an undefined numeric type.
E-105	Parameter has an invalid exponent.
E-106	A digit was expected in the parameter but was not found.
E-114	Specified arbitrary block length is invalid.
E-123	Command is not found.
E-126	Wrong number of parameters for command.
E-201	Parameter value out of range.
E-202	Error in conversion of parameter type.
E-203	Command is a "secure" command, but secure commands are disabled.
E-204	Suffix is invalid.
E-205	Expected Boolean parameter is invalid.
E-206	Error in conversion to signed 16-bit integer.
E-207	Error in conversion to unsigned 16-bit integer.
E-208	Error in conversion to signed 32-bit integer.
E-209	Error in conversion to unsigned 32-bit integer.
E-210	Error in conversion to floating-point number.
E-211	Error in conversion to character pointer.
E-212	Error in conversion to byte pointer.

Table 5.7 Error Codes

Error Code	Explanation
E-214	Response is too long to output.
E-222	Set value is over range.
E-223	Set value is under range.
E-226	Error in arbitrary block specification.
E-501	Interlock Open forces Laser output off.
E-503	Laser Voltage limit forces output off. "Open Circuit" error.
E-504	Laser Current Limit forces output off.
E-505	Laser Voltage Limit forces output off.
E-507	Laser Monitor Diode Power Limit forces output off.
E-508	External TEC Output Off Status forces LAS output off.
E-509	External TEC Temperature Limit forces LAS output off.
E-510	Out of Tolerance status forced LAS output off.
E-511	Laser Hardware Error forces output off. (e.g. low power line voltage).
E-529	Laser Output is off, but Laser status thought it was on.
E-535	Laser Mode changed while output on.
E-601	Internal error: recalled bin has incorrect checksum. (Settings do not match bin).
E-602	Internal error: task synchronization error.
E-620	Internal error: resource unavailable.
E-621	Internal error: message undeliverable to task.
E-622	Internal error: could not send message to mainframe.
E-710	AC Power Low Error detected
E-711	AC Power Low Error detected
E-713	Power Brown-Out Error detected
E-802	Calibration error: measurement entered before calibration was ready.

INDEX

S

T

W